Chapter 4
Geology, Geomorphology, Minerals, and Soils

The evaluation in this chapter is based on a review of existing literature and data, along with information obtained from shoreline erosion surveys, wetland delineations, and geotechnical investigations and surveys. The information included in the technical analysis is also derived from the following sources:

- CALFED Bay-Delta Program Final Programmatic EIS/EIR (CALFED 2000a)
- *North-of-the-Delta Offstream Storage Investigation Initial Alternatives Information Report* (DWR and Reclamation 2006)
- Contra Costa Water District Alternative Intake Project Draft EIR/EIS (CCWD 2006)

4.1 Affected Environment

This section describes the affected environment related to geology, seismicity, soils/erosion, mineral resources, and geomorphology for the dam and reservoir modifications proposed under SLWRI action alternatives. For a more in-depth description, see the *Geologic Technical Report.*

The environmental setting for the geology, seismicity, soils/erosion, mineral resources, and geomorphology assessment of the Shasta Lake and vicinity portion of the primary study area comprises the watersheds draining to Shasta Lake and the land area forming the shoreline of Shasta Lake. Five major drainages flow into Shasta Lake and form “arms” of the lake: Big Backbone Creek, the Sacramento River, the McCloud River, Squaw Creek, and the Pit River. This section also refers to the East and West “arms” of the Main Body of Shasta Lake as Main Body East Arm and Main Body West Arm.

4.1.1 Geology

The geology of the study area is described below for both the primary and extended study areas. The bedrock geology of the study area is described in the following paragraphs. The boundaries of geomorphic provinces referenced in Section 4.1.1 are shown in Figure 4-1.

Shasta Lake and Vicinity

The Shasta Lake and vicinity portion of the primary study area is illustrated in Figure 4-2. The drainages contributing to Shasta Lake cover a broad expanse of land with a widely diverse and complicated geology. Shasta Lake is situated geographically at the interface between the Central Valley, Klamath Mountains, and Modoc Plateau and Cascades geomorphic provinces.

The bedrock geology for the Shasta Lake and vicinity area is shown in Figure 4-3. The mapping legend that accompanies Figure 4-3 is presented in Table 4-1. Shasta Lake itself and adjacent lands (i.e., Shasta Lake and vicinity) are underlain by rocks of the Klamath Mountains and, to a much more limited extent, the Modoc Plateau and Cascades geomorphic provinces. The regional topography is highly dissected, consisting predominantly of ridges and canyons with vertical relief ranging from the surface of Shasta Lake at 1,070 feet above mean sea level (msl) to ridges and promontories more than 6,000 feet above msl. This diversity in topography is primarily a result of the structural and erosional characteristics of rock units in the Shasta Lake and vicinity area.

Klamath Mountains Geomorphic Province The Klamath Mountains Geomorphic Province is located in northwestern California between the Coast Ranges on the west and the Cascade Range on the east. The Klamath Mountains consist of Paleozoic metasedimentary and metavolcanic rocks and Mesozoic igneous rocks that make up individual mountain ranges extending to the north. The Klamath Mountains Geomorphic Province consists of four mountain belts: the eastern Klamath Mountain belt, central metamorphic belt, western Paleozoic and Triassic belt, and western Jurassic belt. Low-angle thrust faults occur between the belts and allow the eastern blocks to be pushed westward and upward. The central metamorphic belt consists of Paleozoic hornblende, mica schists, and ultramafic rocks. The western Paleozoic and Triassic belt, and the western Jurassic belt consist of slightly metamorphosed sedimentary and volcanic rocks.

