

# 16. Geology, Minerals, Soils, and Paleontology

## 16.1 Introduction

This chapter describes the geologic, minerals, soils, and paleontologic setting for the Extended, Secondary, and Primary study areas. Descriptions and maps of these three study areas are provided in Chapter 1 Introduction.

The regulatory setting for geology, minerals, soils, and paleontological resources are discussed briefly in this chapter, and are presented in greater detail in Chapter 4 Environmental Compliance and Permit Summary.

This chapter focuses primarily on the Primary Study Area. Potential impacts in the Secondary and Extended study areas were evaluated and discussed qualitatively. Potential local and regional impacts from constructing, operating, and maintaining the alternatives were described and compared to applicable significance thresholds. Mitigation measures are provided for identified significant or potentially significant impacts, where appropriate. Because none were identified for minerals, no mitigation is included in this chapter for that resource.

## 16.2 Environmental Setting/Affected Environment

### 16.2.1 Extended Study Area

#### 16.2.1.1 Geology

Of the 48 contiguous states, California contains the highest and the lowest elevations only 80 miles apart, plus a variety of rocks, structures, and mineral resources equaled by few areas in the world (Norris and Webb, 1990).

California's landscapes are extremely varied, ranging from the broad nearly flat floor of the Great Valley to the jagged glaciated Sierra Nevada. Eleven geomorphic provinces<sup>1</sup> are recognized (Figure 16-1): the Sierra Nevada, the Klamath Mountains, the Cascade Range, the Modoc Plateau, the Basin and Range, the Mojave Desert, the Colorado Desert, the Peninsular Ranges, the Transverse Ranges, the Coast Ranges, and the Great Valley.

California's geologic diversity, in part, is attributed to its location astride two major tectonic plates: the North American Plate and the Pacific Plate. The active San Andreas Fault, heading north out of the Gulf of California, westward along the Transverse Ranges, then northwestward within and west of the Coast Ranges up to Cape Mendocino, separates the North American Plate from the Pacific Plate. Active faulting is an important feature of California's structural pattern. The San Andreas Fault has been crucial in California's geologic history since at least the Miocene epoch (approximately 23 million years ago [MYA]). The ground surface at the fault has moved as much as 350 miles. Other important faults are the Calaveras and Hayward in the San Francisco Bay area, the Nacimiento in the southern Coast Ranges, the San Jacinto of the Peninsular Ranges, the Sierra Nevada in eastern California, and the Garlock, which separates the Mojave Desert from the Sierra Nevada and the Basin and Range.

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<sup>1</sup> The geomorphic provinces are topographic-geologic groupings based primarily on landforms and late Cenozoic structural and erosional history.

The oldest rocks found in California are metamorphic rocks as much as 1.8 billion years old, which occur in the San Gabriel and San Bernardino mountains and in the Mojave and Basin and Range provinces. During the Paleozoic era (approximately 600 MYA), most of California was below sea level and thick sequences of marine sediments were deposited. These sediments ranged from near-shore limestone in the east to deeper-water deposits composed of volcanic detritus<sup>2</sup> from offshore islands mixed with oceanic crustal materials. Marine conditions continued into the Mesozoic era (beginning approximately 260 MYA) but with active subduction<sup>3</sup> as the Pacific Plate plunged under the North American Plate. The sea withdrew to the west and mountains developed in eastern California accompanied by some granitic intrusive activity. With some pauses or interruptions, subduction continued through the latter part of the Mesozoic era when granitic intrusions were again voluminous and very widespread.

Granitic rocks from the Mesozoic era are by far the most abundant igneous rocks in California and are exposed in most provinces. Sedimentation continued offshore in deep marine basins from material stripped off the rising mountains to the east and from volcanic material derived from a chain of offshore volcanic islands; these sediments later become known as the Franciscan Complex. Marine sedimentation decreased in the Cenozoic era (beginning approximately 70 MYA), confined primarily in and west of the San Joaquin Valley and in scattered locations in Southern California. Subduction slowed considerably later in the Cenozoic era, but compressive forces continued, raising the Coast Ranges and eventually closing off the Central Valley from the Pacific Ocean. Beginning in the Eocene epoch and continuing to the Pleistocene, the Central Valley inland basin gradually filled in with continental deposits. During the Pleistocene epoch<sup>4</sup> (approximately 2.6 MYA), extensive glaciation sculpted the Sierra Nevada and other mountain ranges, and large inland lakes developed west of the Sierra Nevada.

### **16.2.1.2 Minerals**

California's geology has resulted in a wealth of mineral resources, including industrial, metallic, and nonmetallic minerals. These minerals are important to the state's economy. California ranks second in the U.S. in non-fuel mineral production; in 2005, over 30 non-fuel mineral commodities – valued at \$3.7 billion – were produced from 820 California mines (CGS, No Date). California's major mineral resources include sand, gravel, crushed stone, building stone, gold, silver, iron, evaporite<sup>5</sup> minerals, and clay.

Sand and gravel are California's most valuable industrial minerals. Most sand and gravel is mined from alluvial deposits, which include sediment from streams and alluvial fans. Other important industrial minerals are crushed stone and limestone.

Gold, silver, and iron are the major metallic minerals mined in California. The most productive gold mining areas include the Sierra Nevada, the Klamath Mountains, and the Mojave Desert. Silver is mined in the Sierra Nevada and iron is mined in the Mojave Desert region. Copper and zinc were mined extensively in the past century, particularly in the Klamath Mountains and the Sierran foothills; production has decreased substantially in recent decades.

Other economically important nonmetallic minerals include borates, which are mined in southern California, and gypsum and clay minerals.

<sup>2</sup> Volcanic detritus is loose fragments, such as sand or gravel, which has been worn away from rock.

<sup>3</sup> Subduction is a geologic process in which one edge of one crustal plate is forced below the edge of another.

<sup>4</sup> An epoch is the shortest division of geologic time.

<sup>5</sup> Evaporite is a nonclastic sedimentary rock composed primarily of minerals produced from a saline solution as a result of extensive or total evaporation of the solvent. Examples include gypsum, anhydrite, rock salt, primary dolomite, and various nitrates and borates.

Oil has been found in 18 counties in California, primarily in the San Joaquin Valley and Southern California. Small amounts of oil are also produced in the northern California near Eureka. Natural gas is generally formed with oil; however, natural gas is produced in the Sacramento Valley without any recoverable oil resources.

Ultramafic<sup>6</sup> rocks, possibly containing localized veins of asbestos, occur widely throughout California (CGS, 2000a).

### 16.2.1.3 Soils

California has over 700 distinct soil series map units.<sup>7</sup> California soil types vary extensively. In the mountains of northern California, where precipitation is higher and vegetation abundant, soil depths are generally deeper with a greater abundance of clay. At lower elevations, such as the Sacramento Valley, rich alluvial soils predominate, supporting an extensive agricultural region. Soils within the southern California coastal plains and adjacent mountains are more clastic (i.e., clay-poor) due to lower precipitation and less vegetation. Soil development east of the Sierra Nevada and the desert portions of Southern California is less extensive.

### 16.2.1.4 Paleontology

Table 16-1 shows the fossil locations and number of fossils found in a database search of the Extended Study Area. Fossils found in the Extended Study Area range from microfossils (fossils of single-celled organisms) to large megafossils (fossils of larger organisms, ranging from small invertebrates to large mammals). Several counties contain more fossil localities than there are actual fossils on record. Typically, these localities represent sites where fossils have been discovered, but the specimens have yet to be added to the database. Because no impacts to paleontological resources are anticipated in the Extended Study Area, a full paleontological inventory review of the Extended Study Area was not conducted.

**Table 16-1  
Fossils and Fossil Locations within the Extended Study Area**

County	UCMP Database		PaleoBiology Database	
	Fossils	Localities	Species	Localities
Alameda	1520	401	63	12
Butte	136	130	100	23
Calaveras	27	31	2	2
Colusa	67	138	25	4
Contra Costa	10,712	2,446	0	0
El Dorado	360	22	0	0
Fresno	2,819	1,890	405	65
Glenn	21	73	28	5
Imperial	179	68	171	12

<sup>6</sup> Ultramafic rocks are igneous rocks that form in high temperature environments well below the surface of the earth. By the time they are exposed at the surface by uplift and erosion, ultramafic rocks may be partially to completely altered to serpentinite, a type of metamorphic rock in which small amounts of chrysotile asbestos are common.

<sup>7</sup> The soil series is the lowest category of the national soil classification system. The name of a soil series or the phase of a soil series is the most common reference term used in soil map unit names. The name of a soil series is also the most common reference term used as a soil map unit component. The purpose of the soil series category is closely allied to the interpretive uses of the system, though map unit components provide the interpretive applications within soil survey for most detailed purposes. Soil series are the most homogeneous classes in the system of taxonomy (NRCS, 2011).

**Table 16-1  
Fossils and Fossil Locations within the Extended Study Area**

County	UCMP Database		PaleoBiology Database	
	Fossils	Localities	Species	Localities
Kern	9,171	1,620	1,183	151
Kings	823	768	60	32
Los Angeles	8,964	1,690	1,069	127
Madera	214	8	27	1
Merced	287	169	41	8
Monterey	1,078	1,202	18	7
Napa	61	101	0	0
Nevada	430	60	247	9
Orange	1,041	938	1,142	123
Placer	31	38	1	1
Plumas	138	73	6	1
Riverside	1364	162	732	172
Sacramento	46	13	20	3
San Benito	677	390	1	1
San Bernardino	4,729	701	761	178
San Diego	7,693	1,743	1,866	260
San Joaquin	814	85	13	9
San Luis Obispo	1429	967	90	34
Santa Barbara	2,672	1,398	906	133
Santa Clara	59	81	67	8
Santa Cruz	2,062	450	220	54
Shasta	9,504	620	899	153
Solano	367	196	135	13
Stanislaus	924	175	82	21
Sutter	74	35	0	0
Tehama	390	284	456	79
Toulumne	221	45	0	0
Tulare	12	25	0	0
Ventura	4,585	982	1,890	200
Yolo	300	104	108	13

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, n.d.

## 16.2.2 Secondary Study Area

### 16.2.2.1 Geology

The Secondary Study Area occurs primarily in the eastern portion of the Coast Range Geomorphic Province and the northwestern portion of the Great Valley Geomorphic Province (Figure 16-1). Additionally, portions of the Klamath Mountains, Cascades, Modoc Plateau, Basin and Range, and the Sierra Nevada geomorphic provinces are within the Secondary Study Area. These are described below.

## **Coast Range Geomorphic Province**

The Coast Range Geomorphic Province is characterized by a series of north-northwest trending ranges and valleys; few are continuous for more than 100 miles. The province extends approximately 600 miles from Point Arguello northward to the Klamath Range (Norris and Webb, 1990) and varies in width from a few miles to 70 miles.

The Coast Ranges are complex and consist of many types of rocks ranging in age from Jurassic (206 MYA) to Tertiary (present time). The Franciscan Formation is composed of metamorphosed sedimentary and igneous rocks. It represents the basement rocks of the Coast Ranges to the west of the project area. The general structural trend is northwest.

The eastern portion of the Coast Range is composed of a thick sequence of Upper Mesozoic (65 to 145 MYA) sedimentary rocks known as the Great Valley Sequence (GVS). The section consists principally of sedimentary rocks that are folded and faulted, and are not affected by other than mild metamorphism. The GVS is divided into several formations that are generally based upon particle size. Although the naming system for these formations has been subject to many revisions (e.g., Blake et al., 1992; Dickinson and Rich, 1972; Rich, 1971; Ingersoll, 1979), for this study, the pertinent formations of the GVS (from oldest to youngest) include the Stony Creek, Lodoga, Boxer, Venado, Cortina, and Yolo. Quaternary (1.8 MYA to Present) units in the Coast Range include stream deposits consisting of clay, silt, sand, gravel, cobbles, and boulders found in recent stream channels. Stream deposits are derived from the older components of the Franciscan Complex and the GVS. Hillside deposits occur along slopes or at their bases. It consists of soil, but contains a sizable fraction of angular rock fragments and some organic material. Landslide deposits are similar to hillside deposits, but are more defined and generally deeper. Landslide deposits tend to occur on steeper slopes.

## **Great Valley Geomorphic Province**

The Great Valley Geomorphic Province is a nearly flat alluvial plain extending from the Tehachapi Mountains in the south to the Klamath Mountains in the north; to the Sierra Nevada in the east and the Coast Ranges in the west. The valley consists of the San Joaquin River drainage to the south of the Sacramento-San Joaquin Delta, and the Sacramento River drainage to the north. This northwest-trending trough has been filled with a thick (several miles deep) (Wahrhaftig and Birman, 1965) accumulation of sediments eroded from the adjacent ancestral Sierra Nevada and Klamath Mountain ranges from the Jurassic to the Present. It has a long stable eastern shelf supported by subsurface granite and a short western flank with basin sediments. The western edge has eroded to form a series of northwest-trending eastward-dipping ridges of sandstone and conglomerate separated by valleys underlain by siltstone and mudstone.

Rock units on the surface in the Great Valley Geomorphic Province close to the Secondary Study Area range in age from Miocene to Recent (23.8 MYA to Present).

The Lovejoy basalt is a dense and very hard extrusive volcanic rock (i.e., lava flow). The basalt originated approximately 23 million years ago from an unknown volcanic center near the eastern margin of the Sierra Nevada. Lovejoy exposures are found in the Orland Buttes on the west side of the Central Valley and as far south as Vacaville. Extensive outcrops of the Lovejoy are located in the Oroville area.

The Tehama Formation occurs as thin, discontinuous, and deeply weathered stream-transported fan deposits throughout the western edge of the Sacramento Valley that were derived from the erosion of the Coast Ranges and Klamath Mountains. Eastward, the deposits thicken and merge, forming a broad thick

plain that contains pale green to tan semi-consolidated sand, tuffaceous<sup>8</sup> sand, and silt with lenses of gravel. The Tehama Formation is the primary groundwater aquifer of the Sacramento Valley west of the Sacramento River. The Nomlaki Tuff Member occurs near the bottom of the Tehama Formation and has been age-dated at approximately 3.3 million years. It consists of white, tan, or pink dacite pumice tuff and lapilli tuff that is approximately 30 feet thick along the west side of the valley. Most of the tuff is believed to have been deposited as an ash fall from a major volcanic eruption east of the project region.

The Red Bluff Formation occurs primarily in the northern portion of the Sacramento Valley, where it overlies the Tehama Formation. Its largest area is in the vicinity of the City of Red Bluff where it is approximately 50 feet thick. It consists largely of gravels with minor amounts of interbedded sands. The upper surface usually consists of a hardpan soil. In the Red Bluff area, rock fragments are metamorphic and igneous types, indicating that the sediments were transported from the north Coast Ranges and Klamath Mountains. The formation was probably deposited during a period when glaciers were active in the adjacent mountain areas. Streams draining the glacial areas were heavily choked with coarse debris and suspended fine-grained material. The suspended clay and silt particles filled the voids after deposition of the gravel so that most of the Red Bluff gravels are not very permeable. The Red Bluff remnants represent an extensive Pleistocene (1.8 MYA to 11,600 years ago) nearly level erosional surface that once covered much of the northern Sacramento Valley.

The Riverbank Formation consists of weathered reddish gravel, sand, and silt. It is differentiated from the younger Modesto Formation by its terraces being higher topographically and by its more developed soil profile. The upper layer is unconsolidated, but compact dark brown to red alluvium and forms the lower of the Riverbank terraces. The lower layer is a red semi-consolidated gravel, sand, and silt. Its surface is higher topographically and more dissected than the upper layer and has a stronger soil profile.

The Modesto Formation consists of the lowest distinct alluvial terraces lying above the Holocene (11,600 years ago to Present) stream deposits. It includes tan and light gray gravelly sand, silt, and clay. The upper layer is unconsolidated and unweathered, and it forms the lowest terraces approximately ten feet thick over older alluvial deposits. The lower layer can be slightly weathered and forms terraces that are higher than the upper layer. Soils on the lower layer contain clay and are red.

Recent stream channel deposits, floodplain, and flood basin deposits make up the remainder of rock types that crop out in the Sacramento Valley. Stream channel and floodplain deposits consist of well-sorted sand, gravel, and silt adjacent to the major streams. Flood basin deposits are the finest grained materials, consisting mostly of clay and silt. The deposits are thin and poorly permeable. Flood basin deposits in the project area occur in the Colusa Basin along the west side of the Sacramento River from approximately Princeton southward.

The Tuscan and Laguna formations, important water-bearing formations beneath the Sacramento Valley, crop out along the eastern portion of the Sacramento Valley. Further discussion of these formations is included in Chapter 10 Groundwater Resources.

### **Klamath Mountains Geomorphic Province**

The Klamath Mountain Geomorphic Province is divided into four north-south trending terranes<sup>9</sup>. From east to west, these terranes are the Eastern Klamath, Central Metamorphic, Western Paleozoic and

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<sup>8</sup> Tuffaceous sand is a rock composed of compacted volcanic ash varying in size from fine sand to coarse gravel.

<sup>9</sup> Terranes are areas having a preponderance of a particular rock or rock groups.

Triassic, and Western Jurassic. The terranes increase in age from west to east, except for the Central Metamorphic Terrane, which is slightly older than the Eastern Klamath Terrane. The rock units generally dip to the east, with the older eastern units overlying the younger western units. To varying degrees, these rock units are exposed throughout the 40-mile reach of the mainstem Trinity River. Older gold-bearing stream channel deposits, as well as recent channel deposits, occur along rivers and creeks.

### **Cascades Geomorphic Province**

The Cascades Geomorphic Province, from southern British Columbia to south of Lassen Peak, is a volcanic terrane ranging in age from Pliocene to Holocene. The province has been divided into the Western Cascade series and the High Cascade series. The Western Cascade series consists of Miocene-aged basalts, andesites, and dacite flows interlayered with rocks of explosive origin, including rhyolite tuff, volcanic breccia, and agglomerate. This series is exposed at the surface in a belt 15 miles wide and 50 miles long from the Oregon border to the town of Mount Shasta. Early High Cascade rocks formed very fluid basalt and andesite that extruded from fissures to form low shield volcanoes. Large composite cones like Mount Shasta and Mount Lassen had their origins during the Pleistocene. Mount Lassen was the only active volcano in California in the 20th century. Mount Shasta was last active in the 18th century when steam and ash erupted from the summit cone (Norris and Webb, 1990).