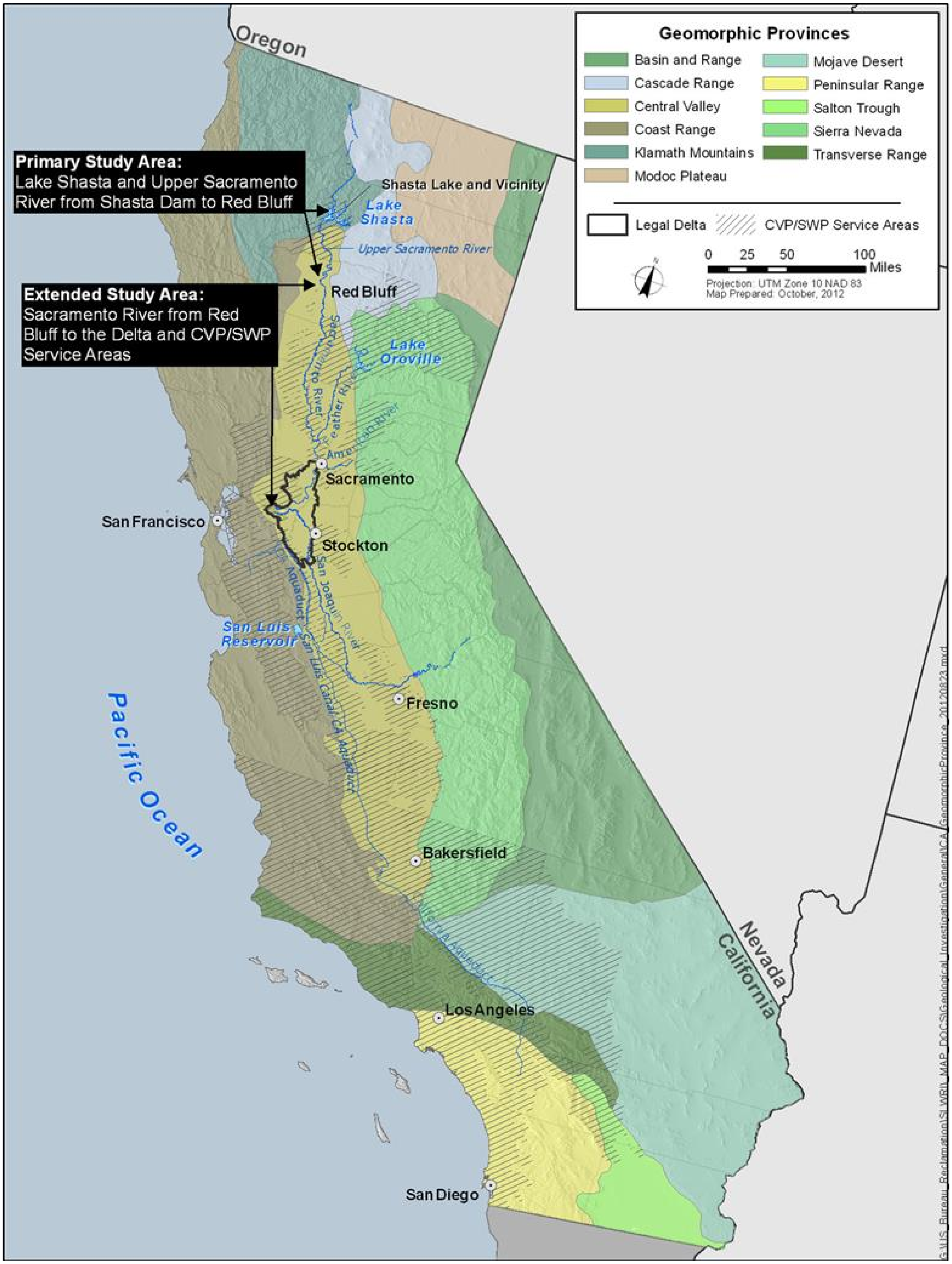

Figure 4-1. Geomorphic Provinces of California

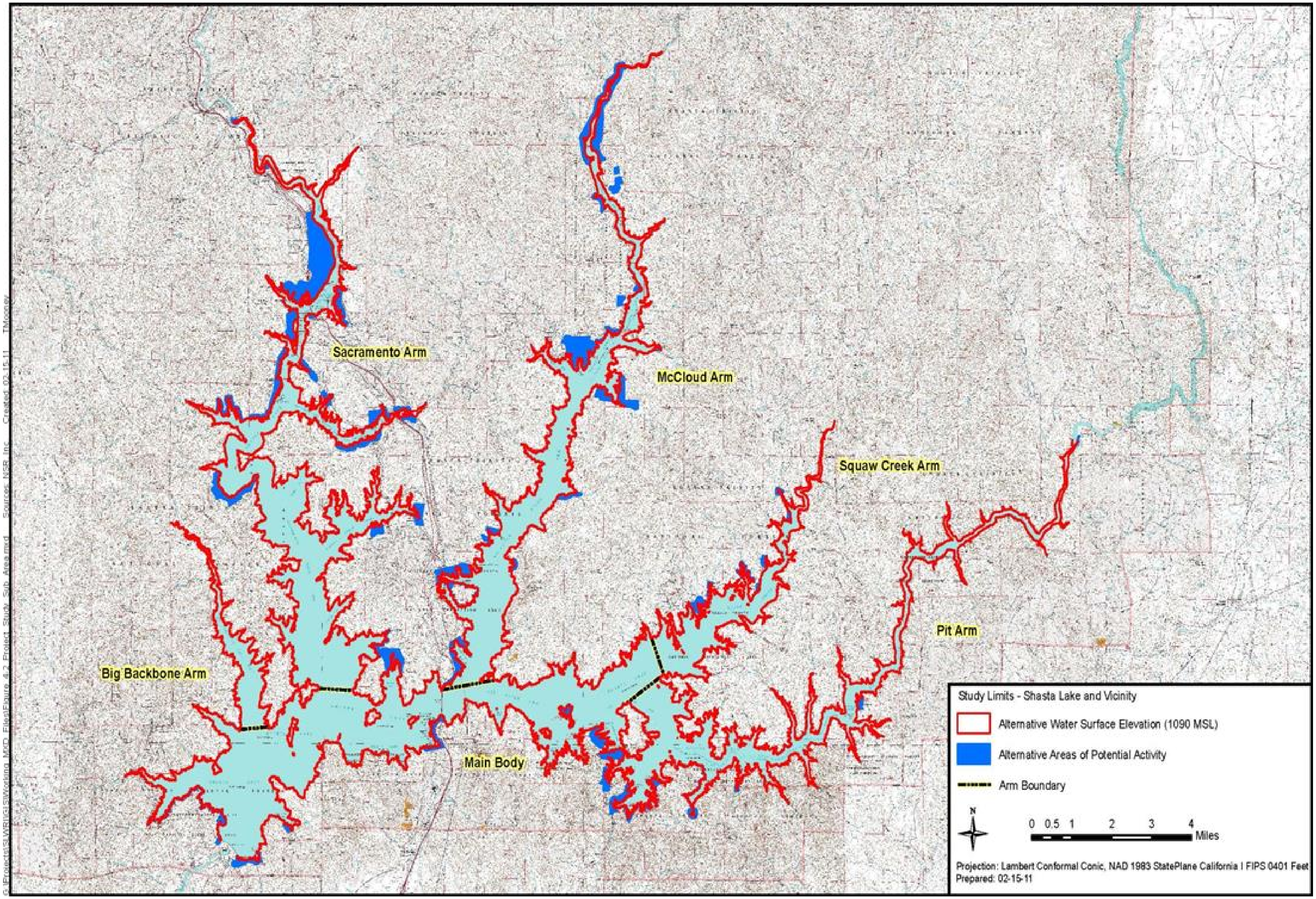

Figure 4-2. Shasta Lake and Vicinity Portion of the Primary Study Area

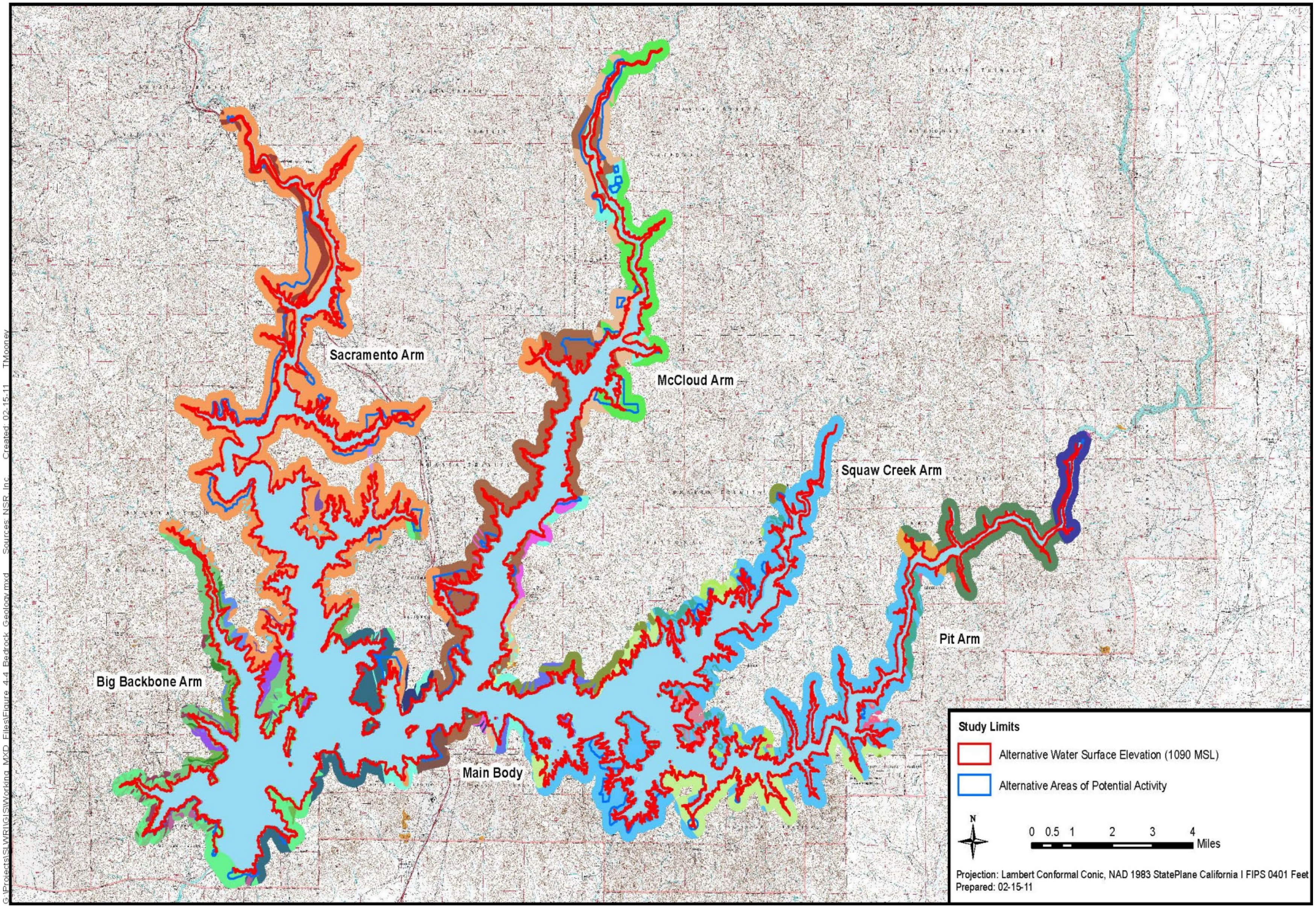

Figure 4-3. Bedrock Geology – Shasta Lake and Vicinity

Table 4-1. Key to Bedrock Geology Map Units – Shasta Lake and Vicinity

Map Unit, Formation, Description
Cb, Baird, meta-pyroclastic & keratophyre; & undiff.
Cbg, Bragdon, shale; graywacke; minor conglomerate
Cbgcp, Bragdon, chert-pebble & quartz conglomerate
Cbgp, Bragdon, pyroclastic; tuff; tuffaceous sediments
Cbgs, Bragdon, black siliceous shale
Cblss, Baird, skarn; lime silicate minerals; magnetite; locally
Cbmv, Baird, greenstone & greenstone breccia
Cbp, Baird, mafic pyroclastic rocks w/ minor tuffaceous mudsto
Db, Balaklala rhyolite, non-porphyritic & with small quartz phenocrysts (1
Dbc, Balaklala rhyolite, porphyritic with large quartz phenocrysts [>4 mm];
Dbp, Balaklala rhyolite, volcanic breccia; tuff breccia; volcanic conglomer
Dbt, Balaklala rhyolite, tuff & tuffaceous shale
Dc, Copley, greenstone; & undiff.
Dct, Copley, greenstone tuff & breccia; shaly tuff & shale
Dk, Kennett, siliceous shale & rhyolitic tuff; & undiff.
Dkls, Kennett, limestone
Dkt, Kennett, tuff; tuffaceous shale; shale
EHaev, , Andesite of Everitt Hill
Ja, Arvison, volcaniclastic & pyroclastic; & undiff.
Jp, Potem, argillite & tuffaceous sandstone; & undiff.
Pmbh, Bully Hill rhyolit, meta-andesite (quartz keratophyre); meta-dacite; p
Pmbhp, Bully Hill rhyolit, pyroclastic; tuff & tuff breccia
Pmd, , quartz diorite; albite - two pyroxene qd; mafic qd
Pmdk, Dekkas, mafic flows & tuff with minor mudstone & tuffaceou
Pmdkp, Dekkas, breccia; tuff; tuff breccia
Pmml, McCloud, limestone
Pmmls, McCloud, skarn; lime silicate minerals; magnetite; locally
Pmn, Nosoni, tuffaceous mudstone w/ lesser mafic flows; sandsto
Pmpr, Pit River stock, quartz diorite; granodiorite & plagiogranite; 261
Trh, Hosselkus Limeston, limestone; thin-bedded to massive; gray; fossilife
Trm, Modin, andesitic volcaniclastic & pyroclastic rocks; cong
Trp, Pit, shale; siltstone; metavolcanic; w/ limestone; & un
Trpmv, Pit, meta-andesite; meta-dacite; porphyritic & non-; ma
Trpp, Pit, pyroclastic; tuff & tuff breccia
Tt, Tuscan Formation, undivided: volcaniclastic; lahars; tuff; sandston
Tva, Western Cascades, andesite
Tvb, Western Cascades, basalt
di, , intermediate dikes
dia, , diabase dikes & small intrusive bodies
dpp, , plagioclase (+/- hornblende; quartz) porphyritic d
lake, , Shasta Lake; et al

A large portion of the Shasta Lake and vicinity area is underlain by rocks of the eastern Klamath Mountain belt. The strata of the eastern belt constitute a column 40,000–50,000 feet thick, and represent the time from the Ordovician period (about 490 years before present) to the Jurassic period (about 145 million years before present). The stratigraphic column of formations that compose the eastern Klamath Mountain belt, including a scale of geologic time, is shown in Table 4-2 (Hackel 1966). Important eastern belt rocks that underlie Shasta Lake and vicinity include metavolcanics of Devonian age (i.e., Copley Greenstone and Balaklala Rhyolite formations), metasedimentary rocks of Mississippian age (i.e., Bragdon Formation), thin-bedded to massive sedimentary rocks of Permian age (i.e., McCloud Limestone Formation), and metasedimentary and metavolcanic rocks of Triassic age (i.e., Pit, Modin, and Bully Hill Rhyolite formations) (Reclamation 2009). Intrusive igneous rocks (e.g., localized granitic bodies) make up fewer than 5 percent of the rocks in the area but are well represented on the Shasta Lake shoreline, particularly in the south-central area of the lake. Mesozoic intrusive dikes are scattered in the western portion of the map area.

Table 4-2. Stratigraphic Column of Formations of the Eastern Klamath Mountain Belt

Period/Age Before Present (million years)	Formation	Thickness (feet)	General Features
Jurassic (145–200)	Potem Formation	1,000	Argillite and tuffaceous sandstones, with minor beds of conglomerate, pyroclastics, and limestone.
	Bagley Andesite	700	Andesitic flows and pyroclastics.
	Arvison Formation of Sanborn (1953)	5,090	Interbedded volcanic breccia, conglomerate, tuff, and minor andesitic lava flows.
Triassic (200–250)	Modin Formation	5,500	Basal member of volcanic conglomerate, breccia, tuff, and porphyry, with limestone fragments from the Hosselkus formation.
	Brock Shale	400	Dark massive argillite interlayered with tuff or tuffaceous sandstone.
	Hosselkus Limestone	0–250	Thin-bedded to massive light-gray limestone.
	Pit Formation	2,000–4,400	Predominantly dark shale and siltstone, with abundant lenses of metadacite and quartz-keratophyre tuffs.
	Bully Hill Rhyolite	100–2,500	Lava flows and pyroclastic rocks, with subordinate hypabyssal intrusive bodies.
Permian (250–300)	Dekkas Andesite	1,000–3,500	Chiefly fragmental lava and pyroclastic rocks, but includes mudstone and tuffaceous sandstone.
	Nosoni Formation	0–2,000	Mudstone and fine-grained tuff, with minor coarse mafic pyroclastic rocks and lava.
	McCloud Limestone	0–2,500	Thin-bedded to massive light-gray limestone, with local beds and nodules of chert.

Table 4-2. Stratigraphic Column of Formations of the Eastern Klamath Mountain Belt (contd.)

Period/Age Before Present (million years)	Formation	Thickness (feet)	General Features
Carboniferous (300–360)	Baird Formation	3,000–5,000	Pyroclastic rocks, mudstone, and keratophyre flows in lower part; siliceous mudstone, with minor limestone, chert, and tuff in middle part; and greenstone, quartz, keratophyre, and mafic pyroclastic rocks and flow breccia in upper part.
	Bragdon Formation	6,000±	Interbedded shale and sandstone, with grit and chert-pebble conglomerate abundant in upper part.
Devonian (360–420)	Kennett Formation	0–400	Dark, thin-bedded, siliceous mudstone and tuff.
	Balaklala Rhyolite	0–3,500	Light-colored quartz-keratophyre flows and pyroclastics.
	Copley Greenstone	3,700+	Keratophyric and spilitic pillow lavas and pyroclastic rocks.
Silurian (420–450)	Gazelle Formation	2,400+	Siliceous graywackes, mudstone, chert-pebble conglomerate, tuff, and limestone.
Ordovician (450–490)	Duzel Formation	1,250+	Thinly layered phyllitic greywacke, locally with radiolarian chert and limestone.

The McCloud Limestone is prominently exposed within the McCloud, Pit, Main Body, and Big Backbone arms of Shasta Lake. Within the lake footprint, the McCloud Arm has the largest exposure of this limestone, followed by the Pit, Main Body, and Big Backbone arms. Along the McCloud Arm, this limestone crops out on the eastern shore from the mouth at the main body of the lake to Hirz Bay. Above Hirz Bay, it is intermittently exposed on both sides of the McCloud Arm. Along the Pit Arm near the mouth of Brock Creek, the McCloud Limestone is exposed along the north and southern banks. The McCloud Limestone is exposed near the southern shore of Allie Cove in the eastern portion of the Main Body of the lake. Along the Big Backbone Arm, the McCloud Limestone is exposed near the eastern shore between the outlets of Shoemaker and Limerock creeks. Outside the Shasta Lake footprint, an outcrop of the McCloud Limestone is exposed along the McCloud River approximately 10 miles upstream from the mouth into the McCloud Arm. The McCloud Limestone is also exposed on the north side of Bohemotash Mountain, which is approximately 2 miles from the mouth of Big Backbone Creek at the Big Backbone Arm.

“Skarn” is a geologic term that refers to metamorphic rocks formed in the contact zone of magmatic intrusions (e.g., granite) with carbonate-rich rocks (e.g., limestone). Skarn deposits are rich in lime-silicate minerals and locally contain magnetite. Permian-aged skarn deposits are present within the McCloud Arm. The deposits are located near the mouths of Marble and Potter creeks and on the peninsula at the eastern margin of the inlet of the McCloud Arm. The skarn deposits occur adjacent to the McCloud Limestone at the mouths of Marble and Potter creeks, but the McCloud Limestone is absent near skarn deposits on the peninsula.

A small area of the fossiliferous Cretaceous Chico Formation, consisting of Great Valley marine sedimentary rocks, occurs near Jones Valley Creek, a tributary to the Pit Arm. Although this rock unit occurs in the immediate vicinity, it is not exposed along the shoreline of the lake and falls outside the Shasta Lake and vicinity area. Some outcrops of McCloud Limestone, especially in the vicinity of the McCloud River Bridge, are also fossiliferous.

Modoc Plateau and Cascades Geomorphic Provinces The Cascade Range and Modoc Plateau together cover approximately 13,000 square miles in the northeast corner of California. The Cascade Range and Modoc Plateau (collectively the Modoc Plateau and Cascades Geomorphic Province) are very similar geologically and consist of young volcanic rocks that are of Miocene to Pleistocene age. Included in this province are two composite volcanoes, Mount Shasta and Lassen Peak, and the Medicine Lake Highlands, a broad shield volcano.

The Cascade volcanics have been divided into the Western Cascade series and the High Cascade series. The Western Cascade series rocks consist 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. After a short period of uplift and erosion that extended into the Pliocene, volcanism resumed creating the High Cascade volcanic series. The High Cascade series forms a belt 40 miles wide and 150 miles long just east of the Western Cascade series rocks. Early High Cascade rocks formed from very fluid basalt and andesite that extruded from fissures to form low shield volcanoes. Later eruptions during the Pleistocene contained more silica, causing more violent eruptions. Large composite cones like Mount Shasta and Lassen Peak had their origins during the Pleistocene (Norris and Webb 1990).

The Modoc Plateau 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 otherwise 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.

Volcanic rocks of the Modoc Plateau and Cascades Geomorphic Province are present adjacent to the eastern and northeastern boundaries of the Shasta Lake and vicinity area. In the vicinity of Shasta Lake they occur near the Pit Arm and along the upper Sacramento Arm. These rocks are generally younger than 4 million years old. Volcaniclastic rocks, mudflows, and tuffs of the Tuscan Formation occur in the Pit River area, and localized volcanic deposits occur in isolated locations.

The areal extent of bedrock types within the Shasta Lake and vicinity area is presented in Table 4-3 for the portion of the area between 1,070 feet and 1,090 feet above msl (i.e., Impoundment Area), and in Table 4-4 for the portion potentially disturbed by construction activities (i.e., Relocation Areas).

Table 4-3. Areal Extent of Bedrock Types – Shasta Lake and Vicinity (Impoundment Area)

Map Unit	Formation	Bedrock Types	Acres	% of Total Impoundment Area
Cb	Baird	Meta-pyroclastic and keratophyre	145.3	5.82%
Cbg	Bragdon	Shale; graywacke; minor conglomerate	468.9	18.77%
Cbgcp	Bragdon	Chert-pebble and quartz conglomerate	3.3	0.13%
Cbgs	Bragdon	Black siliceous shale	0.0	0.00%
Cblss	Baird	Skarn; lime silicate minerals	1.2	0.05%
Cbmv	Baird	Greenstone and greenstone breccia	6.7	0.27%
Cbp	Baird	Mafic pyroclastic rocks	4.8	0.19%
Db	Balaklala rhyolite	Non-porphyritic and with small quartz phenocrysts	52.8	2.11%
Dbc	Balaklala rhyolite	Porphyritic with large quartz phenocrysts	3.3	0.13%
Dbp	Balaklala rhyolite	Volcanic breccia; tuff breccia; volcanic conglomer	12.9	0.52%
Dbt	Balaklala rhyolite	Tuff and tuffaceous shale	5.9	0.24%
Dc	Copley	Greenstone and undiff.	48.9	1.96%
Dct	Copley	Greenstone tuff & breccia	33.4	1.34%
di		Intermediate dikes	0.6	0.02%
dia		Diabase dikes	0.2	0.01%
Dk	Kennett	Siliceous shale and rhyolitic tuff	20.0	0.80%
Dkls	Kennett	Limestone	1.9	0.07%
Dkt	Kennett	Tuff; tuffaceous shale; shale	11.2	0.45%
dpp		Plagioclase	0.7	0.03%
Ehaev		Andesite	17.9	0.72%
Ja	Arvison	Volcaniclastic and pyroclastic	9.6	0.38%
lake	Shasta Lake		924.0	36.99%
Pmbh	Bully Hill rhyolite	Meta-andesite	84.6	3.39%
Pmbhp	Bully Hill rhyolite	Pyroclastic; tuff & tuff breccia	11.0	0.44%

Table 4-3. Areal Extent of Bedrock Types – Shasta Lake and Vicinity (Impoundment Area) (contd.)

Map Unit	Formation	Bedrock Types	Acres	% of Total Impoundment Area
Pmd		Quartz diorite	47.5	1.90%
Pmdk	Dekkas	Mafic flows and tuff	18.9	0.76%
Pmdkp	Dekkas	Breccia; tuff; tuff breccia	16.7	0.67%
Pmml	McCloud	Limestone	26.7	1.07%
Pmmls	McCloud	Skarn; lime silicate minerals; magnetite	2.2	0.09%
Pmn	Nosoni	Tuffaceous mudstone	66.4	2.66%
Pmpr	Pit River Stock	Quartz diorite; granodiorite	11.2	0.45%
Trh	Hosselkus Limestone	Limestone; thin-bedded to massive; gray; fossilife	7.5	0.30%
Trm	Modin	Andesitic volcaniclastic and pyroclastic rocks	27.9	1.12%
Trp	Pit	Shale; siltstone; metavolcanic; wi limestone	374.8	15.00%
Trpmv	Pit	Meta-andesite; meta-dacite	12.0	0.48%
Trpp	Pit	Pyroclastic; tuff and tuff breccia	16.6	0.66%
Tva	Western Cascades	Andesite	0.5	0.02%

Table 4-4. Areal Extent of Bedrock Types – Shasta Lake and Vicinity (Relocation Areas)

Map Unit	Formation	Bedrock Types	Acres	% of Total Relocation Area
Cb	Baird	Meta-pyroclastic and keratophyre	530.8	15.90%
Cbg	Bragdon	Shale; graywacke; minor conglomerate	1,088.4	32.59%
Cbgcp	Bragdon	Chert-pebble and quartz conglomerate	0.6	0.02%
Cbmv	Baird	Greenstone & greenstone breccia	25.6	0.77%
Db	Balaklala rhyolite	Non-porphyritic and with small quartz phenocrysts	9.8	0.29%
Dbc	Balaklala rhyolite	Porphyritic with large quartz phenocrysts	7.8	0.23%
Dbp	Balaklala rhyolite	Volcanic breccia; tuff breccia; volcanic conglomer	3.9	0.12%
Dbt	Balaklala rhyolite	Tuff and tuffaceous shale	1.1	0.03%
Dc	Copley	Greenstone and undiff.	61.5	1.84%
Dct	Copley	Greenstone tuff and breccia	84.9	2.54%

Table 4-4. Areal Extent of Bedrock Types – Shasta Lake and Vicinity (Relocation Areas) (contd.)

Map Unit	Formation	Bedrock Types	Acres	% of Total Relocation Area
Dk	Kennett	Siliceous shale and rhyolitic tuff	10.3	0.31%
Dkls	Kennett	Limestone	0.4	0.01%
Dkt	Kennett	Tuff; tuffaceous shale; shale	0.0	0.00%
Ehaev		Andesite	261.4	7.83%
Ja	Arvison	Volcaniclastic and pyroclastic	0.7	0.02%
lake	Shasta Lake		242.0	7.25%
Pmbh	Bully Hill rhyolite	Meta-andesite	53.0	1.59%
Pmbhp	Bully Hill rhyolite	Pyroclastic; tuff and tuff breccia	7.5	0.22%
Pmd		Quartz diorite	100.5	3.01%
Pmdk	Dekkas	Mafic flows and tuff	8.8	0.26%
Pmdkp	Dekkas	Breccia; tuff; tuff breccia	18.5	0.55%
Pmml	McCloud	Limestone	174.9	5.24%
Pmn	Nosoni	Tuffaceous mudstone	182.5	5.46%
Pmpr	Pit River Stock	Quartz diorite; granodiorite	42.8	1.28%
Trp	Pit	Shale; siltstone; metavolcanic; wi limestone	408.5	12.23%
Trpp	Pit	Pyroclastic; tuff and tuff breccia	11.5	0.34%
Tva	Western Cascades	Andesite	2.0	0.06%

Cave and Karst Resources

Karst geomorphology is named after the Karst region in Slovenia, where limestone has been geologically carved into world-famous caves and other karst landforms. Caves and karst landforms are found along the Big Backbone Arm, the McCloud Arm, and the Pit Arm (Brock Creek).

Nine caves in the National Recreation Area (NRA) adjacent to Shasta Lake—Dekkas Rock Staircase Cave, Lake Level Cave, Clay Doe Cave, Jolly Time Cave, Blanchet Cave, two caves known as the McCloud Bridge Caves, and two caves known as the Town Mountain Caves—could be periodically inundated under the five comprehensive plans (USFS 2012). The first three of these caves are registered under the Federal Cave Resource Protection Act of 1988. Dekkas Rock Staircase and the two McCloud Bridge caves are already periodically inundated under the current elevation of the dam. Field investigations performed to date have not identified any other caves that would be affected by the raising of Shasta Dam.

Upper Sacramento River (Shasta Dam to Red Bluff)

The portion of the study area along the Sacramento River downstream to the Red Bluff Pumping Plant encompasses portions of the Cascade Range, Klamath Mountains, and Central Valley Geomorphic Provinces.