### **Modoc Plateau Geomorphic Province**

The Modoc Plateau Geomorphic Province consists of a high plain of irregular volcanic rocks of basaltic origin. The numerous shield volcanoes and extensive faulting on the plateau give the area more relief than may be expected for a plateau. The Modoc Plateau averages 4,500 feet in elevation and is considered a small part of the Columbia Plateau, which covers extensive areas of Oregon, Washington, and Idaho.

### **Basin and Range Geomorphic Province**

The Basin and Range Geomorphic Province, located east of the Modoc Plateau and the Sierra Nevada, extends eastward into western Utah. It is characterized as north-south trending mountain ranges separated by low wide alluvial valleys derived from eroded materials from the adjacent mountain ranges. In general, the drainage is internal (i.e., no outlet to the sea) with saline lakes occupying low spots. One area, the Sierra Valley, drains westward into the Middle Fork Feather River. Rocks range from metamorphic rocks of pre-phanerozoic age (approximately 1.8 billion years ago to Recent) lakebed and stream deposits. Paleozoic and early Mesozoic sedimentary and metamorphic rocks constitute the bulk of the bedrock. The topography of the Basin and Range is a result of crustal extension within this part of the North American Plate. The crust has been stretched up to 100 percent of its original width, and underneath the Basin and Range, it is of the thinnest in the world.

### **Sierra Nevada Geomorphic Province**

The Sierra Nevada Geomorphic Province is comprised principally of Cretaceous granitic pluton<sup>10</sup>, remnants of Paleozoic and Mesozoic metavolcanic and metasedimentary rocks, and Cenozoic volcanic and sedimentary rocks. The Paleozoic and Mesozoic metavolcanic and metasedimentary rocks were intruded by the granitic plutons approximately 77 to 225 MYA, resulting in local uplift and deformation of the overlying older rock. Regional uplift and rapid erosion of most of the overlying metamorphic rocks closely followed intrusion of the plutons, exposing the underlying granitic rocks. Continued uplift and

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<sup>10</sup> Plutons are masses of igneous rock that have solidified below the surface of the earth.

erosion, accompanied by volcanic activity and alpine glaciation, resulted in the present pattern of deep-walled valleys that characterize the Sierra Nevada.

### **16.2.2.2 Minerals**

The mineral resources within the Secondary Study Area are the same as was described for the Extended Study Area. The exceptions are iron and gypsum, which are mined in southern California, but are not found in the Secondary Study Area.

The Stony Creek Fan in Glenn County has an estimated aggregate material availability of 160 million cubic yards (DWR, 2002).

Ultramafic rocks, possibly containing localized veins of asbestos, occur in the Coast Ranges, Klamath Mountains, and the Sierra Nevada (CGS, 2000a). Chromite was mined intermittently from ultramafic rocks in Glenn County in the vicinity of the town of Chrome. Mining activity ceased in the 1940s.

### **16.2.2.3 Soils**

Soils in the western portion (i.e., the Coast Range foothills) of the Secondary Study Area are a byproduct of erosion of the underlying sedimentary rocks. Typical foothill soils are shallow to deep, generally well-drained, and fine- to medium-textured. Soil depth on steep slopes is moderate to very thin; slightly weathered sandstone and intensely weathered mudstones can be encountered within just a few inches of the surface. Soil depth increases on the gentler slopes, generally reaching its maximum thicknesses along valley bottoms. These deeper soils are more developed, moderately drained, and finer-grained; organic material is more common in the low-lying deeper soils.

Soils in the central portion (i.e., the Sacramento Valley) of the Secondary Study Area are a byproduct of the underlying weathered alluvial deposits. Most valley soils are alluvial silt loams, clays, and sands deposited by the Sacramento River and tributaries draining the west side of the valley. These soils are typically very deep to moderately deep, poorly drained, and fine-textured. The majority of the alluvial soils on the valley floor has high agricultural productivity and is designated as Prime Agricultural<sup>11</sup> soils. Some soils are limited in their ability to support many forms of agriculture because of alkali problems and/or drainage problems caused by the presence of a cemented hardpan or dense clay layer. These poorly drained soils are particularly well suited for growing rice.

Soils in the northern and eastern portions of the Secondary Study Area (i.e., the Klamath, Cascades, and Sierra Nevada) are a byproduct of the underlying metamorphic, volcanic, and intrusive rocks. In general, they are more clay-rich than the alluvial soils of the Sacramento Valley.

### **16.2.2.4 Paleontology**

Table 16-2 shows the fossil locations and number of fossils found in the Secondary Study Area. As in the Extended Study Area, the recovered fossils range from microfossils to the bones of large mammals. Several counties contain more fossil localities than actual fossils because not all fossils from known localities have been added to the database at this time (the localities have been listed, but the specimens from those sites have yet to be entered into the database). Construction activities in the Secondary Study Area are limited to the installation of a new pump at the Red Bluff Pumping Plant, and maintenance activities are limited to the dredging of the intakes; neither operation will involve excavation into

<sup>11</sup> Prime Agricultural means that the soil meets the physical and chemical criteria for Prime Farmland or Farmland of Statewide Importance, as determined by the USDA Natural Resources Conservation Service (NRCS).

sediments with the potential to yield fossils. Because these activities are not expected to affect paleontological resources, a full paleontological inventory review of the Secondary Study Area was not conducted.

**Table 16-2  
Fossils and Fossil Locations within the Secondary Study Area**

County	UCMP Database		PaleoBiology Database	
	Fossils	Localities	Species	Localities
Alameda	1,520	401	63	12
Butte	136	130	100	23
Colusa	67	138	25	4
Contra Costa	10,712	2,446	0	0
Del Norte	4	65	18	3
El Dorado	360	22	0	0
Glenn	21	73	28	5
Humboldt	3,522	782	96	8
Marin	377	342	38	8
Placer	31	38	1	1
Sacramento	46	13	20	3
San Francisco	34	122	4	3
San Mateo	405	730	124	16
Santa Clara	59	82	67	8
Shasta	9,504	620	899	153
Solano	367	196	135	13
Sonoma	301	504	20	8
Sutter	74	35	0	0
Tehama	390	284	456	79
Trinity	118	32	0	0
Yolo	300	104	108	13
Yuba	0	3	0	0

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, n.d.

### 16.2.3 Primary Study Area

#### 16.2.3.1 Geology

Table 16-3 lists the Coast Range rock units and the Sacramento Valley rock units within the Primary Study Area. Figure 16-2 is a generalized geologic map of the Primary Study Area (CGS, 2000b). Detailed mapping of the rock units within the Sacramento Valley (Helley and Harwood, 1985) is shown in Figure 16-3.

**Table 16-3  
Coast Range Rock Units in the Primary Study Area**

Coast Range Rock Units		
Geologic Period	Rock Unit	
Quaternary 1.8 MYA to Present	Stream channel deposit, slope wash, landslide deposits	
Upper Cretaceous 65 to 100 MYA	Cortina Formation (Includes Venado and Sites sandstone members Boxer Formation	Franciscan Formation
Lower Cretaceous 100 to 145 MYA	Lodoga Formation Stony Creek Formation	
Great Valley Rock Units		
Geologic Period	Geologic Epoch	Rock Unit
Quaternary	Holocene 11,600 years ago to Present	Stream channel deposits Flood plan deposits Basin deposits
Tertiary	Pleistocene 2.6 MYA to 11,600 years ago	Upper Modesto Formation Lower Modesto Formation Upper Riverbank Formation Lower Riverbank Formation Red Bluff Formation
	Pliocene 5.3 to 1.8 MYA	Tehama Formation
	Miocene 23.8 to 5.3 MYA	Lovejoy Basalt

**Sites Reservoir Inundation Area, Sites Reservoir Dams, and Recreation Areas**

Sites Reservoir and its dams would be located in sedimentary rocks of the GVS. The GVS is composed of Jurassic-Cretaceous marine sandstones, siltstones, and mudstones trending north by northwest and dipping steeply to the east. Older sedimentary rocks of the GVS occur to the west, and younger sedimentary rocks occur to the east.

Within the footprint of the Sites Reservoir, the GVS is primarily composed of the Boxer Formation. The Boxer Formation consists of thinly bedded mudstones with thin to medium sandstone/siltstone. The mudstone of the Boxer Formation is more erodible than the sandstone, thus forming the broad gentle relief of the Antelope Valley. The saddle dam foundations along the northeastern portion of the reservoir would be sited in the Boxer Formation.

The prominent ridge along the eastern shore of Sites Reservoir is formed from the contact between the underlying Boxer Formation and the more resistant Cortina Formation. The Cortina Formation consists of a greater proportion of sandstone, with moderate to thick mudstone interlayers. The basal member of the Cortina Formation, the Venado Sandstone, is the geologic unit in which the Golden Gate Dam and the Sites Dam foundations would be built.

Younger deposits of Late Quaternary (8,000 year ago to Present) deposits occur within the Sites Reservoir footprint, primarily along the stream valleys of Stone Corral Creek, Antelope Creek, Funks Creek, and Grapevine Creek in Antelope Valley. The deposits are composed primarily of fine-grained sands, silts,

and clays derived from the surrounding Boxer Formation. Larger fragments of igneous and metamorphic rock occur in the deposits and are derived from upland areas west of the valley. They generally occur as stream channel and floodplain deposits; minor colluvium deposits occur on higher gentler slopes away from the streams. Floodplain deposits typically contain beds of sandy gravel and silty sand. Stream channel deposits consist of sandy silt and gravel inset into either the floodplain or terrace deposits. In general, the deposits are rather thin (less than 30 to 50 feet) with a maximum thickness reached adjacent to the downcut stream channels on the eastern side of Antelope Valley.

The five recreation areas would be located on either the Boxer Formation or the Cortina Formation.

### **Sites Pumping/Generating Plant, Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, Sites Reservoir Inlet/Outlet Structure, Sites Electrical Switchyard, and Field Office Maintenance Yard**

The Sites Generating/Pumping Plant would be sited on the eastern slope of a prominent ridge composed of sandstones and mudstones of the Cortina Formation. Quaternary alluvium covers the alignment trace of the intake canal. The tunnel alignment would be in mostly Cortina Formation mudstones and sandstone, except for its western opening which would be in mudstones of the Boxer Formation. The Inlet/Outlet Structure would be sited in the Boxer Formation. The Sites Electrical Switchyard would be sited in sandstone of the Cortina Formation. The Field Office Maintenance Yard would be sited primarily in sandstone with occasional thin beds of mudstone of the Lodoga Formation.

### **Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard**

Bedrock within and surrounding the existing Funks Reservoir is composed primarily of thinly bedded mudstones of the Yolo Member of the Cortina Formation. Due west of Funks Reservoir, the Sites member of the Cortina Formation is older geologically, and occurs as a more resistant ridge of thin to medium bedded sandstone and siltstones. Typically, the mudstone members are more susceptible to weathering and erosion, forming broad low valleys or swales between the more resistant sandstone. A more resistant outcrop of sandstone occurs near the downstream portion of Funks Reservoir in the vicinity of the existing Funks Dam. The Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard would be sited in thinly bedded mudstones of the Yolo Member of the Cortina Formation. Younger deposits of the Late Quaternary (8,000 year ago to Present) occur on top of the bedrock around and inundated by Funks Reservoir; the Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard would also be sited on these deposits.

### **Glenn-Colusa Irrigation District Canal**

Geologic units along the alignment trace of the GCID Canal consist of (from youngest to oldest) the Basin Deposits, Upper and Lower Modesto Formation, and Upper and Lower Riverbank Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

The GCID Canal headworks are located on the Lower Riverbank Formation. From approximately one mile south of the headworks to Stony Creek, the Canal then crosses the Lower Modesto Formation. Between Stony Creek and Willows, the Canal crosses the Upper and Lower Modesto Formation and the Riverbank Formation, as well as basin deposits. From Willows south to the Funks Reservoir, the Canal crosses primarily basin deposits and isolated deposits of Upper Modesto Formation and Upper Riverbank Formation.

### **Tehama-Colusa Canal**

Geologic units along the alignment of the T-C Canal consist of (from youngest to oldest) the Basin Deposits, Upper and Lower Riverbank Formation, Upper and Lower Modesto Formation, Red Bluff Formation, Tehama Formation, and Cortina Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

From Willow Creek to Funks Reservoir, the Canal crosses primarily deeply weathered mudstones, siltstones, and minor thin beds of sandstone of the Cortina Formation between drainage divides and younger alluvium or basin deposits at stream crossings.

### **Delevan Pipeline and Delevan Transmission Line**

Geologic units along the alignment of the Delevan Pipeline consist of (from youngest to oldest) recent Sacramento River stream deposits, Basin Deposits, Lower Riverbank Formation, Lower Modesto Formation, and Cortina Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

### **Terminal Regulating Reservoir, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, Delevan Pipeline Electrical Switchyard, Terminal Regulating Reservoir Pumping/Generating Plant, and Terminal Regulating Reservoir Electrical Switchyard**

Geologic units underneath and adjacent to the proposed location of the TRR, GCID Canal Connection to the TRR, TRR Pipeline, TRR Pipeline Road, Delevan Pipeline Electrical Switchyard, TRR Pumping/Generating Plant, and TRR Electrical Switchyard consist of Basin Deposits and the Lower Riverbank Formation. Descriptions of these geologic units are included in Section 16.2.2.1.

### **Delevan Pipeline Intake Facilities and Delevan Pipeline Discharge Facility**

Geologic units underneath the proposed location of the Delevan Pipeline Intake Facilities and Delevan Pipeline Discharge Facility consist of recent Sacramento River stream deposits, Lower Modesto Formation, and the Tehama Formation. Descriptions of these geologic units are included in Section 16.2.2.1. The stream deposits and Lower Modesto Formation are relatively thin (less than 20 feet) and are underlain by the more resistant Tehama Formation. The Tehama Formation is less readily erodible and defines the western edge of the Sacramento River channel.

### **Road Relocations and South Bridge**

Geologic units underneath the proposed location of the road relocations consist of the Boxer and Cortina Formations of the GVS (Section 16.2.2.1). Additionally, these older deposits are occasionally overlain by younger sedimentary deposits of Late Quaternary (8,000 year ago to Present).

### **Project Buffer**

Geologic units underneath the portion of the Project Buffer that would surround Sites Reservoir and the inlet/outlet facilities, as well as the Holthouse Reservoir Complex, consist primarily of the Boxer and Cortina formations of the GVS (Section 16.2.2.1), with smaller portions of Basin Deposits, upper and lower members of both the Riverbank and Modesto formations, and Red Bluff Formation.

Geologic units underneath the portion of the Project Buffer that would surround the TRR facilities consist of Lower Riverbank Formation, Basin Deposits, and Red Bluff Formation.

Geologic units underneath the portion of the Project Buffer that would surround the Delevan Pipeline Intake/Discharge Facilities consist of Lower Modesto Formation and recent Sacramento River stream deposits.

### **16.2.3.2 Minerals**

With the exception of an inactive dimensional stone quarry to the east of the proposed Sites Dam location, no known economic mineral resources occur in Primary Study Area. No locally important mineral resources exist within the Primary Study Area (Glenn County, 1997 and Colusa County, 1989).

Natural gas production occurs widely in the Primary Study Area with large gasfields in the Sacramento Valley, such as the Willows-Beehive Bend Field. Between 1948 and 1972, 10 exploratory wells were drilled within the footprint of the proposed Sites Reservoir; all 10 wells were “dry holes” (i.e., produced no natural gas). Approximately 10 exploratory wells (all “dry holes”) were also drilled near the alignment of the Delevan Pipeline.

Ultramafic rocks possibly containing localized veins of asbestos are not found within the Primary Study Area or in watersheds draining into the Primary Study Area (CGS, 2000a).

### **16.2.3.3 Soils**

The soils in the Primary Study Area have been mapped by the U. S. Department of Agriculture, Soil Conservation Service (now the NRCS), and are described in the soil surveys of Colusa and Glenn counties (NRCS, 2006 and Begg, 1965). In addition, the NRCS provides soil data in GIS format and software (Soil Data Viewer) for detailed analysis of soil properties.

The Primary Study Area includes two physiographic provinces: the Sacramento Valley and the Coast Range foothills (NRCS, 2006).

Floodplains extending along both sides of the Sacramento River slope gently away from the river to the Butte Sink to the east and Colusa Basin to the west. Frequent overflows under natural conditions have deposited loamy soils high in content of silt and fine sand. A levee system combined with Shasta Reservoir upstream helps to control Sacramento River waters so that floodplains are no longer flooded on a regular basis.

The soils on the floodplains along the Sacramento River are very fertile and are among the best soils in the Sacramento Valley. Several sloughs originally disseminated from the Sacramento River into the Butte Sink and Colusa Basin. Water flow was stopped by construction of levees on the Sacramento River. These sloughs, particularly the Sycamore Slough, carried river sediments several miles from the river, creating the very productive Vina soils. West from the floodplains along the Sacramento River, the Colusa Basin extends north and south through the Primary Study Area. Overflows containing clayey sediments from the Sacramento River and foothill streams regularly filled the Colusa Basin. Because of the construction of levees on the Sacramento River, only sediments from the foothill streams now reach the basin. The basin is mostly leveled for rice production. Salts in the clayey sediments from the foothill streams were deposited in the basin soils, particularly Willows soils, and reclamation of the soils has been ongoing since early in the 20th century. Most basin soils have been reclaimed to several feet. The very deep clay deposits that are characterized by extremely slow permeability and a shallow water table hamper further reclamation.

Alluvial fans exist along the west side of the Sacramento Valley. They originate at the base of the foothills, at elevations of 200 to 400 feet, and gently descend to the east for several miles to the Colusa Basin. Under natural conditions, streams from the foothills flooded these alluvial fans, depositing fertile

loamy soils. Many of the streams have been diverted from their natural channels, and levees have been constructed in some areas to control flooding.

Most of the foothill region is drained by streams flowing east to the Sacramento Valley. These streams occasionally carry heavy volumes from high rainfall events, and cause flooding in the Sacramento Valley along the west-side alluvial fans and in the Colusa Basin. Increased runoff has scoured and lowered the stream channels of many foothill streams. Some streams have been diverted or channelized in the Sacramento Valley. The foothill streams eventually find their way to the Colusa Basin and to the Colusa Basin Drain. Occasionally, the flow exceeds the capacity of the south-flowing Colusa Basin Drain, and widespread flooding occurs in the basin.