Central Valley Geomorphic Province The Central Valley Geomorphic Province is a large, asymmetrical, northwest-trending, structural trough formed between the uplands of the California Coast Ranges to the west and the Sierra Nevada to the east, and is approximately 400 miles long and 50 miles wide (Page 1985). The Coast Ranges to the west are made up of pre-Tertiary and Tertiary semiconsolidated to consolidated marine sedimentary rocks. The Coast Ranges sediments are folded and faulted and extend eastward beneath most of the Central Valley. The Sierra Nevada to the east side of the valley is composed of pre-Tertiary igneous and metamorphic rocks.

Along the western side of the Sacramento Valley, rocks of the Central Valley Geomorphic Province include Upper Jurassic to Cretaceous marine sedimentary rocks of the Great Valley Sequence; fluvial deposits of the Tertiary Tehama Formation; Quaternary Red Bluff, Riverbank, and Modesto Formations; and Recent alluvium.

The Great Valley Sequence was formed from sediments deposited within a submarine fan along the continental edge. The sediment sources were the Klamath Mountains and Sierra Nevada to the north and east, and include mudstones, sandstones, and conglomerates.

Tertiary and Quaternary fluvial sedimentary deposits unconformably overlie the Great Valley Sequence. The Pliocene Tehama Formation is the oldest, derived from erosion of the Coast Ranges and Klamath Mountains, and consists of pale green to tan semiconsolidated silt, clay, sand, and gravel. Along the western margin of the valley, the Tehama Formation is generally thin, discontinuous, and deeply weathered.

The Red Bluff Formation is a broad erosional surface, or pediment, of low relief formed on the Tehama Formation between 0.45 and 1.0 million years ago. Thickness varies to about 30 feet.

Recent alluvium consists of loose sedimentary deposits of clay, silt, sand, gravel, and boulders. The deposits may originate from landslides, colluvium, stream channel deposits, and floodplain deposits. Landslides occur along the project area but are generally small, shallow debris slides or debris flows.

Stream channel deposits generally consist of unconsolidated sand and gravel, with minor amounts of silt and clay. Floodplain deposits are finer grained and consist almost entirely of silt and clay (DWR 2003).

Lower Sacramento River and Delta

The study area along the lower Sacramento River and the Delta encompasses the Central Valley Geomorphic Province, as described above for the upper Sacramento River portion of the primary study area.

The Delta is a broad depression in the Franciscan bedrock that resulted from an east-west expansion of the San Andreas and Hayward fault systems, filled by sediments deposited over many millions of years via the Sacramento and San Joaquin rivers and other tributary rivers and streams.

CVP/SWP Service Areas

The CVP/SWP service areas encompass portions of the Central Valley, Sierra Nevada, Coast Ranges, Cascade Range, Peninsular Ranges, Transverse Ranges, Mojave Desert, Modoc Plateau, and Klamath Mountains geomorphic provinces.

The south-of-Delta CVP/SWP service areas include two distinct, noncontiguous areas. In the north are the San Felipe Division's CVP service area and the South Bay SWP service area; to the south are the SWP service areas. The northern section of this region encompasses the Coast Ranges Geomorphic Province and the southern portion of this section includes portions of the Peninsular Ranges, Transverse Ranges, and Mojave Desert geomorphic provinces. Additional information on the geomorphic provinces is available in the *Geologic Technical Report*.

4.1.2 Geologic Hazards

Geologic hazards are described below for both the primary and extended study areas.

Shasta Lake and Vicinity

Six types of geologic hazards have the potential to occur within and near the Shasta Lake and vicinity portion of the primary study area: seismic hazards, volcanic eruptions and associated hazards, mudflows, snow avalanches, slope instability, and seiches.

Seismic Hazards Seismic hazards consist of the effects of ground shaking and surface rupture along and around the trace of an active fault. Ground shaking is the most hazardous effect of earthquakes because it is the most widespread and accompanies all earthquakes. Ground shaking can range from high to low intensity and is often responsible for structural failure, leading to the largest loss of life and property damage during an earthquake. The Modified Mercalli intensity ratings reflect the relationship between earthquake magnitudes and shaking intensity. Higher magnitude earthquakes typically produce higher shaking intensities over wider areas, which may result in greater damage.

Surface rupture occurs when an earthquake results in ground rupture, causing horizontal and/or vertical displacement. Surface rupture typically is narrow in rock and wider in saturated soils, and also typically tends to occur along previous fault lines.

An active fault is defined by the Alquist-Priolo Earthquake Fault Zoning Act as a fault that has caused surface rupture within the last 11,000 years. The nearest active fault to the southern portion of the Shasta Lake and vicinity area is the Battle Creek Fault Zone, located approximately 27 miles south of Shasta Dam (CDMG 2006a). The maximum credible earthquake for the southern portion of the Shasta Lake and vicinity area has a moment magnitude of 7.3. A maximum peak ground acceleration of 0.101*g*[1] was calculated for the southern portion of the Shasta Lake and vicinity area based on an earthquake moment magnitude of 6.5 from the Battle Creek Fault Zone. The Northeastern California Fault system, located approximately 28 miles south of Shasta Dam, may be capable of causing the highest ground shaking at the site. A maximum peak ground acceleration of 0.126*g* was calculated for the Shasta Dam location.

According to the California Geological Survey's Alquist-Priolo Act Active Fault Maps, the nearest active fault north of the Shasta Lake and vicinity area is the Hat Creek–Mayfield–McArthur Fault Zone, located about 50 miles to the northeast of Shasta Dam (Jennings 1975). This fault zone is composed of numerous parallel north-northwest–trending normal faults. According to the Alquist-Priolo Act maps, the Hat Creek–Mayfield–McArthur Fault is capable of generating magnitude 7.0 earthquakes with a relatively long return period of 750 years (Petersen et al. 1996).

Other earthquake fault zones within or near the Shasta Lake and vicinity area include the following:

- Pittville Fault located in portions of the Day Bench
- Rocky Ledge Fault located north of Burney in Long Valley and east of Johnson Park

Northeast of the Shasta Lake and vicinity area, portions of Shasta and Siskiyou counties include the area between Lassen Peak and the Medicine Lake Highlands. This area is cut by a series of active normal faults that are part of the Sierra Nevada–Great Basin dextral shear zone (Shasta County 2004). These faults are capable of affecting the upper watersheds northeast of the Sacramento Valley. These faults include the previously mentioned Hat Creek–Mayfield–McArthur Fault Zone, the Gillem-Big Crack faults near the California-Oregon border southeast of Lower Klamath Lake, and the Cedar Mountain Fault southwest of Lower Klamath Lake. The faults in this zone are capable of earthquakes up to magnitude 7.0. Farther northeast, the Likely Fault is judged capable of a magnitude 6.9 earthquake. In the northeast corner of the state, the Surprise Fault is capable of a magnitude 7.0 earthquake.

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[1] Peak ground acceleration is expressed in units of "*g*," the acceleration caused by Earth's gravity. Thus, 1*g* = 9.81 meters per second squared (i.e., m/s^2).

Seismic activity has been reported in the area of Shasta Dam and Shasta Lake, and has typically been in the 5.0 magnitude or lower range. The nearest seismic activity to Shasta Dam and Shasta Lake was a magnitude 5.2 earthquake that occurred 3 miles northwest of Redding, near Keswick Dam, in 1998 (Petersen 1999).

Volcanic Eruptions and Associated Hazards Volcanic hazards include potential eruptions, and their products and associated hazards. In the Shasta Lake and vicinity area these include lava flows, pyroclastic flows, domes, tephra, and mudflows and floods triggered by eruptions. Three active centers of volcanic activity, all associated with the Modoc Plateau and Cascades Geomorphic Province, occur near enough to the Shasta Lake and vicinity area to merit discussion: the Medicine Lake Highlands, Lassen Peak, and Mount Shasta.

The Medicine Lake Highlands is located approximately 65 air miles northeast of Shasta Lake and includes a broad shield volcano that has a large caldera at its summit and more than 100 smaller lava cones and cinder cones on its flanks. The volcano developed over a period of 1 million years, mainly through lava flows. The most recent activity was approximately 500 years ago, when a large tephra eruption was followed by an extrusion of obsidian. Volcanic activity is likely to persist in the future (USFS 1994), specifically as local lava flows and tephra eruptions.

Lassen Peak lies 50 miles southeast of Shasta Lake. Lassen Peak is a cluster of dacitic domes and vents that have formed over the past 250,000 years. The most recent eruption occurred in 1914. That eruption began as a tephra eruption with steam blasts, and climaxed with a lateral blast, hot avalanches, and mudflows. Most ash from the 1914 eruption was carried to the east of the volcano.

The most prominent, active volcanic feature in the vicinity of Shasta Lake is Mount Shasta, which is located approximately 45 miles north of Shasta Lake. Mount Shasta has erupted at least once per 800 years during the last 10,000 years, and about once per 600 years during the last 4,500 years. Mount Shasta last erupted in 1786. Eruptions during the last 10,000 years produced lava flows and domes on and around the flanks of Mount Shasta. Pyroclastic flows extended up to 12 miles from the summit. Most of these eruptions also produced mudflows, many of which reached tens of miles from Mount Shasta.

Eruptions of Mount Shasta could endanger the communities of Weed, Mount Shasta, McCloud, and Dunsmuir. Such eruptions will most likely produce deposits of lithic ash, lava flows, domes, and pyroclastic flows that may affect low- and flat-lying ground almost anywhere within 12 miles of the summit. However, on the basis of its past behavior, Mount Shasta is not likely to erupt large volumes of pumiceous ash (tephra) in the future. Areas subject to the greatest risk from air-fall tephra are located mainly east and within about 30 miles of the summit (Miller 1980).

Floods commonly are produced by melting of snow and ice during eruptions of ice-clad volcanoes like Mount Shasta, or by heavy rains that may accompany eruptions. By incorporating river water as they move down valleys, mudflows may grade into slurry floods carrying unusually large amounts of rock debris. Eruption-caused floods can occur suddenly and can be of large volume. If floods caused by an eruption occur when rivers are already high, floods far larger than normal can result. Streams and valley floors around Mount Shasta could be affected by such floods as far downstream as Shasta Lake. The danger from floods caused by eruptions is similar to that from floods having other origins, but floods caused by eruptions may be more damaging because of a higher content of sediment that would increase the bulk specific gravity of the fluid (Miller 1980).

Mudflows Small mudflows not caused by eruptions are common at Mount Shasta. Relatively small but frequent mudflows have been produced historically (1924, 1926, 1931, and 1977) by melting of glaciers on Mount Shasta during warm summer months. Mudflows that occurred during the summer of 1924 entered the McCloud River and subsequently flowed into the Sacramento River (Miller 1980).

Snow Avalanches Avalanche hazards near the Shasta Lake and vicinity area typically occur in steep, high-elevation terrane. These areas are generally above the tree line or in sparsely vegetated areas. Significant avalanche areas are limited to locations on the upper slopes outside of the Shasta Lake and vicinity area.