The Coast Range foothills range from approximately 200 to 2,500 feet in elevation. The lower foothills have rolling slopes in many areas and have clayey soils and very few oak trees. In most foothill areas, the soils are strongly sloping and are shallow or moderately deep over sandstone and mudstone of the Great Valley Sequence. Most small valleys in the foothills have gently sloping clayey soils and some areas of loamy soils.

The NRCS has mapped 61 soil types within the Primary Study Area. Appendix 16A provides the soil map unit name, the county in which it occurs, a map unit description, and several soil properties, such as erosion potential, shrink/swell potential, corrosion of steel potential, and corrosion of concrete potential. Soil property values were derived using the NRCS Soil Data Viewer software.

**Sites Reservoir Inundation Area (1.27 MAF and 1.81 MAF)**

Thirty-four soil types occur within the proposed Sites Reservoir footprint for Alternative A (1.27 MAF). Of these, 13 soil types make up approximately 92 percent of the total area (Table 16-4). The remaining 21 soil types make up less than eight percent of the total area.

**Table 16-4  
Major Soil Types at Sites Reservoir (Alternative A)**

Soil Type	Acreage	Percent of Total	Cumulative Percent of Total
Capay clay	2,961.7	24.25	24.25
Altamont-Sehorn complex	2,315.8	18.96	43.20
Sehorn-Altamont complex	1,872.8	15.33	58.54
Corval loam	1,529.4	12.52	71.06
Altamont silty clay	841.4	6.89	77.94
Corning clay loam	348.9	2.86	80.80
Millsholm-Contra Costa association	311.4	2.55	83.35
Altamont-Contra Costa clays	193.8	1.59	84.94
Hillgate loam	191.2	1.57	86.50
Clear Lake clay	176.5	1.44	87.95
Zamora silty clay	174.2	1.43	89.37
Myers clay	172.4	1.41	90.78
Millsholm-Rock outcrop association	160.1	1.31	92.09

Thirty-six soil types occur within the proposed Sites Reservoir footprint for Alternatives B and C (both are 1.81 MAF). Of these, 15 soil types make up approximately 93 percent of the total area (Table 16-5). The remaining 21 soil types make up less than seven percent of the total area.

**Table 16-5  
Major Soil Types at Sites Reservoir (Alternatives B and C)**

Soil Type	Acreage	Percent of Total	Cumulative Percent of Total
Capay clay	3,070.7	21.49	21.49
Altamont-Sehorn complex	2,633.9	18.43	39.92
Sehorn-Altamont complex	2,441.7	17.09	57.01
Corval loam	1,608.8	11.26	68.27
Altamont silty clay	902.7	6.32	74.58
Millsholm-Contra Costa association	527.7	3.69	78.28
Corning clay loam	357.3	2.50	80.78
Altamont-Contra Costa clays	324.6	2.27	83.05
Millsholm-Rock outcrop association	315.1	2.21	85.25
Myers clay	214.8	1.50	86.76
Hillgate loam	192.9	1.35	88.11
Altamont soils	192.5	1.35	89.45
Zamora silty clay	178.6	1.25	90.70
Clear Lake clay	176.5	1.24	91.94
Nacimiento-Contra Costa association	164.9	1.15	93.09

### **Sites Reservoir Dams**

Fourteen soil types occur within the footprints of the Sites Dam, Golden Gate Dam and associated small saddle dam, and the six northern saddle dams for Alternative A. The Sites Dam location is predominantly underlain by the Millsholm-Contra Costa association soil type (14.3 acres) and a smaller amount of Corval loam (1.0 acre). The Golden Gate Dam and associated small saddle dam locations are underlain entirely by the Millsholm-Rock outcrop association soil type (41.0 acres). The six northern saddle dam locations are underlain primarily by Nacimiento-Contra Costa association (15.2 acres), Capay clay (11.0 acres) and Altamont soils (5.6 acres) with lesser amounts of Zamora silty clay (2.8 acres), Sehorn-Millsholm association (1.0 acre), and Millsholm very rocky sandy loam, Willows clay, Tehama clay loam, Altamont-Contra Costa clays, and Myers clay (each less than 0.5 acre).

The same fourteen soil types occur within the footprints of the Sites Dam, Golden Gate Dam, and nine northern saddle dams for Alternatives B and C. The Sites Dam location is predominantly underlain by the Millsholm-Contra Costa association soil type (18.1 acres) and a smaller amount of Corval loam (1.2 acres). The Golden Gate Dam location is underlain by the Millsholm-Rock outcrop association soil type (15.1 acres), the Capay clay (10.8 acres), the Corval loam (10.4 acres), and lesser amounts of Millsholm-Contra Costa association (0.6 acre) and Sehorn-Altamont complex (0.05 acre) soil types. The nine northern saddle dam locations are underlain primarily by Nacimiento-Contra Costa association (37.1 acres), Capay clay (20.0 acres), Altamont soils (17.0 acres), Sehorn-Millsholm association (8.1 acres), Altamont-Contra Costa clay (3.2 acres) and Sehorn-Altamont complex (3.0 acres) with lesser amounts of Zamora silty clay (2.6 acres), and Tehama clay loam, Willows clay, Millsholm-Rock outcrop association, and Sehorn-Millsholm-Gullied land complex (each less than 1.6 acres).

Soil cover at the proposed Sites and Golden Gate damsites is very thin and is derived from the interbedded sandstone and siltstones of the Venado Sandstone. Soil cover at the seven (Alternative A) and nine (Alternatives B and C) saddle damsites is moderately deep with gradual transition into the mudstones and siltstones of the Boxer Formation.

### **Recreation Areas**

The Recreation Areas would be underlain predominantly by Sehorn-Altamont complex (302.9 acres), Millsholm-Contra Costa association (264.8 acres), Nacimiento-Contra Costa association (217.0 acres), Millsholm-Contra Costa complex (129.1 acres), Altamont-Sehorn complex (119.5 acres), and Capay clay (96.0 acres) soils. The remaining 74.1 acres would be underlain by five other soil types in lesser amounts.

### **Road Relocations and South Bridge**

The Road Relocations and South Bridge (including a 200-foot-wide construction disturbance area) would be underlain by 43 different soil types. Total affected area is approximately 1,329 acres. The predominant soil types are Millsholm-Contra Costa association (273.1 acres), Sehorn-Altamont complex (234.9 acres), and Capay clay (210.7 acres). The remaining 610.6 acres are composed of 40 other soil types with acreages ranging from 79.5 acres to 0.1 acre.

### **Sites Pumping/Generating Plant, Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure, Sites Reservoir Inlet/Outlet Structure, Sites Electrical Switchyard, and Field Office Maintenance Yard**

The Sites Pumping/Generating Plant would be located within the footprint of the proposed Inlet/Outlet Structure. The Tunnel would be entirely underground with openings in the outlet and inlet structures. The Inlet/Outlet Structure would be underlain predominantly by Millsholm-Rock outcrop association (34.7 acres), Corval loam (24.1 acres), and Sehorn-Altamont complex (15.0 acres) soils, with lesser amounts of Capay clay (8.7 acres), and Millsholm-Contra Costa association (7.6 acres) soils. Nearly 10 acres of Inlet/Outlet structure would be located in the footprint of the existing Funks Reservoir; no NRCS soils data are available for that area. The Sites Electrical Switchyard would be underlain by the Millsholm-Rock outcrop association. The Field Office Maintenance Yard would be underlain almost entirely by the Millsholm-Rock outcrop complex (18.0 acres) with a small portion by Capay clay (0.3 acre).

### **Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard**

No NRCS soils data are available for the footprint of the existing Funks Reservoir. The proposed Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard would be underlain predominantly by Capay clay (129.2 acres) and Capay clay loam (74.0 acres) soils with lesser amounts of Hillgate clay loam (62.2 acres), Altamont-Sehorn complex (39.8 acres), Corval clay loam (36.1 acres), and Altamont silty clay (18.9 acres).

### **Terminal Regulating Reservoir, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant, and Terminal Regulating Reservoir Electrical Switchyard**

The TRR, GCID Canal Connection to the TRR, TRR Pumping/Generating Plant, and TRR Electrical Switchyard would be underlain by Capay clay loam (114.2 acres) and Hillgate clay loam (90.6 acres) soils, with 4.7 acres of Corval clay loam.

### **Glenn-Colusa Irrigation District Canal Facilities Modifications**

The three modifications are primarily within the footprint of the existing GCID Canal; soil data within the footprint is unavailable (i.e., noted as water on soil map). At the railroad siphon location, Myers clay is present on both sides of the Canal. At the new headgate location, Hillgate loam is present on both sides of the Canal. The 200-foot canal lining feature is entirely within the footprint of the existing GCID Canal.

### **Delevan Pipeline, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, and Delevan Pipeline Electrical Switchyard**

The Delevan Pipeline would be underlain predominantly by Willows silty clay (96.5 acres) and Hillgate clay loam (51.8 acres) with lesser amounts of Capay clay loam (28.0 acres), Corval clay loam (23.2 acres), Moonbend silt loam (8.5 acres), Corbiere silt loam (6.4 acres), and Vina loam (2.1 acres). The construction disturbance area for the Delevan Pipeline (totaling approximately 2,365 acres) would be underlain predominantly by Willows silty clay (1,175.6 acres), Hillgate clay loam (379.8 acres), Capay clay loam (277.3 acres), Corval clay loam (247.3 acres), Moonbend silt loam (101.3 acres), and Corbiere silt loam (84.9 acres). Six other soil types make up the remaining 86 acres in lesser amounts.

The TRR Pipeline, TRR Pipeline Road, and Delevan Pipeline Electrical Switchyard would be underlain predominantly by Hillgate clay loam (6.5 acres) with a lesser amount of Capay clay loam (2.1 acres). The construction disturbance area for these three facilities would be entirely within the construction disturbance area of the Delevan Pipeline.

### **Delevan Transmission Line**

The Delevan Transmission Line route would be located within the construction disturbance area of the Delevan Pipeline, except for a four-mile portion extending west of the proposed TRR. This discussion addresses only that portion of the transmission line outside of the Delevan Pipeline construction disturbance area. The proposed Delevan Transmission Line route (west of the TRR) would be underlain predominantly by Altamont silty clay (23.6 acres), Corval loam (9.5 acres), Millsholm-Rock outcrop association, (8.3 acres), Capay clay (5.8 acres), and Altamont-Sehorn complex (5.4 acres). Seven other soil types make up the remaining 20.6 acres in lesser amounts.

### **Delevan Pipeline Intake Facilities (Alternative A and C)**

The proposed Delevan Pipeline Intake Facilities would be underlain by Vina loam (17.4 acres). A portion of the facility (1.7 acres) would extend into the river; no NRCS soils data are available for that area.

### **Delevan Pipeline Discharge Facility (Alternative B)**

The proposed Delevan Pipeline Discharge Facility would be underlain by Vina loam (7.64 acres). A portion of the facility (0.1 acre) would extend into the river; no NRCS soils data are available for that area.

### **Project Buffer**

The Project Buffer would surround all Primary Study Area Project facilities, with the exception of the Delevan Pipeline, Delevan Transmission Line, portions of the roads, and the GCID Canal Facilities Modifications. The soil types underlying the Project Buffer are, therefore, similar to soils described above for the facilities that it would surround.

### **16.2.3.4 Paleontology**

#### **Methodology**

Geological maps and geological literature were reviewed to provide the physiographic and geological context for the Primary Study Area. Internet queries and two standard online databases were also used to determine the relative potential for paleontological resources to be found in each of the rock units described below. The databases are the University of California Museum of Paleontology at Berkeley (UCMP, n.d.), and the Paleobiology Database (n.d.), managed by a consortium of academic institutions and supported, in part, by the National Science Foundation. The results of the search of paleontological site records are presented in Appendix 16B.

The following tasks were completed to establish the paleontologic sensitivity and distribution of rock units (including unconsolidated sediments) exposed within the Primary Study Area:

- The study area was defined and its physiographic and geologic context was described.
- A stratigraphic inventory (i.e., a review of the composition and relative positions of the rocks) of the area was completed, and the mapped geologic units within the Primary Study Area were identified.
- A paleontological records review of the area was completed to identify previously recorded fossil resources and the context of their discovery.

The mapped geologic units were assigned levels of paleontological sensitivity based on the fossil remains previously documented within that unit and on other relevant geological and paleontological data.

The paleontological sensitivity of the Primary Study Area was assessed by identifying the geological units that might yield fossils, and therefore, have paleontological potential using the approach described above. A description of the geological units is provided above; Appendix 16C presents the results of the review of the available geological literature focused on paleontological sensitivity assessment.

The distribution of stratigraphic units was determined through geologic mapping and used as a proxy for paleontological sensitivity. The features of the proposed project were then laid out on the geological map, and the Project facilities that have the potential to cross units of varying paleontological sensitivity (high, moderate, unknown, low, or no sensitivity) were delineated.

#### **Paleontological Inventory of the Primary Study Area**

Guidelines for paleontological resources assessments (SVP, No Date) call for the inventory of all geological units within one mile of the ground-disturbing activities associated with any project (Appendix 16C) to ensure that both surficial geologic units and geologic units that would be encountered in the subsurface are adequately analyzed. These geological units are then evaluated for paleontological sensitivity. During the preparation of this chapter, several data gaps were identified that complicate characterization of the paleontological sensitivity of the Primary Study Area. These include the following:

- Geologic maps at the necessary level of detail for this analysis tend to group all pre-Tertiary formations into the same category.
- There are few published geological studies of the GVS and overlying Neogene and Quaternary sediments within the limits of the project.
- There are proportionately few paleontological studies of these same rocks.

Older rocks referred to as the GVS occur only on the western portion of the Primary Study Area in the foothills of the North Coast Ranges. In the Sacramento Valley, much younger Pliocene (approximately 5.3 to 2.6 MYA) and Quaternary (2.6 MYA to present) sediments are found.

The results of the search of paleontological site records are summarized in Table 16-6. A comprehensive list of sites recorded in Glenn and Colusa counties is provided in Appendix 16B. Although the Primary Study Area includes only the Project area plus a one-mile buffer, all localities were recorded for each formation because the paleontological sensitivity of a geologic unit is based on the abundance of fossils within the entire unit (though local variations in the rock are taken into account).

**Table 16-6  
Results of Paleontological Records Search by Geological Unit for the Primary Study Area**

Formation, Member, or Unit Name <sup>a</sup>		Number of Localities on Record <sup>a</sup>	
		UCMP Database	Paleobiology Database
<b>Great Valley Sequence rocks (marine sediments older than 65 million years)</b>			
1	Boxer	2 <sup>b</sup>	0
2	Antelope Shale	13	2
3	Fiske Creek	1 <sup>b</sup>	0
4	Julian Rocks	0	0
5	Brophy Canyon	0	0
6	Cortina	0	0
7	Venado Sandstone	9	0
8	Yolo	3	0
9	Sites	5 <sup>b</sup>	0
10	Funks	4	1
11	Rumsey	0	0
12	Guinda	16	0
13	Forbes	25	6
14	Dobbins Shale	1	0
15	Hoodoo Hills	0	0
<b>Late Neogene and Quaternary Sediments (younger than approximately 5.7 million years)</b>			
1	Tehama (sites in Colusa, Glenn, and Tehama Counties only)	6	0
2	Red Bluff	2 <sup>c</sup>	0
3	Victor <sup>d</sup>	1	0
4	Riverbank	9	2
5	Modesto	5	0

<sup>a</sup>Includes names that are no longer in use, but which may still be attached to fossil collection records (Appendix 16C).

<sup>b</sup>Limited to microfossil collections.

<sup>c</sup>Collections from the early 20th Century may now be attributed to a different unit, most likely the Tehama Formation.

<sup>d</sup>Name superseded, but collections from the early 20th Century may still bear this designator.

Note:

UCMP = University of California Museum of Paleontology at Berkeley

Source: UCMP, n. d.; PaleoBiology Database, n.d. (Appendix 16B)

**PRELIMINARY – SUBJECT TO CHANGE**

Many of the recorded paleontological localities in the GVS are microfossil samples (chiefly small plankton fossils, including foraminifera and diatoms). The use of microfossils in age dating, correlation, and in paleoenvironmental studies is well documented. However, rocks bearing only microfossils are not typically assigned high or even moderate levels of paleontological sensitivity because these fossils are very abundant and found in many different sedimentary units, and therefore are not scientifically significant as individuals. Also, although microfossils usually possess scientific significance as an assemblage, isolated specimens or samples of microfossils normally have little scientific use.

### *Cretaceous Marine Units*

The databases consulted (UCMP, n.d.; PaleoBiology Database, n.d.) included references to paleontological sites in 10 of the 15 Cretaceous geological units comprising the GVS. Of these, three (the Boxer, Fiske, and Sites formations) are known to yield only microfossils (chiefly foraminifera and radiolaria). The remaining seven of the GVS units in the Primary Study Area yield scientifically significant megafossils.

The comparative lack of marine sedimentary units that have yielded megafossils is consistent with the inferred paleoenvironments represented by these units. They are deep-ocean sediments consisting of muds of the abyssal ocean floor and trench, and sandstones of deep submarine fans. The depth of water during deposition of the GVS has been calculated as greater than 13,000 feet (Ingersoll, 1979). At that depth, few animals can be expected to be incorporated into the paleontological record due to a combination of geochemical and ecological factors, including low probability of preservation due to both the low density of animals at abyssal depths (the deep sea floor), and the fact that seawater at such depths dissolves calcite shells. In considering the paucity of fossil record from the GVS, Haggart and Ward (1984) observed that many paleontologists have had difficulty correlating Cretaceous strata of the GVS due to the lack of large fossils. Therefore, most studies have relied on microfossils to determine the relative age and stratigraphic position of these units, and most records for the GVS in the databases consulted (UCMP, n.d.; PaleoBiology Database, n.d.) consist of these microfossil assemblages.

Changes in the species composition of microfossils that lived at shallow depths have been the principal means of assigning strata to different ages within the Cretaceous period. However, with more intensive collecting, Haggart and Ward (1984) demonstrated that megafossils, primarily mollusks, can be found in at least the Santonian and Campanian strata (85.8 to 70.6 MYA) on the west side of the Sacramento Valley. Some of these fossils have been instrumental in clarifying the timing of deposition of the upper portion of the GVS (Haggart and Ward, 1984). The paleontological records of the seven GVS units that yield megafossils are discussed in Table 16-7.

**Table 16-7**  
**Great Valley Sequence Units in the Primary Study Area that Yield Megafossils**

**Antelope Shale:** The gastropod *Paosia (Trajanella) colusaensis* was recovered from rocks that are likely from either the Antelope Shale or the overlying Venado Sandstone (Squires, 2004). The specimens were from near the town of Sites and are donated specimens, so the exact locale for this collection is uncertain. The gastropods *Paosia californica* and *Turitella petersoni* are from the upper part of the Antelope Shale (Brown and Rich, 1961). Similar to the Venado Sandstone above it, many of the invertebrates are thought to be shallow water fauna redeposited in submarine deposits, which may compromise some of their scientific value because the original context or depositional setting of the specimens would be in doubt.

**Venado Sandstone:** Similar to the Antelope Shale, many of the invertebrates found in the Venado are thought to have been redeposited in submarine deposits. The UCMP database notes that the collections there include important specimens of the Cenomanian to early Turonian (99.6 to 89.3 MYA) bivalve *Yaadia leana*.

**Table 16-7  
Great Valley Sequence Units in the Primary Study Area that Yield Megafossils**

<p><b>Yolo Formation:</b> The Turonian (93.5 to 89.3 MYA) Yolo Formation has yielded mollusks of the genus <i>Turridea</i> (Oqvist, n.d.) as well as an array of ammonites (Squires, 2004). Also present in this unit is the gastropod <i>Paosia californica</i> (Squires, 2004).</p>
<p><b>Funks Formation:</b> The texanitid ammonites (a type of cephalopod) are relatively rare in Cretaceous sediments of the Pacific Coast, and the Funks Formation is important because it has yielded more than two dozen specimens of <i>Protexanites thompsoni</i> (Jones, 1966), a member of this group. The type site is approximately one mile north of Putah Creek, well south of the current Primary Study Area.</p>
<p><b>Guinda Formation:</b> The gastropod <i>Paosia californica</i> and the bivalve <i>Cucullaea melhaseana</i> have been recovered from this unit (Squires, 2004). The uppermost portions of this formation yield specimens of the index fossil <i>Bostrychoceras elongatum</i>, an ammonite (Haggart and Ward, 1984).</p>
<p><b>Dobbins Shale:</b> The lower half of the Dobbins Shale contains the ammonite <i>Bostrychoceras elongatum</i>, establishing that the species' range continued into this unit from the underlying Guinda Formation. Uppermost portions of the Dobbins Shale contain abundant specimens of the pelecypod <i>Inoceramus schmidtii</i>, a lower Campanian (83.5 to 70.6 MYA) index fossil (Haggart and Ward, 1984).</p>
<p><b>Forbes Formation:</b> The transition between the Dobbins Shale and the overlying Forbes Formation contains the important ammonite <i>Baculites chicoensis</i>, which allows correlation of this unit of the GVS with the upper member of the Chico Formation on the east side of the Sacramento Valley (Haggart and Ward, 1984).</p>

### *Pliocene and Quaternary Terrestrial Units*

#### **Tehama Formation**

The diverse fossil assemblage from the Pliocene (5.3 to 2.6 MYA) Tehama Formation (including the outdated Victor and Red Bluff Formations [Appendix 16C]) documents conditions in California not long before the beginning of the environmental changes accompanying the Pleistocene (2.6 to 0.01 MYA) ice ages, and the animals living in those environments. Recent discovery of the remains of a giant tortoise (*Geochelone*) from the Tehama Formation near Red Bluff (Sierra College, 2007) adds to the list of animals from the Tehama Formation that already included several records of the giant tortoise, as well as *Pliomastodon* (mastodon); *Mammuth* (mammoth); *Equus simplicidens*, *Pliohippus*, and *Nannippus* (horses); *Camelops hesternus* (North American camel); Megalonychidae and *Mealonyx* (ground sloth); *Platygonus* (a pig-like animal); *Canis* (dog); *Odocoileus* (a genus of deer); *Thomomys* (pocket gopher); *Neotoma* (wood or pack rat); *Peromyscus* (deer mice); *Reithrodontomys* (harvest mice); *Osteichtheys* (fish); and the hyena-like dog *Borophagus diversidens*.

#### **Riverbank Formation**

A variety of Pleistocene age (2.6 to 0.01 MYA) fossils were identified in extensive gravel pit excavations in east Sacramento (Hansen and Begg, 1970). They report a variety of Rancholabrean fossils (from about 125,000 to 10,000 years B.P.) collected from two gravel quarries in the Riverbank Formation. These fossils include: *Archoplites* (sunfish), two bird species, *Bison antiquus* (bison), *Camelops hesternus* (camel), *Canis dirus* (dire wolf), *Canis latrans* (coyote), *Clemmys marmorata* (pond turtle), *Colubridae* (colubrid snake), *Cyprinidae* (carp), *Equus* (horse), *Mammuthus* (mammoth), *Microtus* (meadow mouse or vole), *Neotoma* (wood rat), *Odocoileus* (deer), *Paramylodon harlani* (ground sloth), *Perognathus* (pocket mouse), *Scapanus latimanus* (mole), *Spermophilus* cf. *S. beecheyi* (ground squirrel), *Sylvilagus* (rabbit), *Thomomys bottae* (pocket gopher), as well as remains of trees such as *Pseudotsuga* (Douglas fir), *Platanus* (sycamore), and *Salix* (willow)

A variety of fossils of extinct large mammals were collected by Hilton et al. (2000), including *Glossotherium harlani* and *Paramylodon harlani* (ground sloths), *Bison antiquus* (bison), *Equus* sp.

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(horse), *Camelops hesternus* (camel), *Sciurus* sp. (squirrel), and *Mammuthus* sp. (mammoth), as well as plant fossils during the excavations for a large sports arena north of Sacramento. These fossils were found in excavations approximately 13 to 30 feet below the ground surface. These fossils were attributed to the Riverbank Formation.

Dundas and Cunningham (1993) also collected Pleistocene-age ground sloth (*Glossotherium harlani*) and Columbian mammoth (*Mammuthus columbi*) remains from the Riverbank Formation in the Extended Study Area.

### **Modesto Formation**

Similar to the Riverbank Formation, the Modesto Formation is represented by a variety of deposits, mainly river deposits, but also terrestrial sediment such as dune fields and sand sheets. The fossil record of the Late Pleistocene Modesto Formation is, therefore, similar to the Riverbank Formation, although the taxa represented in the Modesto are generally from a more recent time period. The extinct North American camel is well represented in collections from the Modesto. Other vertebrates that have been recovered from the Modesto Formation include Jefferson's ground sloth (*Megalonyx*), mammoth (*Mammuthus*), and an extinct species of bison.

### **Sensitivity Criteria**

The paleontological sensitivity of a rock unit is determined by the likelihood that it will yield identifiable, unique, or scientifically important fossils. Well-developed and documented fossil-bearing formations are less likely to yield a unique paleontological resource, but the resources may nevertheless retain scientific importance.

An individual fossil specimen may be considered unique or significant if it is (1) identifiable, (2) complete, (3) well preserved, (4) useful in determining the age of the formation, (5) useful in interpreting the ancient environment, (6) a member of a rare species, or (7) a skeletal element different from, or a specimen more complete than, those now available for its species. The value or importance of different fossil groups varies, depending on the age and depositional environment of the rock unit that contains the fossils, their rarity, the extent to which they have already been identified and documented, and the ability to recover similar materials under more controlled conditions (such as part of a research project).

The following tasks were completed to establish the paleontological sensitivity of each rock unit potentially exposed in the Primary Study Area:

- Designated certain unit names as not applicable (n/a) because they duplicate other names being used, or because they are otherwise no longer used by geologists
- Considered the scientific significance of the fossil finds from the unit
- Assessed the potential paleontological productivity of each rock unit exposed within one mile of the proposed project features, based on available documentation
- Considered the potential for a rock unit exposed at the project feature site to contain a unique paleontological resource

## **Paleontological Sensitivity of Sediments in the Primary Study Area**

The paleontological sensitivity of any part of the Primary Study Area depends almost entirely on its geology. Table 16-8 presents a summary of the paleontological sensitivity for the rock units that may be affected by proposed project features in the Primary Study Area.

**Table 16-8  
Paleontological Sensitivity of the Rock Units Within One Mile of Any  
Proposed Primary Study Area Project Facility**

<b>Formation, Member, or Unit Name Attributed<sup>a</sup></b>		<b>Sensitivity<sup>b</sup></b>	<b>Remarks</b>
<b>Great Valley Sequence Rocks (Upper Cretaceous; Older than 65 Million Years)</b>			
1	Boxer	low	-
2	Antelope Shale	moderate	-
3	Fiske Creek	low	Temporally equivalent with the Boxer formation
4	Julian Rocks	low	Temporally equivalent with the Boxer formation
5	Brophy Canyon	low	Temporally equivalent to the lower Boxer formation
6	Cortina	low	-
7	Venado Sandstone	moderate	-
8	Yolo	moderate	-
9	Sites	moderate	-
10	Funks	moderate	-
11	Rumsey <sup>c</sup>	moderate	-
12	Guinda <sup>c</sup>	moderate	-
13	Forbes <sup>c</sup>	moderate	-
14	Dobbins Shale <sup>a</sup>	moderate	-
15	Hoodoo Hills <sup>a</sup>	n/a	Name no longer in use
<b>Pliocene and Quaternary Sediments (Younger than Approximately 5.7 Million Years)</b>			
1	Tehama	high	-
2	Red Bluff	low	-
3	Victor	n/a	Name no longer in use
4	Riverbank	moderate	Surficial sediments affected by soil development are not paleontologically sensitive; most fossil sites are from near the Sacramento River or its major tributaries
5	Modesto	moderate	Surficial sediments affected by soil development are not paleontologically sensitive. Includes unnamed Pleistocene units; most fossil sites are from near the Sacramento River or its major tributaries

<sup>a</sup>Some of these names are outdated and no longer in use, but nevertheless fossil localities are recorded as occurring within them. Databases are not updated when the geological nomenclature is revised.

<sup>b</sup>Sensitivity ratings were assigned based on the guidelines outlined by the SVP (n.d.), and by *Instructional Memorandum 2008-009* (USDI BLM, 2008). They are:

- High: A geologic unit known to be paleontologically productive and to contain fossil assemblages that include scientifically important species.
- Moderate: A geologic unit that is known to yield scientifically significant fossil specimens, but may not be paleontologically productive in any given area.
- Low: A geologic unit that is known to yield few identifiable fossils.

<sup>c</sup>These units do not outcrop within the Primary Study Area; however, they were included in this analysis because they may be encountered in the subsurface and, given the nature of the nomenclature of the Great Valley Sequence, to ensure all fossils within the Primary Study Area have been adequately analyzed.

The paleontological record of the GVS consists largely of microfossils. None of the GVS units are known to have an abundance of paleontological resources because they were deposited in a deep ocean setting; however, rare macrofossils such as bivalves, ammonites, and gastropods have been found in these units.

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Although uncommon in the GVS, these fossils are important for dating the geologic units they are found in and for comparing geologic units throughout the Great Basin. The Venado, Yolo, Sites, Funks, Rumsey, Guinda, and Forbes formations, and the Dobbins shale, are considered to have a “moderate” paleontological sensitivity rating (Table 16-8). If large fossils, including invertebrate fossils, are encountered during Project construction, they would likely be scientifically significant.

Neither the Modesto nor the Riverbank formations within the Primary Study Area are assigned “high” paleontological sensitivity. These formations have yielded important fossils; however, the recorded paleontological sites are located primarily near the Sacramento River and along its major tributaries. The paleontological productivity of the geologic units deposited at higher elevations in the Primary Study Area does not appear to be substantial. Therefore, the paleontological sensitivity of the Modesto and Riverbank formations is considered “moderate.”

## 16.3 Environmental Impacts/Environmental Consequences

### 16.3.1 Regulatory Setting

Geology, minerals, soils, and paleontological resources are regulated at the federal, State, and local levels. Provided below is a list of the applicable regulations. These regulations are discussed in detail in Chapter 4 Environmental Compliance and Permit Summary of this EIR/EIS.

#### 16.1.1.1 Federal Plans, Policies, and Regulations

- Clean Water Act Section 402, National Pollutant Discharge Elimination System Program
- National Pollutant Discharge Elimination System General Permit for Stormwater Discharges from Construction Sites
- Antiquities Act of 1906
- Archaeological Resources Protection Act of 1979
- Omnibus Public Land Management Act of 2009

#### 16.1.1.2 State Plans, Policies, and Regulations

- California Environmental Quality Act, *Guidelines for the Implementation of CEQA* (Public Resources Code Section 15023, Appendix G)
- Porter-Cologne Water Quality Control Act
- California Department of Fish and Game Code 1602
- California Water Code, Division 3: Dams and Reservoirs
- Surface Mining and Reclamation Act of 1975
- Seismic Hazards Mapping Act of 1990
- Asbestos Airborne Toxic Control Measure for Surfacing Applications (amended 2000)
- Asbestos Airborne Toxic Control Measure for Construction, Grading, Quarrying, and Surface Mining Operations

- Regulatory Design Codes for Buildings, Highways, and Other Structures
- Nonpoint Source Implementation and Enforcement Policy
- *California Public Resources Code* Chapter 1.7 Archaeological, Paleontological, and Historical Sites Section 5097.5

### **16.1.1.3 Regional and Local Plans, Policies, and Regulations**

- Glenn County General Plan
- Colusa County General Plan

### **16.3.2 Evaluation Criteria and Significance Thresholds**

Significance criteria represent the thresholds that were used to identify whether an impact would be significant. Appendix G of the *CEQA Guidelines* suggests the following evaluation criteria for geology, minerals, soils, and paleontological resources:

*Would the Project:*

- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?
- Result in substantial soil erosion or the loss of topsoil?
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), 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 the disposal of wastewater?
- Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local General Plan, Specific Plan, or other land use plan?
- Expose people (working on the Project or the public) during Project construction or operation to naturally occurring asbestos?
- Directly or indirectly destroy of a unique paleontological resource or site or unique geologic feature?

The evaluation criteria used for this impact analysis represent a combination of the Appendix G criteria and professional judgment that considers current regulations, standards, and/or consultation with agencies, knowledge of the area, and the intensity of the environmental effects, as required pursuant to NEPA. For the purposes of this analysis, an alternative would result in a significant impact if it would result in any of the following:

- Effects on a geologic unit or soil unit from Project construction, operation, and maintenance.
- Project construction, operation, and maintenance effects on soil erosion and loss of topsoil.
- Risks to life and property from Project construction, operation, and maintenance on expansive soil.

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- Project construction, operation, and maintenance effects on soils that are incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the wastewater disposal.
- Loss of availability of a known mineral resource that would be of value to the region and the residents of the state.
- Loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.
- Expose people to naturally occurring asbestos during Project construction, operation, or maintenance
- Project construction, operation, and maintenance effects on paleontological resources.

Paleontological resources impacts would include damage or destruction of a scientifically significant fossil, the removal of a scientifically significant fossil from its stratigraphic context, or any other action that reduces the amount of information available to future researchers. The probability that excavations would cause such impacts is proportional to the paleontological sensitivity of the geologic units. Excavations within high-sensitivity geologic units have a high potential to adversely impact paleontological resources. Excavations within moderate-sensitivity sediments have a lower potential to adversely impact paleontological resources, and that potential is frequently limited to specific portions of the unit. Low-sensitivity sedimentary units have a very low, but non-zero, chance of impacting paleontological resources. Excavations that do not impact paleontological resources—or that only impact non-significant fossils, such as microfossils—are not considered to impact paleontological resources. Impacts to sediment of moderate to high paleontological sensitivity, or to scientifically important fossils, would constitute significant impacts in the absence of mitigation.

### **16.3.3 Impact Assessment Assumptions and Methodology**

#### **16.3.3.1 Assumptions**

The following assumptions were made regarding Project-related construction, operation, and maintenance impacts to geologic, mineral, soil, and paleontological resources:

- Direct Project-related construction, operation, and maintenance activities would occur in the Primary Study Area.
- Direct Project-related operational effects would occur in the Secondary Study Area.
- The only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of an additional pump into an existing bay at the Red Bluff Pumping Plant.
- The only direct Project-related maintenance activity that would occur in the Secondary Study Area is the sediment removal and disposal at the two intake locations (i.e., GCID Canal Intake and Red Bluff Pumping Plant).
- No direct Project-related construction or maintenance activities would occur in the Extended Study Area.
- Direct Project-related operational effects that would occur in the Extended Study Area are related to San Luis Reservoir operation; increased reliability of water supply to agricultural, municipal, and industrial water users; and the provision of an alternate Level 4 wildlife refuge water supply. Indirect effects to the operation of certain facilities that are located in the Extended Study Area, and indirect

effects to the consequent water deliveries made by those facilities, would occur as a result of implementing the alternatives.

- The existing bank protection located upstream of the proposed Delevan Pipeline Intake/Discharge facilities would continue to be maintained and remain functional.
- No additional channel stabilization, grade control measures, or dredging in the Sacramento River at or upstream of the Delevan Pipeline Intake or Discharge Facilities would be required.
- Erosion is the wearing away of soil and rock by processes such as mechanical or chemical weathering, mass wasting, and the action of waves, wind, and underground water. Excessive soil erosion can eventually lead to damage of building foundations and roadways. At the Project facility sites, areas that are susceptible to erosion are those that would be exposed during the construction phase and along the reservoir shoreline where soil is subjected to wave action. Typically, the soil erosion potential is reduced once the soil is graded and covered with concrete, structures, asphalt, or slope protection. However, some runoff and soil erosion may occur at discharge points from covered areas.
- Effects to paleontological resources would only occur during disturbance of fossil-bearing geologic units, which are typically associated with the construction phase of any project. No impacts would occur during Project operation activities or maintenance of Project facilities because no excavations within fossil-bearing geologic units would occur in association with operations or maintenance activities. Maintenance for several of the Project components would include dredging of built-up sediment, but such excavation activities would not affect paleontologically sensitive sediment. Paleontological resources are considered to be affected only if they are removed from the sediment or otherwise mechanically damaged, which would only occur during excavations during the Project construction phase.

### **16.3.3.2 Methodology**

A combination of data, published reports, and professional experience with initial investigations for the proposed Project was used to evaluate the Project alternatives for potential impacts due to geology, soils, and minerals. The Extended and Secondary study area impact assessments primarily relied on data and publications (both printed and web-based) from the California Geological Survey and the United States Geological Survey. Professional experience with initial investigations included geological mapping within the Primary Study Area and core-drilling at the proposed damsites.