Slope Instability (Mass Wasting) Slope instability hazards occur in areas of active and relict mass wasting features (e.g., active and relict landslides, debris flows, inner gorge landscape positions, and complexes of these features). Slope instability hazards occur throughout the Shasta Lake and vicinity area, and are most common in areas of steep topography. Locations in the Shasta Lake and vicinity area of mapped slope instability hazards are shown in Figure 4-4.

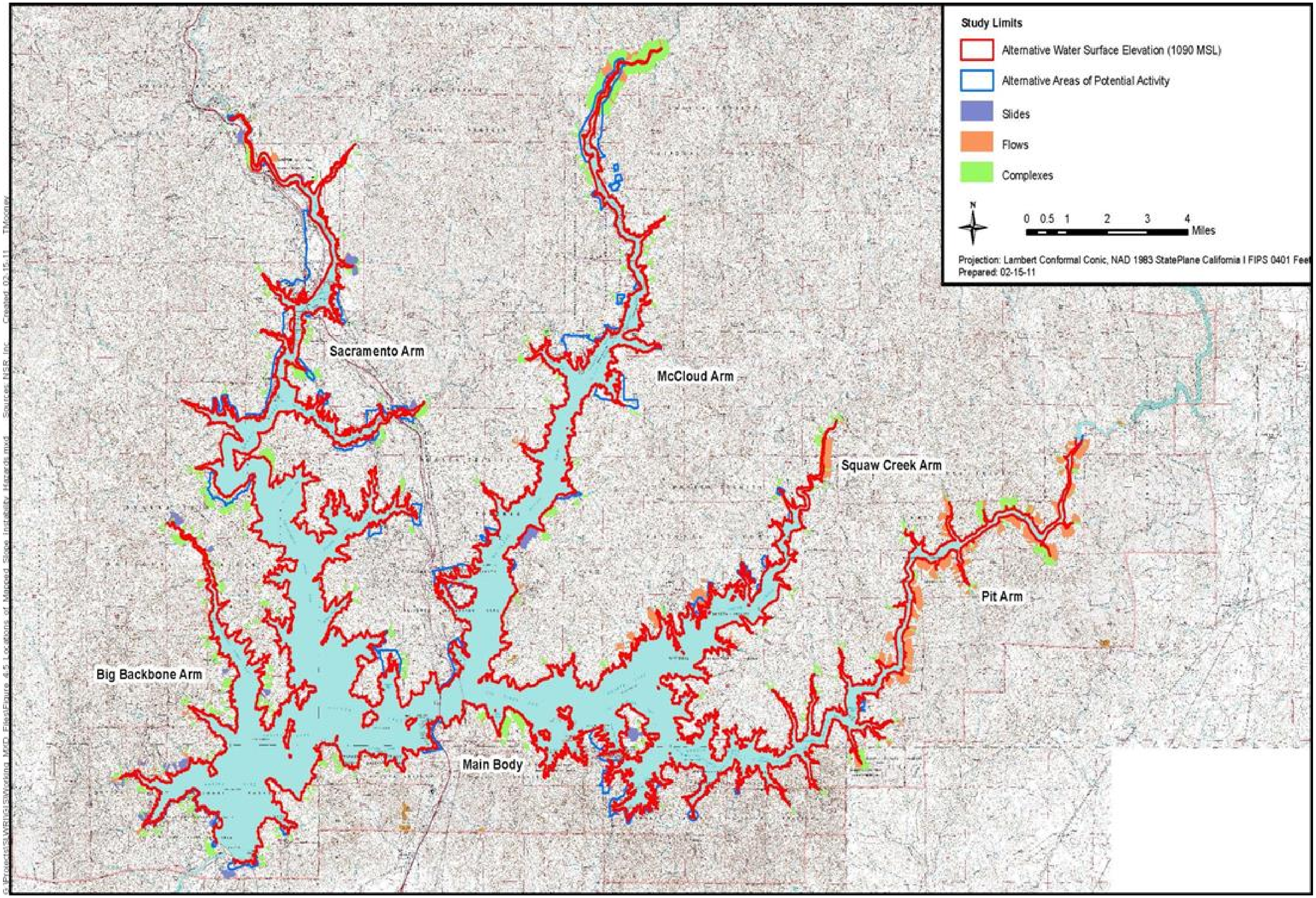


Figure 4-4. Locations of Mapped Slope Instability Hazards – Shasta Lake and Vicinity

The terrane underlying the Shasta Lake and vicinity area and the surrounding region has been influenced by a combination of tectonic uplift, mass wasting, and fluvial and surface erosion processes. The influence of these processes is ongoing, with evidence of ancient and more recent mass wasting features over the entire area, consisting of debris slides, torrents, and flows, with lesser amounts of rotational/translational landslides. The extent or distribution of mass wasting features across the region is believed not to have changed appreciably as a result of land use activities following Anglo-American settlement (USFS 1998).

Much of the topography in the general vicinity of Shasta Lake is steep, with concave swales; therefore, landslides are relatively common, ranging from small mudflows and slumps to large debris slides, debris flows, and inner gorge landslides. Small shallow debris slides associated with localized alluvial/colluvial rock units occur along the shoreline of Shasta Lake. Rockslides caused by mining activities have also occurred on the slopes surrounding Shasta Lake.

The areal extent of mapped slope instability hazards in the Shasta Lake and vicinity area is presented in Table 4-5 for the portion of the area between 1,070 feet and 1,090 feet above msl (Impoundment Area), and in Table 4-6 for the portion potentially disturbed by construction activities under the action alternatives (Relocation Areas). About 173 acres (7 percent) of the Impoundment Area is occupied by features that are potentially unstable. Potentially unstable features occupy about 232 acres (7 percent) of the Relocation Area. Most of the mapped slope instability hazards are debris flows.

Table 4-5. Areal Extent of Mapped Slope Instability Hazards – Shasta Lake and Vicinity (Impoundment Area)

Map Unit	Formation	Acres	% of Impoundment Area Acreage
1050	Slides	9.5375	0.38%
1100	Flows	66.6091	2.67%
1200	Complexes	97.1695	3.89%

Table 4-6. Areal Extent of Mapped Slope Instability Hazards – Shasta Lake and Vicinity (Relocation Areas)

Map Unit	Formation	Acres	% of Relocation Area Acreage
1050	Slides	2.9947	0.09%
1100	Flows	52.9767	1.59%
1200	Complexes	175.8020	5.26%

Seiches A seiche is an oscillation of a body of water in an enclosed or semienclosed basin that varies in period, depending on the physical dimensions of the basin, from a few minutes to several hours, and in height from a few millimeters to a few meters. Seiches arise chiefly as a result of sudden local changes in atmospheric pressure, aided by wind and occasionally tidal currents. Seiches can also be triggered by strong earthquake ground motion or large landslides entering a body of water.

If Mount Shasta were to erupt again, volcanic ash could fall in the study area, though as described previously, Mount Shasta is not likely to erupt large volumes of pumiceous ash (tephra) in the future. Minor seiches in Shasta Lake also could be generated by debris flows in the arms of the lake where its tributaries enter (City of Redding 2000). A large megathrust on the Cascadia subduction zone off the Pacific coast could generate enough ground shaking to generate a seiche in Shasta Lake.

Regardless of its cause, the effects of a seiche would depend on the local conditions at the time. If the reservoir were filled to capacity, there may be some overspill by way of the dam spillways. Substantial overtopping of the dam itself is extremely unlikely, as such an event would require a seiche more than 6 meters high, even if the reservoir were filled to capacity. Excess flows into the Sacramento River triggered by a seiche in Shasta Lake would be attenuated by Keswick Reservoir (City of Redding 2000).

Upper Sacramento River (Shasta Dam to Red Bluff)

The upper Sacramento River portion of the primary study area could potentially be affected by geologic hazards in the region attributed to seismic hazards and volcanic eruptions and associated hazards. Mudflows, snow avalanches, slope instability, and seiches are not considered geologic hazards in this portion of the primary study area.

Seismic Hazards The northeastern area of Shasta County is part of an area between Lassen Peak and the Medicine Lake Highlands (in Siskiyou County), which is cut by a series of active normal faults that are part of the Sierra Nevada–Great Basin dextral shear zone (Shasta County 2004). These faults are likely to affect the upper watersheds northeast of the Sacramento Valley. These faults include the Mayfield–MacArthur–Hat Creek faults, 25–85 miles north of Lake Almanor; the Gillem–Big Crack Faults, near the California-Oregon border southeast of Lower Klamath Lake; and the Cedar Mountain Fault, southwest of Lower Klamath Lake. The faults in this zone are capable of earthquakes up to magnitude 7.0.

Shasta County is a seismically active region but has not experienced significant property damage or loss of life from earthquakes in the past 120 years. The City of Redding (2005) reported that maximum recorded intensities have reached Modified Mercalli VII. The majority of intense seismic activity in Shasta County has occurred in the eastern half of the county, around Lassen Peak (City of Redding 2005).

The *Shasta County General Plan* states that the maximum intensity event expected to occur in eastern Shasta County is Modified Mercalli VIII (Shasta

County 2004). In the western half of Shasta County, the maximum intensity event is expected to be Modified Mercalli VII (City of Redding 2005). Shasta County is entirely within Seismic Zone 3 of the Uniform Building Code. Redding is an area of "moderate seismicity" and the Hat Creek and McArthur areas are of "moderate-to-high seismicity" (Shasta County 2004).

South of Shasta County along the upper Sacramento River, potential surface faulting could be associated with the Great Valley thrust fault system, which is capable of earthquakes up to magnitude 6.8 along the west side of the Sacramento Valley. This fault system forms the boundary between the Coast Ranges and the Sacramento and San Joaquin valleys.

The San Andreas Fault system is located west of the Sacramento and San Joaquin valleys and is made up of a series of faults that lie along a 150-mile-long northwest-trending zone of seismicity. This zone is 10–45 miles west of the Sacramento Valley and extends from Suisun Bay past Lake Berryessa and Lake Pillsbury to near the latitude of Red Bluff. The Green Valley, Hunting Creek, Bartlett Springs, Round Valley, and Lake Mountain faults are the mapped active faults of the San Andreas Fault system most likely to affect the upper watersheds west of the Sacramento Valley. The faults in this system are capable of earthquakes up to 7.1 in magnitude.

The Indian Valley Fault, located southeast of Lake Almanor, and the Honey Lake Fault zone, located east of Lake Almanor, are likely to affect the upper watersheds east of the Sacramento Valley and are capable of a magnitude 6.9 earthquake. Surface rupture occurred in 1975 along the Cleveland Hill Fault south of Lake Oroville. The Foothills Fault system, which borders the east side of the Sacramento and San Joaquin valleys, is judged to be capable of a magnitude 6.5 earthquake.

Volcanic Eruptions and Associated Hazards Shasta County is at the southern end of the Cascade Range (as described above for the geology of the upper Sacramento River). The most recent volcanic activity in Shasta County occurred between 1914 and 1917, when Lassen Peak erupted, producing lava flows, numerous ash falls, and a large mudflow. The mudflow, a result of melting snow and ash, flowed down Lost Creek and Hat Creek (Shasta County 2004).

It is unlikely that a large mudflow from Mount Shasta would endanger Shasta County (Shasta County 2004).