Expansive soils are characterized by a shrink-swell characteristic<sup>12</sup>. Expansive soils are largely comprised of clays, which expand in volume when water is absorbed and shrink when dried. Soil materials at the Project facility sites are composed of a wide variety of soil types. Using the NRCS Soil Data Viewer, the shrink-swell potential was derived for all of the soil types present at Project facility sites.

The Society of Vertebrate Paleontology Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources (SVP, 2010) provide guidelines that establish standard methods for assessing potential impacts to fossils and mitigating these impacts. For the paleontological resources impacts assessment, the paleontological sensitivity and distribution of rock units (including unconsolidated sediments), established during the analysis of the existing environment (refer to Appendix 16C), within the impacts area was considered, as well as the type of excavation or other

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<sup>12</sup> "Shrink-swell" is the cyclical expansion and contraction that occurs in fine-grained clay sediments from wetting and drying. Structures located on soils with this characteristic may be damaged over a long period of time, usually as the result of inadequate foundation engineering or the placement of structures directly on expansive soils.

subsurface disturbance. The features of the Project were laid out on a map showing the distribution of rocks having varying paleontological sensitivity. Impacts were identified for those Project facilities that have the potential to cross units of varying paleontological sensitivity (high, moderate, unknown, low, or no sensitivity).

### 16.3.4 Topics Eliminated from Further Analytical Consideration

No Project facilities or topics that are included in the significance criteria listed above for geology, soils, or minerals were eliminated from further consideration in this chapter.

Within the Primary Study Area, operation and maintenance activities associated with Project facilities would not require excavations; the impacts of these activities are, therefore, not discussed for paleontological resources.

### 16.3.5 Impacts Associated with the No Project/No Action Alternative

#### 16.3.5.1 Geology and Soils

#### Extended, Secondary, and Primary Study Areas – No Project/No Action Alternative

##### *Construction, Operation, and Maintenance Impacts*

**Agricultural Water Use; Municipal and Industrial Water Use; Wildlife Refuge Water Use; and San Luis Reservoir; Trinity Lake; Lewiston Lake; Trinity River; Klamath River downstream of the Trinity River; Whiskeytown Lake; Spring Creek; Shasta Lake; Sacramento River; Keswick Reservoir; Clear Creek; Lake Oroville; Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay**

##### *Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance*

The No Project/No Action Alternative includes implementation of projects and programs being constructed, or those that have gained approval, as of June 2009. The impacts of these projects have already been evaluated on a project-by-project basis, pursuant to CEQA and/or NEPA, and their potential for impacts to geology and soils have been addressed in those environmental documents. Therefore, **there would not be a substantial adverse effect**, when compared to Existing Conditions.

Population growth is expected to occur in California throughout the period of Project analysis (i.e., 100 years), and is included in the assumptions for the No Project/No Action Alternative. A larger human population would require additional development to occur, which could affect, and/or be affected by, local geology and soils. These impacts that would occur as a result of the population growth and development would be managed at the local level (e.g., cities and counties) in accordance with those agencies' regulations. Therefore, **there would not be a substantial adverse effect**, when compared to Existing Conditions.

It is possible that one or more of the projects that are included in the No Project/No Action Alternative could affect or be affected by existing site-specific geologic and/or soils<sup>13</sup> conditions. However, any project being considered for implementation would be subject to CEQA and/or NEPA review and would

<sup>13</sup> Potential impacts relating to geology or soils can be a combination of the two resources. Therefore, geology impacts and soils impacts have been combined as "Geo/Soils" impacts.

be required to mitigate for significant impacts. In addition, the Project would not be constructed if this alternative is implemented. Therefore, **there would not be a substantial adverse effect**, when compared to Existing Conditions.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Refer to the **Impact Geo/Soils-1** discussion. That discussion is also applicable to effects on soil erosion and loss of topsoil.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Refer to the **Impact Geo/Soils-1** discussion. That discussion is also applicable to expansive soils.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

Refer to the **Impact Geo/Soils-1** discussion. It is possible that one or more of the projects that are included in the No Project/No Action Alternative would include septic tanks or alternative wastewater disposal systems sited on soils that are incapable of supporting such systems. However, any project being considered for implementation would be subject to CEQA and/or NEPA review and would be required to mitigate for that impact. In addition, the Project would not be constructed if the No Project/No Action Alternative is implemented. Therefore, **there would not be a substantial adverse effect**, when compared to Existing Conditions.

**16.3.5.2 Minerals**

**Extended and Secondary Study Areas – No Project/No Action Alternative**

*Construction, Operation, and Maintenance Impacts*

**Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir, Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay**

***Impact Min-1: Loss of Availability of a Known Mineral Resource that would be of Value to the Region and the Residents of the State***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended and Secondary study areas. If the No Project/No Action Alternative is implemented, mineral resources would continue to be excavated, stockpiled, imported, or exported, and projected population growth could increase the rate of use of these resources. However, County General Plans and other regulations identify local mineral resources and specify measures to protect those resources from depletion. In addition, the Project would not be constructed if this alternative is implemented. Therefore, implementation of the No Project/No Action

Alternative **would not have a substantial adverse effect** on mineral resources in the Extended and Secondary study areas, when compared to Existing Conditions.

***Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan***

Refer to the **Impact Min-1** discussion as it relates to the Extended and Secondary study areas. That discussion is also applicable to mineral resource recovery sites.

***Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended and Secondary study areas. Ultramafic rocks (which when converted to the metamorphic rock, serpentinite, can contain asbestos), occur in certain areas within the Extended and Secondary study areas. It is possible that one or more projects included in the No Project/No Action Alternative could mine, expose, or use serpentinite and cause naturally occurring asbestos to become airborne. However, any project being considered for implementation would be subject to CEQA and/or NEPA review and would be required to mitigate for that impact. In addition, the Project would not be constructed if this alternative is implemented. Therefore, **there would not be a substantial adverse effect** from the airborne emission of naturally occurring asbestos in the Extended and Secondary study areas, when compared to Existing Conditions.

**Primary Study Area – No Project/No Action Alternative**

*Construction, Operation, and Maintenance Impacts*

***Impact Min-1: Loss of Availability of a Known Mineral Resource that would be of Value to the Region and the Residents of the State***

According to the Land Use Element of the Colusa County General Plan and Aggregate Resource Management Plan for Glenn County, identified mineral resource areas are located outside of the Primary Study Area. Therefore, continued land use activities, as well as projected population growth, within the counties of the Primary Study Area would not affect mineral resources. In addition, the projects included in the No Project/No Action Alternative do not occur within the Primary Study Area, and the Project would not be constructed if this alternative is implemented. Implementation of the No Project/No Action Alternative would not result in the loss of availability of any known mineral resource, or interfere with any existing commercial mining activity and therefore **would not have a substantial adverse effect** on mineral resources, when compared to Existing Conditions.

***Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan***

Refer to the **Impact Min-1** discussion. That discussion is also applicable to mineral resource recovery sites.

***Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance***

Rocks containing naturally occurring asbestos are not present in the Primary Study Area, nor are they present in the watershed draining into the Primary Study Area. Therefore, continued land use activities, as well as projected population growth, within the counties of the Primary Study Area would not expose people to naturally occurring asbestos in these counties. In addition, the projects included in the No

Project/No Action Alternative do not occur within the Primary Study Area, and the Project would not be constructed if this alternative is implemented. Implementation of the No Project/No Action Alternative would not expose people in Glenn and Colusa counties to naturally occurring asbestos, and therefore, **would not have a substantial adverse effect**, when compared to Existing Conditions.

### **16.3.5.3 Paleontology**

#### **Extended and Secondary Study Areas – No Project/No Action Alternative**

##### *Construction, Operation, and Maintenance Impacts*

**Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir, Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay**

##### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended and Secondary study areas. It is possible that projects within the Secondary and Extended study areas that are included in the No Project/No Action Alternative would affect paleontological resources. However, any project considered for implementation would be subject to CEQA and/or NEPA review and would be required to mitigate for paleontological resource impacts. Therefore, **there would not be a substantial adverse effect**, when compared to Existing Conditions.

#### **Primary Study Area – No Project/No Action Alternative**

##### *Construction, Operation, and Maintenance Impacts*

##### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The projects included in the No Project/No Action Alternative do not occur within the Primary Study Area, and the Project would not be constructed if this alternative is implemented. Therefore, **there would not be a substantial adverse effect** to paleontological resources, when compared to Existing Conditions.

### **16.3.6 Impacts Associated with Alternative A**

#### **16.3.6.1 Geology and Soils**

##### **Extended Study Area – Alternative A**

##### *Construction, Operation, and Maintenance Impacts*

**Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir**

##### ***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Because there would be no direct Project-related construction or maintenance activities occurring in the Extended Study Area, there would be no increase in the risk of geologic or soils hazards to people or

structures in the Extended Study Area, when compared to Existing Conditions or the No Project/No Action Alternative. Operation of the Project would result increased water level fluctuations at the San Luis Reservoir and increased reliability of water to agricultural, municipal and industrial water users, and an alternate supply to wildlife refuge users; these water delivery operations would not affect geology or soils. Alternative A would result in **no impact** to geology or soils or in the Extended Study Area, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended Study Area. That discussion is also applicable to effects on soil erosion and loss of topsoil.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Extended Study Area. San Luis Reservoir currently experiences water level fluctuations; changing those would not affect the soils underlying the reservoir. Increased water reliability to agricultural, municipal and industrial water users, and an alternate supply to wildlife refuge users in the Extended Study Area would not affect underlying soils. Therefore, there would be **no impact** to geology or soils, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

The Project does not include a septic tank, alternative wastewater disposal system, or sewer system that would be constructed, operated, or maintained in the Extended Study Area; therefore, there would be **no impact** to geology or soils, when compared to Existing Conditions and the No Project/No Action Alternative.

**Secondary Study Area – Alternative A**

***Construction, Operation, and Maintenance Impacts***

**Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex, Feather River, Sutter Bypass, Yolo Bypass, Folsom Lake, Lake Natoma, American River, Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, and San Francisco Bay**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

The only direct Project-related construction that would occur in the Secondary Study Area is the installation of an additional pump into an existing bay at the Red Bluff Pumping Plant. Direct Project-related operational activities in the Secondary Study Area include the larger reservoirs having more stable water levels (i.e., would not fluctuate as widely) and altered discharge flows in downstream waterways. The only direct Project-related maintenance activity that would occur is the removal of sediment from the existing canal intakes. Because these Project-related activities in the Secondary Study Area are not

expected to result in an increase in geologic or soils hazards to people or structures, when compared to Existing Conditions or the No Project/No Action Alternative, **no impact** to geology or soils is expected, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Secondary Study Area. That discussion is also applicable to effects on soil erosion and loss of topsoil.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Refer to the **Impact Geo/Soils-1** discussion as it relates to the Secondary Study Area. The Red Bluff Pumping Plant is located on soils that have a low shrink/swell capacity. Therefore, **no impact** to geology or soils is expected, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

The Project does not include a septic tank, alternative wastewater disposal system, or sewer system that would be constructed, operated, or maintained in the Secondary Study Area; therefore, there would be **no impact** to geology or soils, when compared to Existing Conditions and the No Project/No Action Alternative.

**Primary Study Area – Alternative A**

*Construction, Operation, and Maintenance Impacts*

**Sites Reservoir Inundation Area (1.27 MAF)**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

The fundamental geology and soils in the Primary Study Area would remain unchanged with construction, operation, and maintenance of all of the Project facilities, when compared to Existing Conditions or the No Project/No Action Alternative; therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

During the construction phase, clearing and grubbing activities would occur. Demolition of existing structures and removal of asphalt and fencing would also occur. In addition, temporary access roads would be constructed within the reservoir footprint. These activities would result in an increase of soil erosion within the reservoir footprint. Construction phase soil erosion is expected to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

During Project operation, reservoir water surface elevations would fluctuate between a minimum of 340 feet and 480 feet. Shoreline erosion would occur along the zone of reservoir water elevation fluctuation. Sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir and not discharged. Shoreline soil erosion is expected to be **potentially significant**.

Maintenance activities, including garbage removal and maintenance of signs and buoys, would not be expected to result in increased soil erosion. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

No structures would be constructed within the proposed reservoir inundation area, except for the Sites Reservoir Inlet/Outlet Structure, which is addressed separately. Therefore, construction, operation, and maintenance of the reservoir would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No septic tanks or alternative wastewater disposal systems would be constructed within the Sites Reservoir Inundation Area. Therefore, construction, operation, and maintenance of the reservoir would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

**Sites Reservoir Dams**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to Sites Reservoir Dams.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The construction of the dams would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a substantial quantity of bedrock, alluvium, and soil obtained from the borrow areas, and the installation of support structures. Equipment and vehicle staging areas would also be required. Construction activities with the potential for sediment delivery to Funks Creek and Stone Corral Creek include fill placement on the downstream face, and the fill stockpiles downstream of the dam. The soils disturbed by Project earthwork and construction activities, as well as stockpiled materials for use in the construction, would be susceptible to water-induced erosion and loss of topsoil. Construction phase soil erosion is anticipated to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

During Project operation and maintenance, no soils would erode because the soils would have been replaced with the dam structures. The dams would be faced with rip-rap protection on the reservoir side and vegetation on the landward side. Soil erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Construction of the dams and saddle dams involves excavating all soils down to firm bedrock. Complete excavation of all soils would remove the expansion potential. Therefore, there would be **no impact**

related to Project construction, operation, or maintenance, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No septic tanks or alternative wastewater disposal systems would be constructed within the damsites. Therefore, construction, operation, and maintenance of the dams would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

**Recreation Areas**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Recreation Areas.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The construction of the Recreation Areas would require grading, including removal and/or stockpiling of surface soils and some bedrock. Construction phase soil erosion is anticipated to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative. During operation, increased runoff from impervious surfaces developed at the recreation areas could increase erosion in local drainages, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative. Maintenance activities, including road grading, vegetation control, and fuels management, could also increase erosion in local drainages, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Approximately 66 percent (802 acres) of the total area of the proposed Recreation Areas is classified by the NRCS as having a high shrink-swell potential. Impacts from constructing, operating, and maintaining Project facilities within the Recreation Areas on expansive soils are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

The Recreation Areas would have vault toilets, and waste would be transported and disposed of outside of the Primary Study Area. Vault toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## Road Relocations and South Bridge

### *Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance*

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Road Relocations and South Bridge.

### *Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil*

Construction of the Road Relocations and South Bridge would require grading and cut/fill operations along the roads' footprints and 200-foot construction disturbance area. Slopes may be steepened, leading to increased erosion potential. Construction phase soil erosion is anticipated to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

During Project operation, increased runoff from impervious road surfaces could increase erosion in local drainages, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative. This potential increase in runoff would require maintenance activities designed to reduce the impacts of the associated erosion.

### *Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil*

More than 50 percent (679 acres) of the total area of the Road Relocations and South Bridge are classified by the NRCS as having a high shrink-swell potential. An additional 125 acres are classified as having a low to high or moderate to high shrink-swell potential. Impacts from constructing, operating, and maintaining the roads and South Bridge on expansive soils are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

### *Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal*

No septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained within the road relocations. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## Sites Pumping/Generating Plant, Sites Electrical Switchyard, Tunnel from the Sites Pumping/Generating Plant to the Sites Reservoir Inlet/Outlet Structure, and Sites Reservoir Inlet/Outlet Structure

### *Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance*

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Sites Pumping/Generating Plant, Sites Electrical Switchyard, Tunnel from the Sites Pumping/Generating Plant to the Sites Reservoir Inlet/Outlet Structure, and Sites Reservoir Inlet/Outlet Structure.

### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Construction of these Project facilities would require the excavation, transport, stockpiling, grading, drilling, blasting. Tunnel construction would require stockpiling of rock spoil removed from the tunnel alignment. Slopes may be steepened leading to increased runoff potential. Construction phase soil erosion is anticipated to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Approximately 25 percent (24 acres) of the total area of these combined Project facilities is classified by the NRCS as having a high shrink-swell potential. Impacts from Project construction, operation, and maintenance are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained at these facilities. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Field Office Maintenance Yard**

### ***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Field Office Maintenance Yard.

### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The construction of the Field Office Maintenance Yard would require removal of topsoil and possibly some bedrock. Increased erosion may occur during construction, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

Less than two percent (0.3 acre) of the total area of the Field Office Maintenance Yard is classified by the NRCS as having a high shrink-swell potential. Project construction, operation, and maintenance impacts

are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

It is anticipated that a septic tank would be located in the vicinity of the Field Office Maintenance Yard. Soils in the vicinity of this Project feature are considered to have “limitations”. Impacts are, therefore, considered **potentially significant** for construction, operation, and maintenance, when compared to Existing Conditions and the No Project/No Action Alternative.

**Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Holthouse Reservoir Complex and the Holthouse Reservoir Electrical Switchyard.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

During the dredging of Funks Reservoir, Funks Reservoir would be de-watered. Draining and maintenance of the reservoir could lead to increased erosion of exposed reservoir sediments, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

Construction of the Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard would require the excavation, transport, stockpiling, grading, drilling, blasting, and use of a moderate quantity of bedrock, alluvium, and soil obtained from the borrow areas. Equipment and vehicle staging areas would also be required. Construction activities with the potential for sediment delivery to Funks Creek include fill placement on the downstream face and the fill stockpiles downstream of the dam. The soils disturbed by Project earthwork and construction activities, as well as stockpiled materials for use in the construction, would be susceptible to water induced erosion and loss of topsoil, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

During Project operation, reservoir water surface elevations would fluctuate up to 14 feet. Shoreline erosion would occur along the zone of reservoir-elevation fluctuation. Sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir and not discharged. Shoreline soil erosion is anticipated to be **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

Periodic maintenance required for the existing Funks Reservoir includes road, vegetation, and fence maintenance, as well as debris removal, on an as-needed basis. The reservoir is currently also drained annually. These maintenance activities are expected to be the same for Holthouse Reservoir. These maintenance activities around the larger reservoir complex could increase erosion in local drainages, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

The existing Funks Reservoir is filled with water; no NRCS soil data is available. To be conservative, construction, operation, and maintenance impacts are considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

Nearly 90 percent (324 acres) of the total area of the Holthouse Reservoir Complex, including the footprint of the Holthouse Reservoir Electrical Switchyard, is classified by the NRCS as having a high shrink-swell potential. Project construction, operation, and maintenance impacts are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained within the Holthouse Reservoir Complex or at the Holthouse Reservoir Electrical Switchyard. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Terminal Regulating Reservoir, Terminal Regulating Reservoir Pumping/Generating Plant, Terminal Regulating Reservoir Electrical Switchyard, Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir, and Glenn-Colusa Irrigation District Canal Facilities Modifications**

#### ***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, GCID Canal Connection to the TRR, and the GCID Canal Facilities Modifications.

#### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The construction of the TRR, GCID Canal Connection to the TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, as well as the proposed modifications to existing GCID Canal Facilities, would require the excavation, transport, stockpiling, grading, and use of a moderate quantity of bedrock, alluvium, and soil obtained from the borrow areas. Increased erosion may occur during Project construction, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative. During Project operation and maintenance, areas would be covered with impervious material or vegetation; additional erosion is anticipated to be minimal, resulting in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

All soils at these facilities are classified by the NRCS as having a high shrink-swell potential. Project construction, operation, and maintenance impacts are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

The TRR Pumping/ Generating Plant would have portable toilets, and waste would be transported and disposed of outside of the Primary Study Area. Portable toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

**Delevan Transmission Line**

***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Delevan Transmission Line.

***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The construction of the Delevan Transmission Line would require the construction of a temporary access road along the alignment and soil excavation for tower footings. During Project construction, erosion is anticipated to occur, resulting in a **potentially significant impact**. Project operation would be an unmanned activity. Maintenance activities, including equipment inspections and vegetation maintenance, are expected to cause minimal soil erosion. Therefore, operation and maintenance would result in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

The Delevan Transmission Line alignment traverses soils that are classified by the NRCS as having a high shrink-swell potential. Project construction, operation, and maintenance impacts are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained along the Delevan Transmission Line. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Delevan Pipeline, Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, and Delevan Pipeline Electrical Switchyard**

### ***Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance***

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Delevan Pipeline, TRR Pipeline, TRR Pipeline Road, and the Delevan Pipeline Electrical Switchyard.

### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Construction of the Delevan Pipeline and TRR Pipeline would require dewatering, as well as trenching of soils and alluvial material down to the design depth. The excess materials could be distributed on a 750-foot-wide strip on either side of the pipelines' alignment. Construction of the TRR Pipeline Road and Delevan Pipeline Electrical Switchyard would also result in ground disturbance. However, during the construction period additional erosion is anticipated to be minimal because the terrain is flat and generally surrounded by rice checks, resulting in a **less-than-significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

During Project operation, because the pipelines would be buried and operated remotely, no additional erosion impacts are anticipated, resulting in **no impact**, when compared to Existing Conditions or the No Project/No Action Alternative. Periodic maintenance inspections would not cause additional erosion impacts, resulting in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***During operation and maintenance of the Delevan Pipeline Electrical Switchyard, areas would be covered with a gravel base; additional erosion is anticipated to be minimal, resulting in a less-than-significant impact, when compared to Existing Conditions or the No Project/No Action Alternative.***

### ***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

More than 80 percent (176 acres) of the total area of these Project features is classified by the NRCS as having a high shrink-swell potential. Project construction, operation, and maintenance impacts of the Delevan Pipeline, TRR Pipeline, TRR Pipeline Road, and Delevan Pipeline Electrical Switchyard are, therefore, considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

### ***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No Project-related septic tanks or alternative wastewater disposal systems would be constructed, operated, or maintained along the Delevan Pipeline, TRR Pipeline, or TRR Pipeline Road, or at the Delevan Pipeline Electrical Switchyard. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## Delevan Pipeline Intake Facilities

### *Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance*

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Delevan Pipeline Intake Facilities.

### *Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil*

The construction of the Delevan Pipeline Intake Facilities would require dewatering; clearing and grading the construction workspace; excavating soils and alluvium from the forebay, afterbay, and pumping plant sites; and filling and re-grading where needed. During the construction period, additional erosion is anticipated, resulting in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative. During Project operation and maintenance, areas would be covered with impervious material or vegetation; no additional erosion impacts are anticipated, resulting in **no impact**, when compared to Existing Conditions or the No Project/No Action Alternative.

### *Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil*

All soil at this Project feature location is classified by the NRCS as having a low shrink-swell potential. Construction, operation, and maintenance impacts are, therefore, considered **less than significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

### *Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal*

The Delevan Pipeline Intake Facilities would have portable toilets, and waste would be transported and disposed of outside of the Primary Study Area. Portable toilets are not considered to be alternative wastewater disposal systems. Therefore, construction, operation, and maintenance would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

## Project Buffer

### *Impact Geo/Soils-1: Effects on a Geologic Unit or Soil Unit from Project Construction, Operation, and Maintenance*

Refer to the **Impact Geo/Soils-1** discussion for the Sites Reservoir Inundation Area. That discussion is also applicable to the Project Buffer.

### *Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil*

During Project construction, existing structures within the Project Buffer would be demolished and fences would be constructed, which may cause a temporary increase in soil erosion. Project construction, operation, and maintenance impacts are considered **potentially significant**, when compared to Existing Conditions and the No Project/No Action Alternative.

The construction and operation of a fuelbreak around the entire perimeter of the Project Buffer, as well as maintenance of the fuelbreak, would cause increases in soil erosion, resulting in a **potentially significant impact**, when compared to Existing Conditions or the No Project/No Action Alternative.

***Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil***

No structures would be constructed within the Project Buffer. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

No Project-related septic tanks or alternative wastewater disposal systems would be constructed within the Project Buffer. Therefore, there would be **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

**16.3.6.2 Minerals**

**Extended and Secondary Study Areas – Alternative A**

*Construction, Operation, and Maintenance Impacts*

**Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir, Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay**

***Impact Min-1: Loss of Availability of a Known Mineral Resource that would be of Value to the Region and the Residents of the State***

Aggregate minerals resources of the Stony Creek Fan (Glenn County) would be used for the NODOS Project. The Stony Creek Fan has an estimated material availability of 160 million cubic yards (DWR, 2002). Approximately 2,136,000 cubic yards of gravel would be imported from the Stony Creek Fan, located north of Willows (in the Secondary Study Area), to construct the Project (approximately 0.29 percent of the available resource). No mineral resources are required to operate and maintain the Project. Alternative A would, therefore, result in a **less-than-significant impact** on mineral resources in the Extended and Secondary study areas, when compared to Existing Conditions and the No Project/No Action Alternative.

Project operation (including operation of San Luis Reservoir) would not require mineral resources, resulting in **no impact** on mineral resources. In addition, the pump installation, operation, and maintenance at the Red Bluff Pumping Plant would not require mineral resources, resulting in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan***

Refer to the **Impact Min-1** discussion. That discussion is also applicable to locally important mineral resource recovery sites.

***Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance***

Ultramafic rocks containing naturally occurring asbestos would not be disturbed during Project construction, operation, or maintenance within the Extended and Secondary study areas. Therefore Alternative A would result in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

**Primary Study Area – Alternative A**

*Construction, Operation, and Maintenance Impacts*

**All Primary Study Area Project Facilities**

***Impact Min-1: Loss of Availability of a Known Mineral Resource that would be of Value to the Region and the Residents of the State***

Mineral resource areas are located outside of the Primary Study Area (Glenn County, 1997 and Colusa County, 1989). Approximately 2,136,000 cubic yards of gravel would be imported from the Stony Creek Fan, located north of Willows (in the Secondary Study Area), to construct the Project (approximately 0.29 percent of the available resource). No mineral resources are required to operate or maintain the Project. Therefore, construction, operation, and maintenance of Alternative A would not result in the loss of availability of any known mineral resource, or interfere with any existing commercial mining activity, resulting in **less-than-significant impact** on mineral resources, when compared to Existing Conditions and the No Project/No Action Alternative.

***Impact Min-2: Loss of Availability of a Locally Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan***

Refer to the **Impact Min-1** discussion. That discussion is also applicable to mineral resource recovery sites.

***Impact Min-3: Expose People to Naturally Occurring Asbestos during Project Construction, Operation, or Maintenance***

Rocks containing naturally occurring asbestos are not present in the Primary Study Area, nor are they present in the watershed draining into the Primary Study Area. Therefore, construction, operation, and maintenance activities associated with Alternative A would not expose people to naturally occurring asbestos, resulting in **no impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### 16.3.6.3 Paleontology

#### **Extended Study Area – Alternative A**

##### *Construction, Operation, and Maintenance Impacts*

##### **Agricultural Water Use, Municipal and Industrial Water Use, Wildlife Refuge Water Use, and San Luis Reservoir**

##### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Because there would be no direct Project-related construction or maintenance occurring in the Extended Study Area, no paleontologically sensitive sediments would be disturbed. Therefore, there would be **no impact** to paleontological resources in the Extended Study Area, when compared to Existing Conditions and the No Project/No Action Alternative.

#### **Secondary Study Area – Alternative A**

##### *Construction, Operation, and Maintenance Impacts*

**Trinity Lake, Lewiston Lake, Trinity River, Klamath River downstream of the Trinity River, Whiskeytown Lake, Spring Creek, Shasta Lake, Sacramento River, Keswick Reservoir, Clear Creek, Lake Oroville, Thermalito Complex (Thermalito Diversion Pool, Thermalito Forebay, and Thermalito Afterbay); Feather River; Sutter Bypass; Yolo Bypass; Folsom Lake; Lake Natoma; American River; Sacramento-San Joaquin Delta; Suisun Bay; San Pablo Bay; and San Francisco Bay**

##### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The only direct Project-related construction that would occur in the Secondary Study Area is the installation of an additional pump into an existing bay at the Red Bluff Pumping Plant. The only direct Project-related maintenance activity that would occur would be the removal of sediment from the existing canal intakes. Because neither of these Project-related activities in the Secondary Study Area is expected to affect paleontologically sensitive sediment, **no impact** to paleontological resources is expected, when compared to Existing Conditions and the No Project/No Action Alternative.

#### **Primary Study Area – Alternative A**

##### *Construction, Operation, and Maintenance Impacts*

##### **Sites Reservoir Inundation Area (1.27 MAF)**

##### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Inundation would not affect paleontological resources; however, excavations (borrow pits and other similar facilities) may occur within the reservoir inundation area. Thus, construction of the 1.27-MAF reservoir would affect rocks of the GVS, including the low sensitivity Boxer Formation and, to a lesser extent, the low to moderate sensitivity Cortina Formation, as well as low sensitivity Quaternary alluvium predominantly located within stream channels. Excavation within the potentially fossiliferous sediments of the GVS within the reservoir footprint would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## Sites Reservoir Dams

### *Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources*

Construction of the footings and anchor walls for Golden Gate Dam and Sites Dam would involve deep excavation into potentially fossiliferous sediments of the GVS. The construction of Golden Gate and Sites dams would predominantly affect the moderate sensitivity Venado Sandstone of the Cortina Formation, and to a lesser extent the low sensitivity Boxer Formation. In addition, the seven saddle dams on the rim of the 1.27-MAF reservoir would affect the Boxer Formation and overlying low sensitivity basin fill. Because these saddle dam excavations would be shallower and of more limited extent than for Golden Gate and Sites dams, the impacts from construction of the saddle dams would be less than those associated with the larger Sites and Golden Gate dams. The deep excavation into potentially fossiliferous members of the GVS, as well as construction activities within other moderately sensitive rock units associated with dam construction, would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## Recreation Areas

### *Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources*

The recreation areas would be constructed predominantly on the rim of the Sites Reservoir inundation area, and would affect the low sensitivity Boxer Formation, the low- to moderate-sensitivity Cortina Formation, and low sensitivity Quaternary alluvium. Construction of the Antelope Island Recreation Area, which would be located within the reservoir, would only impact the Boxer Formation and basin fill (for this analysis, it is considered the same as Quaternary alluvium). Recreation Area construction activities within the potentially fossiliferous member of the GVS would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## Road Relocations and South Bridge

### *Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources*

Similar to the recreation areas, the road relocations would occur predominantly on the rim of and within the inundation area, and in the case of the South Bridge, within the inundation area. Construction associated with these features would affect the low sensitivity Boxer Formation, the low- to moderate-sensitivity Cortina Formation, and low sensitivity Quaternary alluvium. Road construction activities within the potentially fossiliferous member of the GVS would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## Sites Pumping/Generating Plant and Sites Electrical Switchyard

### *Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources*

The Sites Pumping/Generating Plant and its associated switchyard would be located on the eastern margin of the Sites Reservoir, immediately south of the Golden Gate Dam. Project construction would affect the low- to moderate-sensitivity Cortina Formation and a thin veneer of low sensitivity Quaternary alluvium. Construction activities within the potentially fossiliferous member of the GVS associated with construction of these facilities would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

This tunnel would extend through the low sensitivity Boxer Formation to the west and the low- to moderate-sensitivity Cortina Formation to the east. Low sensitivity Quaternary alluvium would be impacted at both ends of the tunnel. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the tunnel would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Sites Reservoir Inlet/Outlet Structure**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The Sites Reservoir Inlet/Outlet Structure would affect the low sensitivity Boxer Formation and low sensitivity Quaternary alluvium within the inundation area, and would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill east of the inundation area. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the Inlet/Outlet Structure would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Field Office Maintenance Yard**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The Field Office Maintenance Yard would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill, resulting in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Funks Reservoir is located east of the Sites Reservoir, on low sensitivity basin deposits underlain by the moderate sensitivity Sites and Yolo members of the Cortina Formation. Dredging is not likely to affect these formations because most reservoirs build up a layer of sediment over time and dredging would be directed at removing that recent accumulation of sediment. Because it is recent, sediment dredging would have **no impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

The Holthouse Reservoir Complex and Holthouse Reservoir Electrical Switchyard would be located adjacent to the existing Funks Reservoir, within the Sacramento Valley. Similar to that described for Sites Reservoir, the inundation of Holthouse Reservoir would not impact paleontological resources, but excavations within the inundation area and excavations associated with the dam construction and the electrical switchyard would impact paleontologically sensitive geologic units. Construction of these features would affect low sensitivity basin fill and, at depth, the moderate sensitivity Riverbank Formation. Excavation and other construction activities associated with the Holthouse Reservoir Complex within the moderate sensitivity Riverbank Formation would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Glenn-Colusa Irrigation District Canal Facilities Modifications**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The majority of the construction associated with the existing GCID Canal consists of repairs or refurbishments, and would only affect previously disturbed sediment, which has a low paleontological sensitivity. Any excavations that extend beyond previously disturbed soil would affect the moderate sensitivity Modesto and Riverbank formations. Due to the possibility of disturbance to moderate sensitivity formations, construction activities associated with modifications to the GCID Canal would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Terminal Regulating Reservoir and Glenn-Colusa Irrigation District Canal Connection to the Terminal Regulating Reservoir**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Similar to the discussion for Sites and Holthouse reservoirs, the inundation of the TRR would not affect paleontological resources. However, excavation within the inundation area may occur, and excavations for dams and other structures around the rim of the inundation area would affect paleontologically sensitive units. The TRR would be located within the Sacramento Valley, and excavations associated with this reservoir would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill.

Construction associated with the connection to the GCID Canal would include the excavation of a canal energy dissipation bay with check structure, the inlet channel to the TRR, and the inlet control structure. These excavations would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill. Construction activities associated with these facilities within moderate sensitivity formations would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Terminal Regulating Reservoir Pumping/Generating Plant and Terminal Regulating Reservoir Electrical Switchyard**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Excavations associated with this pumping/generating plant and electrical switchyard, which would be located at the rim of the TRR, would impact the moderate sensitivity Riverbank Formation and low sensitivity basin fill. Construction activities associated with these facilities within a moderate sensitivity formation would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **Terminal Regulating Reservoir Pipeline, Terminal Regulating Reservoir Pipeline Road, and Delevan Pipeline Electrical Switchyard**

### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Construction of the TRR Pipeline, TRR Pipeline Road, and Delevan Pipeline Electrical Switchyard, which would be located between Holthouse Reservoir and the TRR, would affect the low- to moderate-sensitivity Cortina Formation and low-sensitivity basin fill. Construction activities within the potentially fossiliferous member of the GVS associated with construction of the TRR Pipeline, TRR Pipeline Road, and Delevan

Pipeline Electrical Switchyard would result in a **potentially significant impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Transmission Line**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The Delevan Transmission Line would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill between the Sites Pumping/Generating Plant and the existing WAPA or PG&E transmission line, and low sensitivity Quaternary alluvium and basin deposits, the moderate sensitivity Modesto Formation, the moderate sensitivity Riverbank Formation, and the low- to moderate-sensitivity Cortina Formation between the existing WAPA or PG&E transmission line and the Sacramento River. Construction activities associated with placement of the transmission line tower footings within the potentially fossiliferous member of the GVS, or within moderate sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Pipeline**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The Delevan Pipeline would parallel the Delevan Transmission Line, and along its entire length would affect the same geologic units: low sensitivity Quaternary alluvium and basin deposits, the moderate sensitivity Modesto Formation, the moderate sensitivity Riverbank Formation, and the low- to moderate-sensitivity Cortina Formation. Construction activities associated with the Delevan Pipeline within the potentially fossiliferous member of the GVS, or within moderate sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Pipeline Intake Facilities**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Geologic units that would be affected by construction of the Delevan Pipeline Intake Facilities consist of low sensitivity Quaternary alluvium deposited by the Sacramento River and the underlying moderate sensitivity Modesto Formation and high sensitivity Tehama Formation. Construction activities associated with the Delevan Pipeline Intake Facilities, within moderate and high sensitivity formations, would result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Project Buffer**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Excavations associated with the demolition of existing structures would be limited to previously disturbed sediments of no paleontological sensitivity, and the installation of fencing and creation of a fuelbreak would not involve excavations, and therefore, would not impact paleontological resources. Construction activities associated with the Project Buffer would, therefore, have **no impact** on paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## 16.3.7 Impacts Associated with Alternative B

### 16.3.7.1 Geology and Soils

#### **Extended and Secondary Study Areas – Alternative B**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative B, as they relate to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), would be the same as described for Alternative A for the Extended and Secondary study areas.