Lower Sacramento River and Delta

The lower Sacramento River and Delta portion of the extended study area could potentially be affected by geologic hazards in the region attributed to seismic hazards. Volcanic eruptions and associated hazards, mudflows, snow avalanches, slope instability, and seiches are not considered geologic hazards in this portion of the extended study area.

The nearest active fault to the lower Sacramento River below Red Bluff is the Dunnigan Hills Fault, which has experienced fault displacement within the last 10,000 years (Jennings 1994). The Dunnigan Hills Fault runs along the Sacramento River and is located between 6 and 10 miles west of the river near the town of Dunnigan. The Cleveland Fault is located approximately 30 miles east of the Sacramento River near the city of Oroville. In addition, the Great Valley thrust fault system and San Andreas fault system extend along the Sacramento River to the west, as described above for the upper Sacramento River portion of the primary study area.

Failure of Delta levees is the primary threat to the region as a result of seismic activity. The Delta levees are located in a region of relatively low seismic activity compared to the San Francisco Bay Area (Bay Area). The major strike-slip faults in the Bay Area (the San Andreas, Hayward, and Calaveras faults) are located more than 16 miles from the Delta. The less active Green Valley and Marsh Creek–Clayton faults are more than 9 miles from the Delta. Small but significant local faults are situated in the Delta, and there is a possibility that blind thrust faults occur along the west Delta.

CVP/SWP Service Areas

The CVP/SWP service areas portion of the extended study area could potentially be affected by geologic hazards in the region attributed to seismic hazards. Volcanic eruptions and associated hazards, mudflows, snow avalanches, slope instability, and seiches are not considered geologic hazards in this portion of the extended study area. A number of active faults exist along the Sacramento and San Joaquin rivers in the CVP/SWP service areas.

Major earthquake activity has centered along the San Andreas Fault zone, including the great San Francisco earthquake of 1906 in the Bay Area. Since that earthquake, four events of magnitude 5.0 on the Richter scale or greater have occurred in the Bay Area. The San Andreas and Hayward faults remain active, with evidence of recent slippage along both faults.

In the San Joaquin River region, the Great Valley thrust fault system forms the boundary between the Coast Ranges and the west boundary of the San Joaquin Valley. This fault system is capable of earthquakes up to magnitude 6.7 along the west side of the San Joaquin Valley.

Active faults likely to affect the upper watersheds at the end of the San Joaquin Valley include the White Wolf Fault, which ruptured in 1952 with a magnitude 7.2 earthquake; the Garlock Fault, capable of a magnitude 7.3 earthquake; and several smaller faults 10–30 miles north of the White Wolf Fault.

A list of all of the reported faults, fault zones, and systems, according to the California Geological Survey, that are located south of the Delta in the CVP/SWP service areas is presented in the California Public Resources Code, in Division 2, "Geology, Mines and Mining," Chapter 7.5, "Earthquake Fault Zoning" (CDMG 2006a).

4.1.3 Geomorphology

Geomorphology in the study area is described below for both the primary and extended study areas.

Shasta Lake and Vicinity

As described previously, most of the Shasta Lake and vicinity area is within the Klamath Geomorphic Province. The topography of the study area ranges from moderate to steep, and elevation ranges from approximately 1,070 feet to more than 6,000 feet above msl. The orientation and slopes of the ridges are controlled by the bedrock geology and structure. Generally speaking, the eastern slopes of the ridges are steeper than the western slopes. Hillslope gradient in the Shasta Lake and vicinity area ranges from 0 percent to more than 100 percent.

The regional stream network and boundaries of watersheds adjacent to Shasta Lake are shown in Figure 4-5. The boundaries of watersheds adjacent to Shasta Lake (shown in Figure 4-5) are the same as the boundaries of the area's sixth Field Hydrologic Unit Code watersheds defined by USFS.

Regional-scale characteristics of the streams that are tributary to Shasta Lake are presented in Figure 4-6, where they are organized by arm. The total area of watersheds draining to the lake on a regional scale is 6,665 square miles. Of this total, watersheds that are immediately adjacent and contribute directly to Shasta Lake (i.e., 6th Field Hydrologic Unit Code watersheds) occupy about 512 square miles (Table 4-7). These immediately adjacent watersheds include small portions of the five major tributaries to Shasta Lake (Big Backbone Creek, the Sacramento and McCloud rivers, Squaw Creek, and the Pit River) and small watersheds that are adjacent and directly contributory to the Main Body of the lake.

In general, the stream networks adjacent and directly tributary to Shasta Lake are irregular and dendritic. The drainages are steep, and the drainage density ranges from 3.0 to 6.4 miles of stream per square mile of drainage area (Table 4-7). The drainage density is the lowest in the Main Body of the lake because this area has several small catchments. The density is the highest in the more well-defined arms, a function of their larger catchment areas of the tributary watersheds.

The lengths of streams within watersheds that are adjacent to Shasta Lake are also reported in Figure 4-6, where they again are aggregated by arm and further subdivided by flow regime (intermittent or perennial) and stream gradient. There are about 2,903 miles of ephemeral, intermittent, and perennial stream channels in these adjacent watersheds. Most (64 percent) of the stream channels are intermittent and have a stream slope greater than 10 percent. About 14 percent of the stream channels are perennial, with slopes less than 7 percent.

Generally speaking, channels with gradients of less than 7 percent are known to support fish and other aquatic organisms. About 79 percent of these potential fish-bearing tributaries occur within the Sacramento River, Squaw Creek, and Pit arms.

Again, the values reported in Table 4-7 do not include large parts of the Sacramento River, Squaw Creek, Pit River, McCloud River, and Big Backbone Creek watersheds; only the “face drainages” within the arms themselves are included in the reported values.

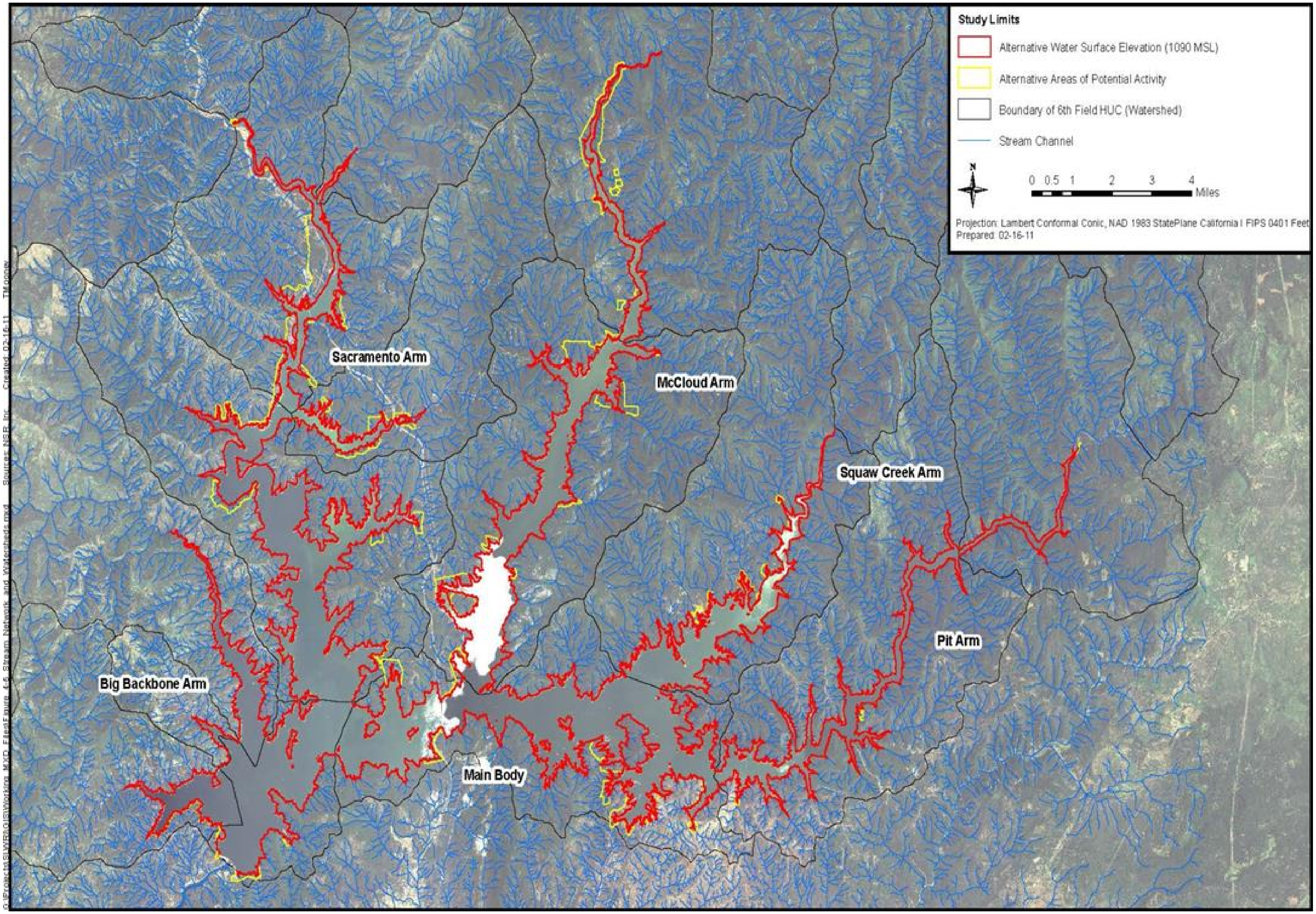
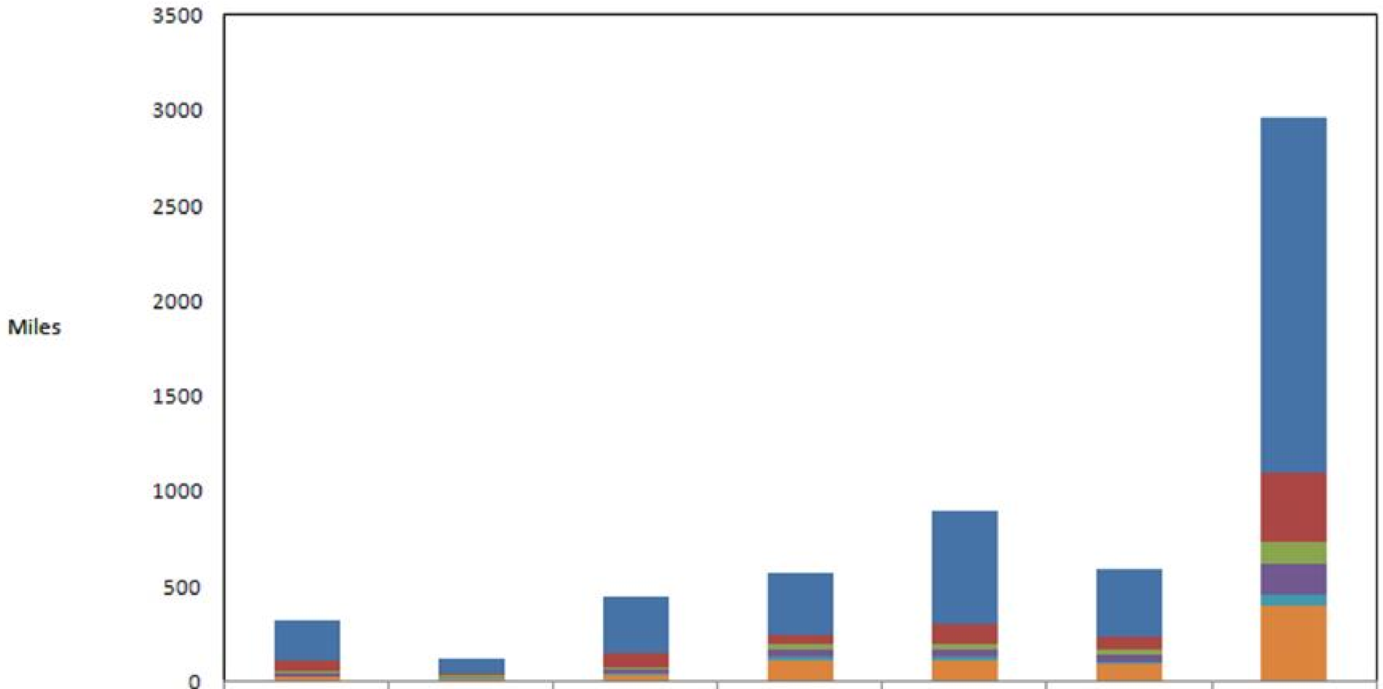


Figure 4-5. Regional Stream Network and Boundaries of Watersheds Adjacent to Shasta Lake and Vicinity



	Big Backbone Creek	Main Body	McCloud River	Pit River	Sacramento River	Squaw Creek	Total Length
Intermittent >10% Grade	214	83	297	321	597	355	1867
Perennial >10% Grade	60	6	75	51	101	71	364
Intermittent 7-10% Grade	4	10	9	31	30	24	108
Perennial 7-10% Grade	18	3	25	36	41	38	161
Intermittent <7% Grade	2	10	5	21	20	8	66
Perennial <7% Grade	30	14	38	109	109	96	396

Figure 4-6. Regional-Scale Characteristics of Streams Tributary to Shasta Lake

Table 4-7. Characteristics of Watersheds Adjacent and Directly Tributary to Shasta Lake

Lake Arm	Drainage Area (square miles)	Stream Length (miles)	Drainage Density (miles/square miles)	Average Elevation (feet)	Max Elevation (feet)	Mean Annual Precipitation (inches)
Big Backbone Creek	60	325	5.4	2,185	4,633	74
Main Body	37	112	3.0	1,260	2,723	67
McCloud River	77	444	5.7	1,911	4,669	79
Pit River	100	551	5.5	1,700	3,246	73
Sacramento River	137	880	6.4	1,825	4,589	76
Squaw Creek	100	583	5.8	2,100	5,046	83
Total	512	2,903	5.7	1,885	5,046	77

Using existing data and information (NSR 2003), the following observations were made about the relative stability of the riverine reaches. Of the five main tributaries influencing Shasta Lake, all except Big Backbone Creek and the Sacramento River are underlain by shallow bedrock that limits channel incision. For this reason, Squaw Creek and the Pit and McCloud rivers are relatively stable streams that are unlikely to change significantly in response to average floods. Although they occur infrequently, debris flows have the potential to substantially affect particularly shallow bedrock reaches of these tributaries, as is evident in Dekkas Creek. The Sacramento River and Big Backbone Creek are relatively dynamic because the channel bed has the potential to undergo physical changes in response to a moderate flood. Although Big Backbone Creek and Squaw Creek have similar watershed areas, Squaw Creek has more bedrock reaches than Big Backbone Creek and therefore is inherently more stable.

Upper Sacramento River (Shasta Dam to Red Bluff)

The geomorphology of the Sacramento River is a product of several factors: the geology of the Sacramento Valley, hydrology, climate, vegetation, and human activity. Large flood events drive lateral channel migration and remove large flow impediments. Riparian vegetation stabilizes riverbanks and reduces water velocities, inducing deposition of eroded sediment. In the past, a balance existed between erosion and deposition along the Sacramento River. However, construction of dams, levees, and water projects has altered streamflow and other hydraulic characteristics of the Sacramento River. In some areas, human-induced changes have stabilized and contained the river, while in other reaches, the loss of riparian vegetation has reduced sediment deposition and led to increased erosion.

Human-induced changes have also affected geomorphology of downstream tributaries to the Sacramento River in the study area. Major tributaries include Clear, Cottonwood and Cow Creeks.

Cow Creek The 275,000-acre Cow Creek Watershed is a large, generally uncontrolled tributary to the Sacramento River on the eastern side of the Sacramento River. The watershed is unique in that land ownership is almost evenly divided between commercial forestland, commercial agriculture, and small rural property owners, with minimum government ownership (WSRCD and CCWMG 2005).

Copper, coal, gravel and quarry stone have been mined from the Cow Creek watershed in the past. In contrast to other tributaries, gold was not discovered on the eastside of the Sacramento River in this area. However, the available timber and grazing lands on the eastern lands became primary supply areas for the initial gold and copper mining that occurred in other parts of the region (WSRCD and CCWMG 2001).

Gravel was mined in Little Cow Creek near Bella Vista (at Dry Creek and at Salt Creek), near Palo Cedro (Graystone Court and near Bloomingdale Road), and in the lower reaches of the main stem of Cow Creek. Mining of gravel in active floodways has likely reduced available spawning gravel in Little Cow Creek and the main stem of Cow Creek. Gravel removal may also have contributed to channel incisement (WSRCD and CCWMG 2005).

Ranching is currently a dominant land use in the watershed. Diversions of water for ranching activities significantly affect instream flow on the lower reaches of Cow Creek during the summer season (WSRCD and CCWMG 2005).

Major issues in the Cow Creek watershed are water quality and quantity for agriculture uses and natural barriers to fish passage (waterfalls) located at the break in geology limit anadromous fish passage into four of the five tributaries to Cow Creek. Geomorphic changes in Cow Creek (i.e., knickpoints) are attributed to natural breaks in the geology of the area and not to human activities. A review of historic aerial photos and available maps show that the configuration of the channel on the main stem has not changed significantly over the last century (WSRCD and CCWMG 2005).

Cottonwood Creek Cottonwood Creek is the largest undammed watershed on the west side of the Sacramento Valley. The watershed is characterized by a flashy hydrology, due to the absence of any flow regulating dams, low intra-annual storage resulting from a combination of very little recharge to aquifers in the upper reaches of the watershed and a small amount of snow pack (CH2M HILL 2005, 2007).

Human impacts on Cottonwood Creek began in the 1850s with placer and dredge gold mining operations. Two major gravel mines currently operate on Cottonwood Creek. The Shea Mine, which is in Shasta County, is immediately downstream of Interstate 5 and the Cottonwood Creek Sand and Gravel Mine (formerly XTRA), which is in Tehama County, is approximately 0.5 mile upstream of Interstate 5 (CH2M HILL, 2001).

Several reports suggest that persistent gravel mining combined with a flashy hydrology contribute to instability in channel conditions, excessive bank erosion and bed degradation in Cottonwood Creek (DWR 1992, Matthews 2003). Cross-sectional survey locations established by the USGS in 1983 and re-surveyed in 2002 show that considerable channel incision has occurred on Cottonwood Creek; in some areas, the channel is scoured to bedrock. These changes are likely caused by instream aggregate mining in excess of annual replenishment rates (Matthews 2003).

Clear Creek To characterize existing fluvial geomorphic conditions, Clear Creek is divided into upper clear Creek and lower Clear Creek, with the delineation occurring at Whiskeytown Dam. Upper Clear Creek (upstream of Whiskeytown Dam) is not discussed further in this section.

The lower Clear Creek watershed has been impacted by direct and indirect human activities for over a century. Widespread alterations to the watershed began in the 1800s, when the channel was placer mined and then dredged for gold, which caused extensive modifications to natural channel form and process by removing point bars, floodplains and riparian vegetation (WSRCD 1996). In some areas, the stream is incised completely down to clay hardpan or bedrock. Clear Creek is straight and highly entrenched in some areas; in others, it has multiple, braided channels due to direct and indirect human impacts (GMA 2007). Later, timber harvesting and associated road building caused excessive erosion throughout the watershed (WSRCD 1996).

The construction of McCormick-Saeltzer Dam in 1903 (dam removed in 2000) caused further changes in streamflow and sediment transport in the stream. Alteration of the natural flow and sediment regime in Clear Creek continued with construction of Whiskeytown Dam in 1963. Whiskeytown Dam greatly reduced the volume and magnitude of historical flows and effectively blocks the downstream transport of coarse sediment to lower Clear Creek (WSRCD 1996).

More recently, instream and off-channel aggregate mining began in 1950 and continued through the mid-1980s. Several hundred thousand cubic yards of aggregate were removed from Clear Creek below the former site of McCormick Saeltzer Dam, destroying the bankfull channel and in some areas completely removing the floodplain (WSRCD 1996).

Lower Clear Creek is the subject of several ongoing geomorphic studies and monitoring efforts, and fish habitat and channel restoration activities intended to offset past impacts on the watershed and stream channel by introducing spawning gravels into lower Clear Creek, implementing erosion control programs, reducing fuels within the watershed (USBR 2012). The Lower Clear Creek Floodway Rehabilitation Project, an extensive effort to restore the natural form and function of the Clear Creek channel and floodplain in areas highly affected by gold and aggregate mining.

Two headcuts have been observed on lower Clear Creek. The upstream-most headcut was observed in 2003, upstream of the former McCormick-Saeltzer Dam location. This headcut is the result of natural channel adjustment following dam removal in 2000 combined with a large storm event that occurred in December 2002 (UC Berkeley 2003). The headcut near the former dam site was observed again during monitoring activities in 2006 (GMA 2007). As of 2011, the channel appears to have stabilized in the vicinity of the former dam, with normal patterns of aggradation and deposition occurring within the reach (UC Berkeley 2011).

A second headcut has been observed farther downstream in Clear Creek, near the location of the Lower Clear Creek Floodway Rehabilitation Project. This headcut is migrating from the upstream end of the restoration site and has been attributed to past gravel mining and reduction of coarse sediment by upstream dams. In some areas above and below the site, the channel has incised to clay hardpan. Continued gravel augmentation upstream of the restoration area may reduce the rate of channel downcutting in the future (GMA 2007).

Lower Sacramento River and Delta

Downstream from Red Bluff, the lower Sacramento River is relatively active and sinuous, meandering across alluvial deposits within a wide meander belt. The active channel consists of point bars composed of sand on the inside of meander bends, and is flanked by active floodplain and older terraces. Most of these features consist of easily eroded, unconsolidated alluvium; however, there are also outcrops of resistant, cemented alluvial units such as the Modesto and Riverbank formations. Geologic outcroppings and human-made structures, such as bridges and levees, act as local hydraulic controls and confine movement of much of the lower Sacramento River. Natural geomorphic processes in the Delta have been highly modified by changes to upstream hydrology (reservoirs and streamflow regulation) and construction of levees, channels, and other physical features.