#### **Primary Study Area – Alternative B**

##### *Construction, Operation, and Maintenance Impacts*

The following Project facilities are included in both Alternatives A and B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to geology and soils:

- Recreation Areas
- Sites Pumping/Generating Plant
- Sites Electrical Switchyard
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- Sites Reservoir Inlet/Outlet Structure
- Field Office Maintenance Yard
- Holthouse Reservoir Complex
- Holthouse Reservoir Electrical Switchyard
- GCID Canal Facilities Modifications
- GCID Canal Connection to the TRR
- TRR
- TRR Pumping/Generating Plant
- TRR Electrical Switchyard
- TRR Pipeline
- TRR Pipeline Road
- Delevan Pipeline
- Delevan Pipeline Electrical Switchyard

The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), as described for Alternative A.

If Alternative B is implemented, the footprint or construction disturbance area of Sites Reservoir and Dams, the Road Relocations and South Bridge, and the Delevan Transmission Line would differ from Alternative A. In addition, the Delevan Pipeline Intake Facilities would be replaced by the Delevan Pipeline Discharge Facility. Impacts due to geology and soils (**Impact Geo/Soils-1**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) would be the same for Alternative B as was described for Alternative A. The effects of operation and maintenance activities associated with these facilities on soil erosion would be the same as described for Alternative A. The differences in the effects of construction activities between alternatives relative to soil erosion are described below.

### **Sites Reservoir Inundation Area (1.81 MAF)**

#### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

During Project operation, reservoir surface elevations would fluctuate between a minimum of 340 feet and 520 feet. Shoreline erosion would occur along the zone of reservoir-elevation fluctuation and would have a greater impact than Alternative A because a greater surface area would be exposed to wave action and associated erosion. Sediment delivery into the reservoir resulting from shoreline erosion would be retained within the reservoir, similar to that described for Alternative A. Soil erosion impacts from Project construction, operation, and maintenance are considered **potentially significant**.

### **Sites Reservoir Dams**

#### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

Construction erosion impacts associated with Alternative B would be similar to those described for Alternative A. However, because of the total of nine saddle dams with Alternative B (compared to seven with Alternative A), and larger footprints for Sites and Golden Gate dams, overall construction erosion impacts associated with the Alternative B dams would increase. Increased soil erosion would result in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Pipeline Discharge Facilities**

#### ***Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil***

The footprint of the Delevan Pipeline Discharge Facility included in Alternative B would be less than half the size of the Delevan Pipeline Intake Facilities described for Alternative A; therefore, construction erosion impacts associated with this facility would be less than that described for Alternative A. However, the increased soil erosion associated with construction activities would still result in a **potentially significant impact**, when compared to Existing Conditions and the No Project/No Action Alternative.

### **16.3.7.2 Minerals**

#### **Extended, Secondary, and Primary Study Areas – Alternative B**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative B, as they relate to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**), would be the same as described for Alternative A for the Extended, Secondary, and Primary study areas.

### **16.3.7.3 Paleontology**

#### **Extended and Secondary Study Areas – Alternative B**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative B, as they relate to paleontological resources (**Impact Paleo-1**), would be the same as described for Alternative A for the Extended and Secondary study areas.

#### **Primary Study Area – Alternative B**

##### *Construction, Operation, and Maintenance Impacts*

The following Primary Study Area Project facilities are included in both Alternatives A and B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources:

- Recreation Areas
- Sites Electrical Switchyard
- Sites Pumping/Generating Plant
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- Sites Reservoir Inlet/Outlet Structure
- Field Office Maintenance Yard
- Holthouse Reservoir Complex
- Holthouse Reservoir Electrical Switchyard
- GCID Canal Facilities Modifications
- GCID Canal Connection to the TRR
- TRR
- TRR Pumping/Generating Plant
- TRR Electrical Switchyard
- TRR Pipeline
- TRR Pipeline Road
- Delevan Pipeline
- Delevan Pipeline Electrical Switchyard

The boundary of the Project Buffer would be the same for Alternatives A and B, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and

maintenance activities that were described for Alternative A. It would, therefore, have the same impact on paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The major differences between Alternatives B and A are related to the increased size of Sites Reservoir with Alternative B. The increase in reservoir size necessitates the addition of two saddle dams and the movement of various project components. In addition, Alternative B replaces the Delevan Pipeline Intake Facilities with the Delevan Pipeline Discharge Facility. The Alternative B facilities' construction impacts on paleontological resources that would differ from those described for Alternative A are discussed below.

### **Sites Reservoir Inundation Area (1.81 MAF)**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The reservoir included in Alternative B would be larger than for Alternative A, but would affect the same geologic units. These units consist of the low sensitivity Boxer Formation and the low- to moderate-sensitivity Cortina Formation, as well as low sensitivity basin fill. However, the larger reservoir may result in greater effects to paleontological resources than would occur with Alternative A. Construction of the 1.81-MAF Sites Reservoir would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Sites Reservoir Dams**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The larger Sites Reservoir Inundation Area included in Alternative B necessitates slightly different locations for each dam and a larger excavation area for the footprints of Sites and Golden Gate dams, and therefore, may result in greater effects to paleontological resources than would occur with Alternative A. The effects on paleontological resources from construction of Alternative B's Sites and Golden Gate dams would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

In addition, Alternative B includes nine saddle dams, whereas Alternative A includes seven saddle dams, so more area would be disturbed with Alternative B than with Alternative A. The saddle dams would be located around the rim of Sites Reservoir, and therefore, would affect the low sensitivity Boxer Formation and low sensitivity basin fill, similar to that described for Alternative A. The effects on paleontological resources from construction of the Alternative B saddle dams would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Road Relocations and South Bridge**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

Excavations for Alternative B would be slightly less extensive than for Alternative A. The lengths of the saddle dam access roads would be reduced for Alternative B because the dams would be larger and are located closer to the main roads. This would, therefore, reduce the potential impacts to paleontological resources in those areas. However, an extension of an access road would be constructed for Alternative B to provide access from Saddle Dam 3 to Saddle Dams 1 and 2. This road extension would affect the Boxer Formation and overlying low sensitivity basin fill. Effects on paleontological resources from construction

associated with road relocations and the South Bridge would be similar for Alternative B to the impacts described for Alternative A and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Transmission Line**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The length of the proposed Delevan Transmission Line for Alternative B is greatly reduced from the length associated with Alternative A and would extend only from the Sites Electrical Switchyard to its connection with the existing WAPA or PG&E transmission line. Effects on paleontological resources from construction of the Alternative B transmission line would, therefore, be greatly reduced, when compared to the Alternative A transmission line. The Alternative B transmission line would extend through the westernmost margin of the Sacramento Valley, and would affect the low- to moderate-sensitivity Cortina Formation and low sensitivity basin fill, and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

### **Delevan Pipeline Discharge Facility**

#### ***Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources***

The smaller size of the Delevan Pipeline Discharge Facility, when compared to the Delevan Pipeline Intake Facilities that are included in Alternative A, would lessen the effects to high and moderate paleontologically sensitive formations. Impacts to paleontological resources would be similar to those discussed for Alternative A and would, therefore, result in a **potentially significant impact** to paleontological resources, when compared to Existing Conditions and the No Project/No Action Alternative.

## **16.3.8 Impacts Associated with Alternative C**

### ***16.3.8.1 Geology and Soils***

#### **Extended and Secondary Study Areas – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative C, as they relate to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**), would be the same as described for Alternative A for the Extended and Secondary study areas.

#### **Primary Study Area – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The following Primary Study Area Project facilities are included in Alternatives A, B, and C. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to geology and soils:

- Recreation Areas
- Sites Pumping/Generating Plant

- Sites Electrical Switchyard
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- Sites Reservoir Inlet/Outlet Structure
- Field Office Maintenance Yard
- Holthouse Reservoir Complex
- Holthouse Reservoir Electrical Switchyard
- GCID Canal Facilities Modifications
- GCID Canal Connection to the TRR
- TRR
- TRR Pumping/Generating Plant
- TRR Electrical Switchyard
- TRR Pipeline
- TRR Pipeline Road
- Delevan Pipeline
- Delevan Pipeline Electrical Switchyard

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative A.

The Alternative C design of the Delevan Transmission Line and Delevan Pipeline Intake Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts on geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore result in the same construction, operation, and maintenance impacts to geology and soils (**Impact Geo/Soils-1**), soil erosion and loss of topsoil (**Impact Geo/Soils-2**), the level of risk to life and property from activities on expansive soil (**Impact Geo/Soils-3**), and soils that are incapable of supporting septic tanks or alternative wastewater disposal systems (**Impact Geo/Soils-4**) as described for Alternative B.

### 16.3.8.2 Minerals

#### **Extended and Secondary Study Areas – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative C, as they relate to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**), would be the same as described for Alternative A for the Extended and Secondary study areas.

#### **Primary Study Area – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The following Primary Study Area Project facilities are included in Alternatives A, B, and C. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to minerals:

- Recreation Areas
- Sites Pumping/Generating Plant
- Sites Electrical Switchyard
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- Sites Reservoir Inlet/Outlet Structure
- Field Office Maintenance Yard
- Holthouse Reservoir Complex
- Holthouse Reservoir Electrical Switchyard
- GCID Canal Facilities Modifications
- GCID Canal Connection to the TRR
- TRR
- TRR Pumping/Generating Plant
- TRR Electrical Switchyard
- TRR Pipeline
- TRR Pipeline Road
- Delevan Pipeline
- Delevan Pipeline Electrical Switchyard

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and maintenance activities that were described for Alternative A. It would, therefore, have the same impact on known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative A.

The Alternative C design of the Delevan Transmission Line and Delevan Pipeline Intake Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**),

locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore result in the same construction, operation, and maintenance impacts to known mineral resources of value (**Impact Min-1**), locally important resources (**Impact Min-2**), and naturally occurring asbestos (**Impact Min-3**) as described for Alternative B.

### **16.3.8.3 Paleontology**

#### **Extended and Secondary Study Areas – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The impacts associated with Alternative C, as they relate to paleontological resources (**Impact Paleo-1**), would be the same as described for Alternative A for the Extended and Secondary study areas.

#### **Primary Study Area – Alternative C**

##### *Construction, Operation, and Maintenance Impacts*

The following Primary Study Area Project facilities are included in Alternatives A, B, and C. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources:

- Recreation Areas
- Sites Electrical Switchyard
- Sites Pumping/Generating Plant
- Tunnel from Sites Pumping/Generating Plant to Sites Reservoir Inlet/Outlet Structure
- Sites Reservoir Inlet/Outlet Structure
- Field Office Maintenance Yard
- Holthouse Reservoir Complex
- Holthouse Reservoir Electrical Switchyard
- GCID Canal Facilities Modifications
- GCID Canal Connection to the TRR
- TRR
- TRR Pumping/Generating Plant
- TRR Electrical Switchyard
- TRR Pipeline
- TRR Pipeline Road
- Delevan Pipeline
- Delevan Pipeline Electrical Switchyard

The boundary of the Project Buffer would be the same for Alternatives A, B, and C, but because the footprints of some of the Project facilities that are surrounded by the Project Buffer would differ between the alternatives, the acreage of land within the Project Buffer would also differ. However, this difference in the size of the area included within the buffer would not change the type of construction, operation, and

maintenance activities that were described for Alternative A. It would, therefore, have the same impact on paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The Alternative C design of the Delevan Transmission Line and Delevan Pipeline Intake Facilities is the same as described for Alternative A. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore, result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as described for Alternative A.

The Alternative C design of the Sites Reservoir Inundation Area and Dams, Recreation Areas, and Road Relocations and South Bridge is the same as described for Alternative B. These facilities would require the same construction methods and operation and maintenance activities regardless of alternative, and would, therefore result in the same construction, operation, and maintenance impacts to paleontological resources (**Impact Paleo-1**) as described for Alternative B.

## 16.4 Mitigation Measures

Mitigation measures are provided below and summarized in Tables 16-9 and 16-10 for the impacts that have been identified as significant or potentially significant.

### 16.4.1 Geology and Soils

**Table 16-9  
Summary of Mitigation Measures for  
NODOS Project Impacts to/from Geology and Soils**

<b>Impact</b>	<b>Associated Project Facility</b>	<b>LOS Before Mitigation</b>	<b>Mitigation Measure</b>	<b>LOS After Mitigation</b>
Impact Geo/Soils-2: Project Construction, Operation, and Maintenance Effects on Soil Erosion and Loss of Topsoil	Sites Reservoir Inundation Area, Sites Reservoir Dams, Recreation Areas, Road Relocations and South Bridge, Sites Pumping/Generating Plant, Tunnel, Sites Reservoir Inlet/Outlet Structure, Sites Electrical Switchyard, Field Office Maintenance Yard, Holthouse Reservoir Complex, Holthouse Reservoir Electrical Switchyard, GCID Canal Facilities Modifications, TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, GCID Canal Connection to the TRR, Delevan Transmission Line, Delevan Pipeline Intake Facilities, Project Buffer	Potentially Significant	Mitigation Measure Geo/Soils-2: Prepare and Implement a Project Construction Erosion Control Plan and a Project Operation and Maintenance Erosion and Sediment Control Plan  Mitigation Measure SW Qual-1c (2): Prepare and Implement a Stormwater Pollution Prevention Plan	Less than Significant

**Table 16-9  
Summary of Mitigation Measures for  
NODOS Project Impacts to/from Geology and Soils**

<b>Impact</b>	<b>Associated Project Facility</b>	<b>LOS Before Mitigation</b>	<b>Mitigation Measure</b>	<b>LOS After Mitigation</b>
Impact Geo/Soils-3: Risks to Life and Property from Project Construction, Operation, and Maintenance on Expansive Soil	Recreation Areas, Road Relocations and South Bridge, Sites Pumping/Generating Plant, Tunnel, Sites Reservoir Inlet/Outlet Structure, Sites Electrical Switchyard, Field Office Maintenance Yard, Holthouse Reservoir Complex, Holthouse Reservoir Electrical Switchyard, GCID Canal Facilities Modifications, TRR, TRR Pumping/Generating Plant, TRR Electrical Switchyard, GCID Canal Connection to the TRR, Delevan Transmission Line, Delevan Pipeline, TRR Pipeline, TRR Pipeline Road, Delevan Pipeline Electrical Switchyard	Potentially Significant	Mitigation Measure Geo/Soils-3: Perform a Geotechnical Investigation due to Expansive Soils at Project Facility Sites	Less than Significant
Impact Geo/Soils-4: Project Construction, Operation, and Maintenance Effects on Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal	Field Office Maintenance Yard	Potentially Significant	Mitigation Measure Geo/Soils-4: Implement Measures for Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal	Less than Significant

Note:

LOS = Level of Significance

***Mitigation Measure Geo/Soils-2: Prepare and Implement a Project Construction Erosion Control Plan and a Project Operation and Maintenance Erosion and Sediment Control Plan***

To minimize soil erosion and loss of topsoil, DWR and Reclamation shall include in the construction contract the requirement for the preparation of an Erosion Control Plan prior to the start of Project construction and its implementation during Project construction. DWR and Reclamation shall also prepare an Erosion and Sediment Control Plan that shall be implemented during Project construction, operation, and maintenance. The Plans shall meet all local requirements and incorporate Best Management Practices (BMPs). BMPs may include, but would not be limited to:

- Preservation of existing vegetation
- The use of silt fences and/or straw bales and sheetpiles to separate project construction sites from waterways.

**PRELIMINARY – SUBJECT TO CHANGE**

- Covering soil stockpiles with mulch or matting, as well as continuous maintenance of erosion control measures
- PennzSuppress® dust suppressant, or an equivalent product, to stabilize soil during and after construction
- Timely revegetation of disturbed sites to minimize post-construction erosion impacts. The use of native seeds and plants to assist in the conservation and enhancement of protected species shall be considered, as required by Section 7(a)(1) of the Endangered Species Act (ESA).

***Mitigation Measure SW Qual-1c (2): Prepare and Implement a Stormwater Pollution Prevention Plan***

The Project is subject to construction-related stormwater permit requirements of the Clean Water Act National Pollutant Discharge Elimination System (NPDES) Permit Program. DWR and Reclamation shall obtain any required permits through the CVRWQCB before any ground-disturbing construction activities occur. DWR and Reclamation shall prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) that identifies BMPs to prevent or minimize the introduction of contaminants into surface waters. BMPs for the Project could include, but are not limited to, silt fencing, straw bale barriers, diversion ditches, fiber rolls, storm drain inlet protection, hydraulic mulch, and stabilized construction entrance. The SWPPP shall include development of site-specific structural and operational BMPs to prevent and control impacts on runoff quality, measures to be implemented before each storm event, inspection and maintenance of BMPs, and monitoring of runoff quality by visual and/or analytical means.

***Mitigation Measure Geo/Soils-3: Perform a Geotechnical Investigation due to Expansive Soils at Project Facility Sites***

A site-specific design-level geotechnical investigation, prepared by a licensed professional, shall be performed. The geotechnical investigation shall include measures to ensure potential damage related to expansive soils and non-uniformly compacted fill and engineered fill are minimized. Mitigation options may range from removal of the problem soils, and replacement, as needed, with properly conditioned and compacted fill, to design and construction of improvements to withstand the forces exerted during the expected shrink-swell cycles and settlements. All design criteria and specifications set forth in the geotechnical investigation shall be implemented to reduce impacts associated with problem soils.

***Mitigation Measure Geo/Soils-4: Implement Avoidance Measures for Soils that are Incapable of Adequately Supporting the Use of Septic Tanks or Alternative Wastewater Disposal Systems where Sewers are not Available for the Wastewater Disposal***

During Project design, Project engineers shall consider the soil types when designing the necessary septic tank facilities, and shall incorporate and implement measures to accommodate such facilities or their alternatives. Alternatives could include mound, lagoon, or constructed wetlands systems (University of Kentucky, 2001).

Implementation of **Mitigation Measures Geo/Soils-2, Geo/Soils-3, and Geo/Soils-4** would reduce the level of significance of Project impacts to geology and soils to **less than significant**.

#### **16.4.2 Minerals**

Because no significant or potentially significant impacts were identified, no mitigation is required or recommended.

### 16.4.3 Paleontology

**Table 16-10  
Summary of Mitigation Measures for  
NODOS Project Impacts to Paleontological Resources**

Impact	Associated Project Facility	LOS Before Mitigation	Mitigation Measure	LOS After Mitigation
Impact Paleo-1: Project Construction, Operation, and Maintenance Effects on Paleontological Resources	All Project Facilities, with the exception of the Project Buffer	Potentially Significant	Mitigation Measure Paleo-1a: Retain a Qualified Paleontological Resource Specialist Prior to the Start of Construction  Mitigation Measure Paleo-1b: Consultation with the Paleontological Resource Specialist Prior to and During Project Construction  Mitigation Measure Paleo-1c: Prepare and Implement a Paleontological Resources Monitoring and Mitigation Plan  Mitigation Paleo-1d: Conduct Paleontological Resources Awareness Training  Mitigation Measure Paleo-1e: Conduct Monitoring During Project Construction and Prepare Monthly Reports  Mitigation Measure Paleo-1f: Ensure Implementation of the Paleontological Resources Monitoring and Mitigation Plan	Less than Significant

Note:  
LOS = Level of Significance

The significance of paleontological resources originates chiefly in their scientific value. Therefore, mitigation of impacts to paleontological resources can be achieved by the recovery of those values. This is accomplished through paleontological resources monitoring, and the scientific recovery of discovered fossils when they are encountered. Through the controlled excavation, study, and appropriate museum curation of fossil materials their scientific value is preserved, and potentially even enhanced through the new knowledge developed during their initial study. These mitigation measures are consistent with those recommended by the Society of Vertebrate Paleontology (SVP, No Date).

***Mitigation Measure Paleo-1a: Retain a Qualified Paleontological Resource Specialist Prior to the Start of Construction***

DWR and Reclamation shall retain a qualified Paleontological Resource Specialist at least 90 days prior to the start of construction. DWR and Reclamation shall keep resumes on file for the Paleontological Resource Specialist as well as qualified Paleontological Resource Monitors working on the Project. The Paleontological Resource Specialist shall meet the minimum or equivalent qualifications for a

paleontological resources manager, as described in the Society of Vertebrate Paleontology guidelines of 1995. The experience of the Paleontological Resource Specialist shall include the following:

- Ability to recognize and collect fossils in the field
- Geological and biostratigraphic expertise
- Proficiency in identifying vertebrate and invertebrate fossils, and in assessing their scientific significance
- At least three years of paleontological resource mitigation and field experience in California and at least one year of experience leading paleontological resource mitigation and field activities

DWR and Reclamation shall ensure that the Paleontological Resource Specialist obtains qualified paleontological resource monitors to monitor Project construction activities, as the Paleontological Resource Specialist determines necessary on the Project. Paleontological Resource Monitors shall have the equivalent of the following qualifications:

- BS or BA degree in geology or paleontology and one year of experience monitoring in California
- AS or AA in geology, paleontology, or biology and four years' experience monitoring in California
- Enrollment in upper division classes pursuing a degree in the fields of geology or paleontology and two years of monitoring experience in California

***Mitigation Measure Paleo-1b: Consultation with the Paleontological Resource Specialist Prior to and During Project Construction***

At least 30 days prior to the start of Project construction, DWR and Reclamation shall provide maps or drawings to the Paleontological Resource Specialist that show the planned construction footprint. Maps shall identify all areas of the Project where ground disturbance is anticipated. (Site grading plan and plan and profile drawings for the utility lines are appropriate for this purpose). The plan drawings shall show the location, depth, and extent of all ground disturbances affecting paleontologically sensitive sediment. If Project construction proceeds in phases, maps and drawings may be submitted prior to the start of each phase. In addition, the proposed schedule of each Project phase shall be provided to the Paleontological Resource Specialist. Before work commences on affected phases, DWR and Reclamation shall notify the Paleontological Resource Specialist of any construction phase scheduling changes. If paleontological resources monitoring is ongoing, DWR and Reclamation shall ensure that the Paleontological Resource Specialist or Paleontological Resource Monitor consults weekly with the Project superintendent or construction field manager to confirm area(s) to be worked the following week and until ground disturbance is completed.

***Mitigation Measure Paleo-1c: Prepare and Implement a Paleontological Resources Monitoring and Mitigation Plan***

DWR and Reclamation shall ensure that the Paleontological Resource Specialist prepares a Paleontological Resources Monitoring and Mitigation Plan (PRMMP) to identify general and specific measures to minimize potential impacts to significant paleontological resources. Approval of the PRMMP by DWR and Reclamation shall occur prior to any ground disturbance. The PRMMP shall function as the formal guide for paleontological resources monitoring, collecting, and sampling activities, and may be modified by the Paleontological Resource Specialist to accommodate new data or Project changes.

This document shall be used as the basis of discussion when on-site decisions or changes are proposed. Copies of the PRMMP shall reside with the Paleontological Resource Specialist, each monitor, DWR's and Reclamation's on-site manager, and DWR and Reclamation.

The PRMMP shall be developed in accordance with professional guidelines, and be consistent with those issued by the Society of Vertebrate Paleontology (SVP, No Date), and shall include, but not be limited to, the following:

Procedures for the performance and sequence of resource-related tasks, such as any literature searches, pre-construction surveys, appropriate worker environmental training module, construction monitoring, mapping and data recovery, discovery situations, fossil preparation and collection, identification and inventory, preparation of final reports, transmittal of materials for curation, and final report shall be provided in the PRMMP, including:

- A discussion of the geologic units expected to be encountered, the location and depth of the units relative to the Project, when known, and the known paleontological sensitivity of those units
- A discussion of the locations of where the monitoring of Project construction activities is deemed necessary, and a proposed plan for monitoring and sampling
- An explanation of why, how, and how much sampling is expected to take place and in what units, including descriptions of different sampling procedures that may be used
- A discussion of procedures to be followed in the event of a significant fossil discovery, diverting construction away from a find, resuming construction, and how notifications will be performed
- A discussion of equipment and supplies necessary for collection of fossil materials and any specialized equipment needed to prepare, remove, load, transport, and analyze large-sized fossils or extensive fossil deposits
- Procedures for inventory, preparation, and delivery for curation into a retrievable storage collection in a public repository or museum, which meet the Society of Vertebrate Paleontology's standards and requirements for the curation of paleontological resources
- Identification of the institution(s) that will be approached to receive data and fossil materials collected, and requirements or specifications for materials delivered for curation

The PRMMP shall also provide guidance for preparation of a Paleontological Resources Report by the designated Paleontological Resource Specialist at the conclusion of ground-disturbing activities that may affect paleontological resources. The Paleontological Resources Report shall include an analysis of the collected fossil materials and related information, including a description and inventory of recovered fossil materials, a map showing the location of paleontological resources encountered, determinations of sensitivity and significance, and a statement by the Paleontological Resource Specialist that Project impacts to paleontological resources have been mitigated below the level of significance.

#### ***Mitigation Measure Paleo-1d: Conduct Paleontological Resources Awareness Training***

Prior to ground disturbance and for the duration of Project construction activities involving ground disturbance, the Paleontological Resource Specialist shall prepare, and DWR and Reclamation shall conduct, weekly paleontological resources awareness training for the following workers: project managers, construction supervisors, forepersons, and general workers involved with or who operate ground-

disturbing equipment or tools. Workers shall not excavate in paleontologically sensitive sediments prior to receiving paleontological resources awareness training. Worker training shall consist of a video or in-person presentation. The paleontological resources awareness training module may be combined with other training modules prepared for cultural and biological resources, hazardous materials, or other areas of interest or concern.

The paleontological resources awareness training shall address the possibility of encountering paleontological resources in the field, the sensitivity and importance of these resources, and legal obligations to preserve and protect those resources. The training shall include:

- A discussion of applicable laws and penalties under the law
- Good quality photographs or physical examples of vertebrate fossils
- Information that the Paleontological Resource Specialist or Paleontological Resource Monitor has the authority to halt or redirect construction in the vicinity of a fossil discovery or unanticipated impact to a paleontological resource
- Instruction that employees are to halt or redirect work in the vicinity of a find and to contact their supervisor and the Paleontological Resource Specialist or Paleontological Resource Monitor
- An informational brochure that identifies reporting procedures in the event of a discovery
- A certification of completion form signed by each worker indicating that he/she has received the training

***Mitigation Measure Paleo-1e: Conduct Monitoring During Project Construction and Prepare Monthly Reports***

DWR and Reclamation shall ensure that the Paleontological Resource Specialist and Paleontological Resource Monitor(s) monitor construction excavations consistent with the PRMMP in areas where potential fossil-bearing materials have been identified, both at reservoir sites and along any constructed linear facilities associated with the Project. In the event that the Paleontological Resource Specialist determines full-time monitoring is not necessary in locations that were identified as potentially fossil-bearing in the PRMMP, the Paleontological Resource Specialist shall notify DWR and Reclamation.

DWR and Reclamation shall ensure that the Paleontological Resource Specialist and Paleontological Resource Monitor(s) have the authority to halt or redirect construction if paleontological resources are encountered. DWR and Reclamation shall ensure that there is no interference with monitoring activities, as directed by the Paleontological Resource Specialist.

DWR and Reclamation shall ensure that the Paleontological Resource Specialist prepares and submits monthly summaries of monitoring and other paleontological resources management activities. The summary shall include the name(s) of the Paleontological Resource Specialist or Paleontological Resource Monitor(s) active during the month, general descriptions of training and monitored construction activities; and general locations of excavations, grading, and other activities. A section of the report shall include the geologic units or subunits encountered, descriptions of samplings, if any, and a list of identified fossils. A final section of the report shall address any issues or concerns about the Project relating to paleontological resources mitigation activities, including any incidents of non-compliance or any changes to the monitoring plan by the Paleontological Resource Specialist. If no monitoring took place during the month, the report shall include an explanation as to why monitoring was not conducted.

### ***Mitigation Measure Paleo-1f: Ensure Implementation of the Paleontological Resources Monitoring and Mitigation Plan***

DWR and Reclamation, through the designated Paleontological Resource Specialist, shall ensure that all components of the PRMMP are adequately performed during construction.

Implementation of **Mitigation Measures Paleo-1a, Paleo-1b, Paleo-1c, Paleo-1d, Paleo-1e, and Paleo-1f** would reduce the level of significance of Project impacts to paleontological resources to **less than significant**.

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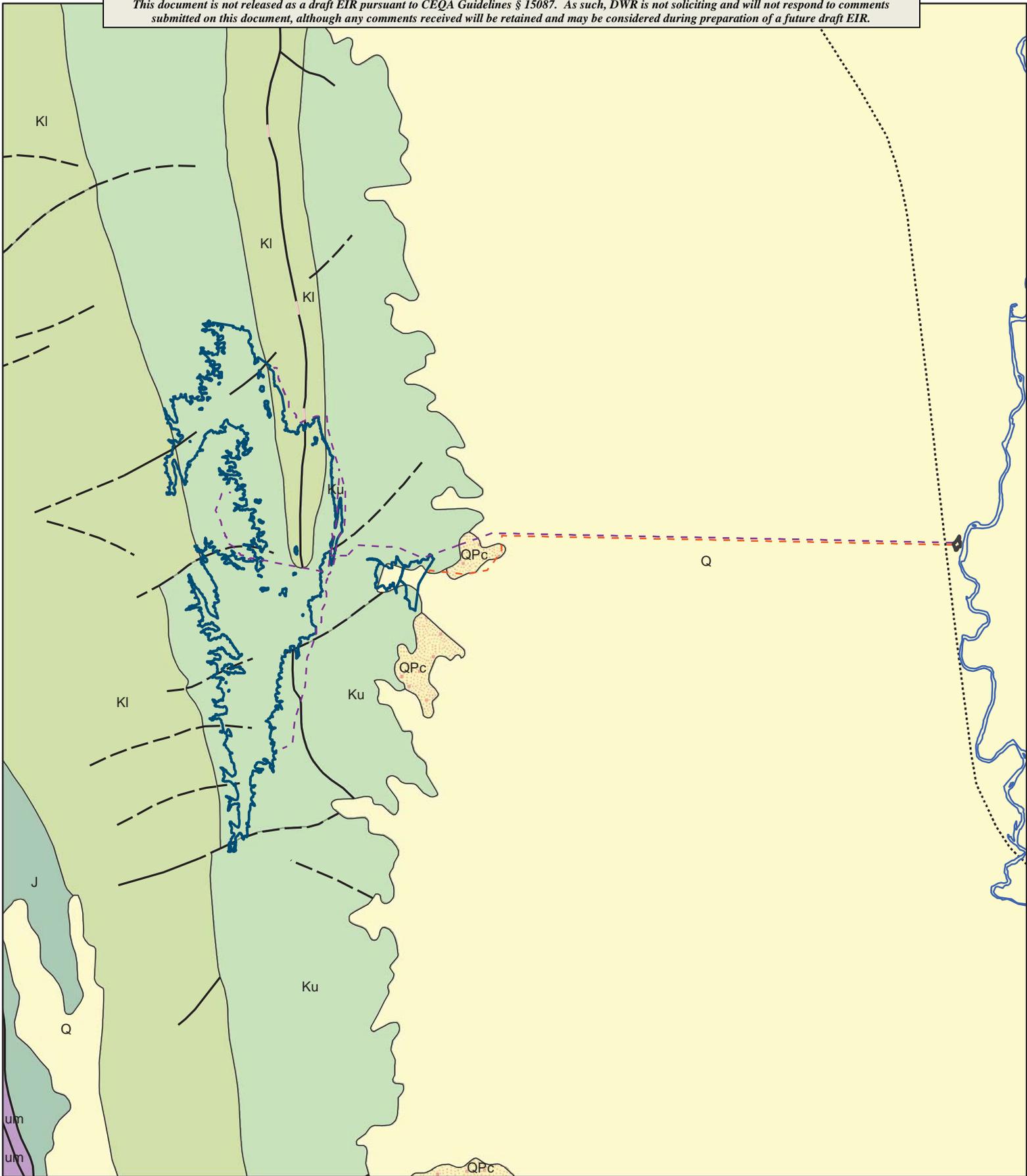


- Legend**
- Delevan Transmission Line and Pipeline
  - Proposed Sites Reservoir
  - Geomorphic Provinces of California

**FIGURE 16-1**  
**Geomorphic Provinces of California**  
*North-of-the-Delta Offstream Storage Project*

0 20 40 80 120 160 Miles

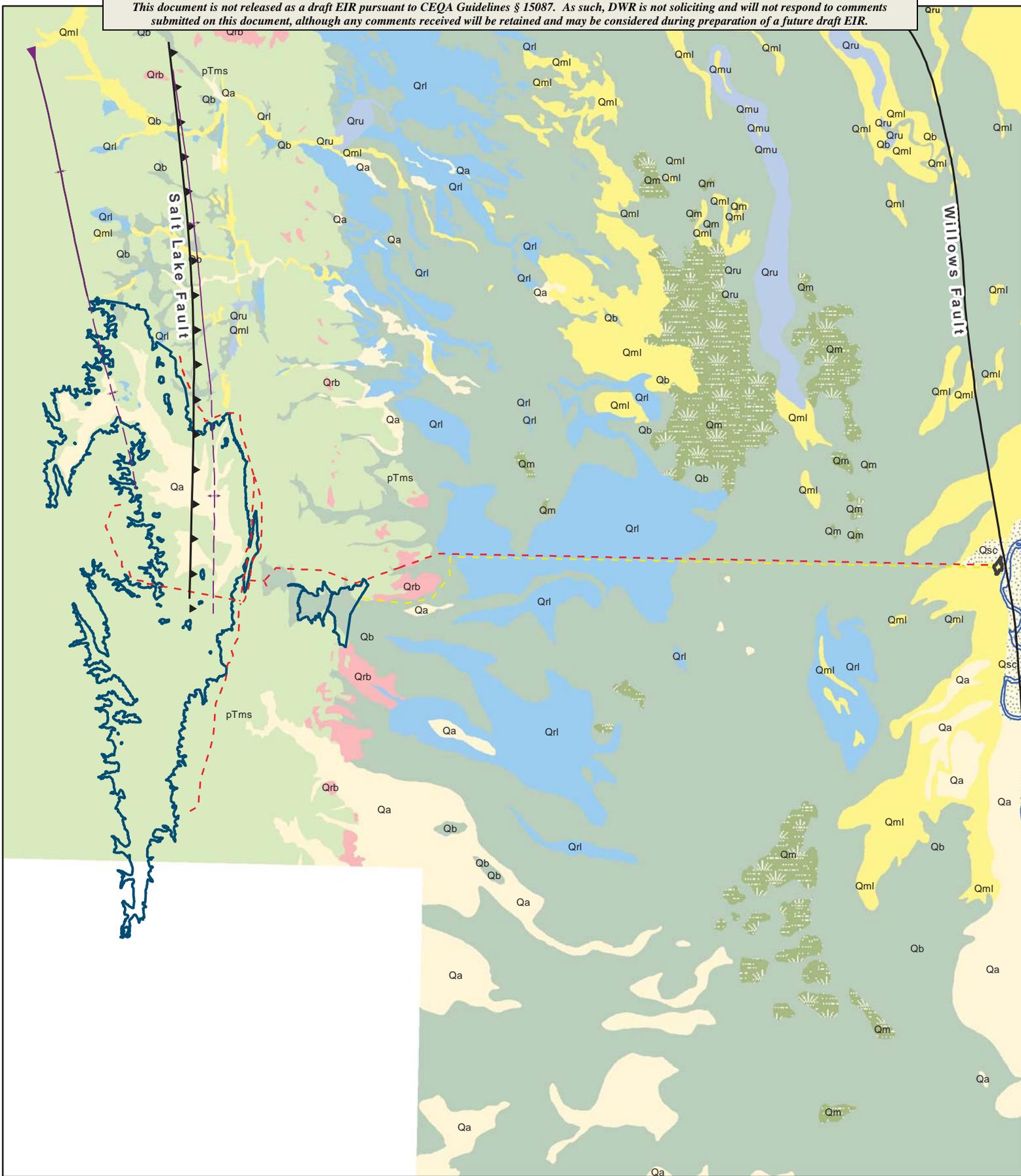




- Legend**
- - - Delevan Transmission Line
  - - - Delevan Pipeline
  - ▭ Sites, Funks, and Holthouse Reservoirs
  - ▭ Delevan Pipeline Intake Structure

**FIGURE 16-2**  
**Generalized Geologic Map**  
**of the Primary Study Area**  
*North-of-the-Delta Offstream Storage Project*





- Legend**
- - - Delevan Transmission Line
  - - - Delevan Pipeline
  - ▭ Delevan Pipeline Intake Structure
  - ▭ Sites, Funks, and Holthouse Reservoirs

**FIGURE 16-3**  
**Rock Units Within the**  
**Sacramento Valley**  
*North-of-the-Delta Offstream Storage Project*