Since construction of Shasta Dam in the early 1940s, flood volumes on the river have been reduced, which has reduced the energy available for sediment transport. Straightening and a reduced rate of meander migration of the river may be associated with flow regulation because of Shasta Dam. The reduction in active channel dynamics is compounded by the physical effects of riprap bank protection structures, which typically eliminate shaded bank habitat and associated deep pools, and halt the natural processes of channel migration.

CVP/SWP Service Areas

Geomorphology in the CVP/SWP service areas is a product of the same factors mentioned above – geology, hydrology and climate, vegetation, and human activity. Geomorphology in the CVP service areas is summarized in the descriptions of the primary study area and the lower Sacramento River and Delta portions of the extended study area.

Geomorphology in the SWP service areas extends into the southern geomorphic provinces of California and along part of the coast. The southern geomorphic provinces and coastal province include the Transverse Ranges, Peninsular Ranges, Mojave Desert, and Coast Ranges. The Transverse Ranges, composed of overlapping mountain blocks, consist of parallel and subparallel ranges and valleys. The Peninsular Ranges Geomorphic Province is composed of northwest- to southeast-trending fault blocks, extending from the Transverse Ranges into Mexico. The Peninsular Ranges are similar to the Sierra Nevada in that they have a gentle westerly slope and generally consist of steep eastern faces. The Mojave Desert Geomorphic Province's topography is controlled by two faults: the San Andreas Fault, trending northwest to southeast, and the Garlock Fault, trending east to west (Jennings 1938). Before development of the Garlock Fault, sometime during the Miocene, the Mojave Desert was part of the Basin and Range Geomorphic Province. The Mojave Desert is now dominated by alluvial basins, which are aggrading surfaces from adjacent upland continental deposits (Norris and Webb 1990). The Coast Ranges have been greatly affected by plate tectonics. The Coast Ranges Geomorphic Province consists of elongate ranges and narrow valleys that run subparallel to the coast. Some of the mountain ranges along the Coast Range terminate abruptly at the sea (Norris and Webb 1990).

4.1.4 Mineral Resources

This section describes the known mineral resources of commercial or otherwise documented economic value in both the primary and extended study areas. The mineral resources of concern include metals and industrial minerals (e.g., aggregate, sand, and gravel, oil and gas, and geothermal resources that would be of value to the region).

Shasta Lake and Vicinity

The following section describes mineral resources in the Shasta Lake and vicinity portion of the primary study area.

Metals The lands in the Shasta Lake and vicinity area are highly mineralized, with a history of significant mineral production. The Shasta Lake and vicinity area encompasses portions of two historic base metal mining districts, the west Shasta and east Shasta copper-zinc districts. The two districts focused on development of massive sulfide (Kuroko-type) deposits of submarine volcanogenic origin that formed contemporaneously with, and by the same process as, the host volcanic rocks. As in other areas in the Klamath Mountains, copper was by far the predominant commodity produced. Zinc, sulfur, iron, limestone, gold, and silver were produced as byproducts of copper production.

The Golinsky mine complex is located in the west Shasta district, approximately 7 miles west of Shasta Dam in the headwaters of Dry Creek and Little Backbone Creek. This inactive, abandoned mine complex is the only large historic producing mine within the Shasta Unit of the Whiskeytown-Shasta-Trinity NRA. Other mines within the NRA occur in the east Shasta district, concentrated between the McCloud and Squaw arms of Shasta Lake. The east Shasta district includes the Bully Hill, Copper City, and Rising Star mines, all of which are located in the Bully Hill area. These mines ceased operation before Shasta Dam was built.

These types of mineral deposits, in conjunction with the historic lode mining methods, have resulted in the discharge of toxic mine waste and acidic waters to Shasta Lake and some tributaries on a recurring basis (USFS 2000). The Golinsky mine complex has been subject to extensive remediation to reduce the discharge of toxic mine waste and acidic waters to Shasta Lake.

Industrial Minerals Industrial minerals occurring in the vicinity of Shasta Lake include alluvial sand and gravel, crushed stone, volcanic cinders, limestone, and diatomite. In 2002, Shasta County produced 462,000 tons of sand and gravel, 852,000 tons of crushed stone (including limestone), and 51,000 tons of volcanic cinders. Limestone (used to produce Portland cement) and diatomite are not included in these figures.

The supply of Portland cement concrete-grade alluvial sand and gravel within the region is more limited than the supply of non-Portland cement concrete-grade material. The primary sources for alluvial sand and gravel near the Shasta Lake and vicinity area are the Sacramento River (downstream from Keswick Dam), Clear Creek, Cottonwood Creek, and Hat Creek. Crushed stone has been produced at a limestone quarry in Mountain Gate, a granite quarry in Keswick, an andesite quarry in Mountain Gate, a shale quarry in Oak Run, and two basalt quarries in the Lake Britton area near Burney. Volcanic cinders are produced at sites east of the Shasta Lake and vicinity area.

Limestone is used in a variety of industrial applications, but the bulk of limestone is used for the production of Portland cement concrete. Most of the limestone resources found in and near the Shasta Lake and vicinity area are located in fairly remote mountainous areas where extraction is uneconomical. However, significant mining of limestone for Portland cement concrete production occurs immediately south of Shasta Lake, in Mountain Gate. Diatomite is produced from sources near Lake Britton, east of the Shasta Lake and vicinity area.

Geothermal Resources Significant geothermal resources occur in the Medicine Lake Highlands, approximately 65 air miles northeast of Shasta Lake. The potential capacity of the Medicine Lake Highlands has been estimated at 480 megawatts (PacifiCorp 2010). Development of the Medicine Lake Highlands' geothermal resources has been the subject of extensive litigation of environmental issues and Native American concerns.

Upper Sacramento River (Shasta Dam to Red Bluff)

Economically viable minerals found within the upper Sacramento River portion of the primary study area consist of alluvial sand and gravel, crushed stone, volcanic cinders, limestone, and diatomite. Additional mineral resources are found in the surrounding regions in Shasta and Tehama counties. These mineral resources include asbestos, barium, calcium, chromium, copper, gold, iron, lead, manganese, molybdenum, silver, and zinc (USGS 2005).

Lower Sacramento River and Delta

Economically viable minerals found within the lower Sacramento River and Delta portion of the extended study area consist of alluvial sand and gravel, crushed stone, calcium, and clay. Additional mineral resources are found in the surrounding regions, including chromium, gold, granite, lithium, manganese, mercury, pumice, and silver (USGS 2005).

CVP/SWP Service Areas

The U.S. Geological Survey's mineral resources database indicates that numerous mineral resources found within the CVP/SWP service areas are or have been mined. These minerals include antimony, asbestos, barium, bismuth, boron, calcium, chromium, clay, copper, diatomite, feldspar, fluorite, gold, gypsum-anhydrite, halite, iron, lead, limestone, magnetite, manganese, marble, mercury, molybdenum, pumice, quartz, sand and gravel, silica, silver, slate, stone (crushed/broken), talc, tin, titanium, tungsten, uranium, and vanadium (USGS 2005).

4.1.5 Soils

Soils and erosion areas are described below for both the primary and extended study areas. Soils in the study area are described in the following sections in terms of their biomass productivity; susceptibility to erosion, subsidence, liquefaction, and expansion; and suitability for on-site application of waste material.

Soil biomass productivity is a measure of the capability of a site to produce biomass. The purpose of this management interpretation is to measure the site's productive capability when vegetative indicators (e.g., crop yields, site trees, and other vegetative biomass data) are not directly available (Miles 1999). Factors that influence soil biomass productivity include soil depth, parent material, available water-holding capacity, precipitation, soil temperature regime, aspect, and reaction (i.e., pH). Soil biomass productivity is characterized using four relative rankings: high, moderate, low, and nonproductive.

The susceptibility of soil to erosion is characterized in terms of the soil's erosion hazard rating. The ratings indicate the hazards of topsoil loss in an unvegetated condition, as might occur following disturbance by construction. Ratings are based on the soil erosion factor (K), slope, and content of rock fragments. (The soil erosion factor (K) is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff, based primarily on soil texture but also considering structure, organic matter, and permeability.). Three ratings are recognized: slight, moderate, and severe. A rating of "slight" indicates that no postdisturbance acceleration of naturally occurring erosion is likely; “moderate” indicates that some acceleration of erosion is likely, and that simple erosion-control measures are needed; and “severe” indicates that significant erosion is expected, and that extensive erosion-control measures are needed.

Land subsidence is broadly defined to mean the sudden sinking or gradual downward settling of the land surface with little or no horizontal motion. Land subsidence can arise from a number of causes: the weathering characteristics of the underlying bedrock (e.g., as occurs for certain limestone formations); decomposition of the organic matter fraction of soils that are derived from peaty or mucky parent materials; aquifer-system compaction; underground mining; and natural compaction. Three processes account for most instances of water-related subsidence: compaction of aquifer systems, drainage and subsequent oxidation of organic soils, and dissolution and collapse of susceptible rocks.

Soil liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction occurs in saturated soils when the pore spaces between individual soil particles are completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. Before an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. When liquefaction occurs, the strength of soils decreases, and the ability of soils to support foundations for buildings and bridges is reduced.

Expansive soils are soils that contain water-absorbing minerals, mainly “active” clays (e.g., montmorillonite). Such soils may expand by 10 percent or more when wetted. The cycle of shrinking and expanding exerts continual pressure on structures, and over time can reduce structural integrity. Soil susceptibility to expansion (i.e., shrinking and swelling) is tested using Uniform Building Code Test Standard 18-1.

Soil suitability for on-site application of waste material focuses on the suitability of the soil to support the use of septic tanks or alternative wastewater disposal systems. Suitability interpretations are based on consideration of soil depth, permeability, rock content, depth to groundwater (including seasonally perched water), and slope.

Shasta Lake and Vicinity

Soils in the Shasta Lake and vicinity area derive from materials weathered from metavolcanic and metasedimentary rocks and from intrusions of granitic rocks, serpentine, and basalt. Soils derived from the metavolcanic sources, such as greenstone, include the Goulding and Neuns families. Soils derived from metasedimentary materials include the Marpa family. Holland family soils are derived from metasedimentary and granitic rocks.

In general, metamorphosed rocks do not weather rapidly, and shallow soils are common in the area, especially on steep landscape positions. Soils from metamorphosed rocks generally contain large percentages of coarse fragments (e.g., gravels, cobbles, stones), which reduce their available water holding capacity and topsoil productivity. Granitic rocks may weather deeply, but soils derived from them may be droughty because of high amounts of coarse quartz grains and low content of "active" clay. Soils derived from granitic rocks commonly are highly susceptible to erosion.

Soil map units in the Shasta Lake and vicinity area are shown in Figure 4-7; Table 4-8 presents the mapping legend that accompanies the figure. The areal extent of soil map units within the Shasta Lake and vicinity area is presented in Table 4-9 for the portion of the area between 1,070 feet and 1,090 feet above msl (Impoundment Area), and in Table 4-10 for the portion potentially disturbed by construction activities (Relocation Areas). Sixty soil map units, comprising soil families and miscellaneous land types (e.g., rock outcrop, limestone), are recognized to occur in the area. Common soil families are Marpa, Neuns, Goulding, and Holland. These are well-drained soils with fine loamy or loamy-skeletal (i.e., gravelly or cobbly) profiles.

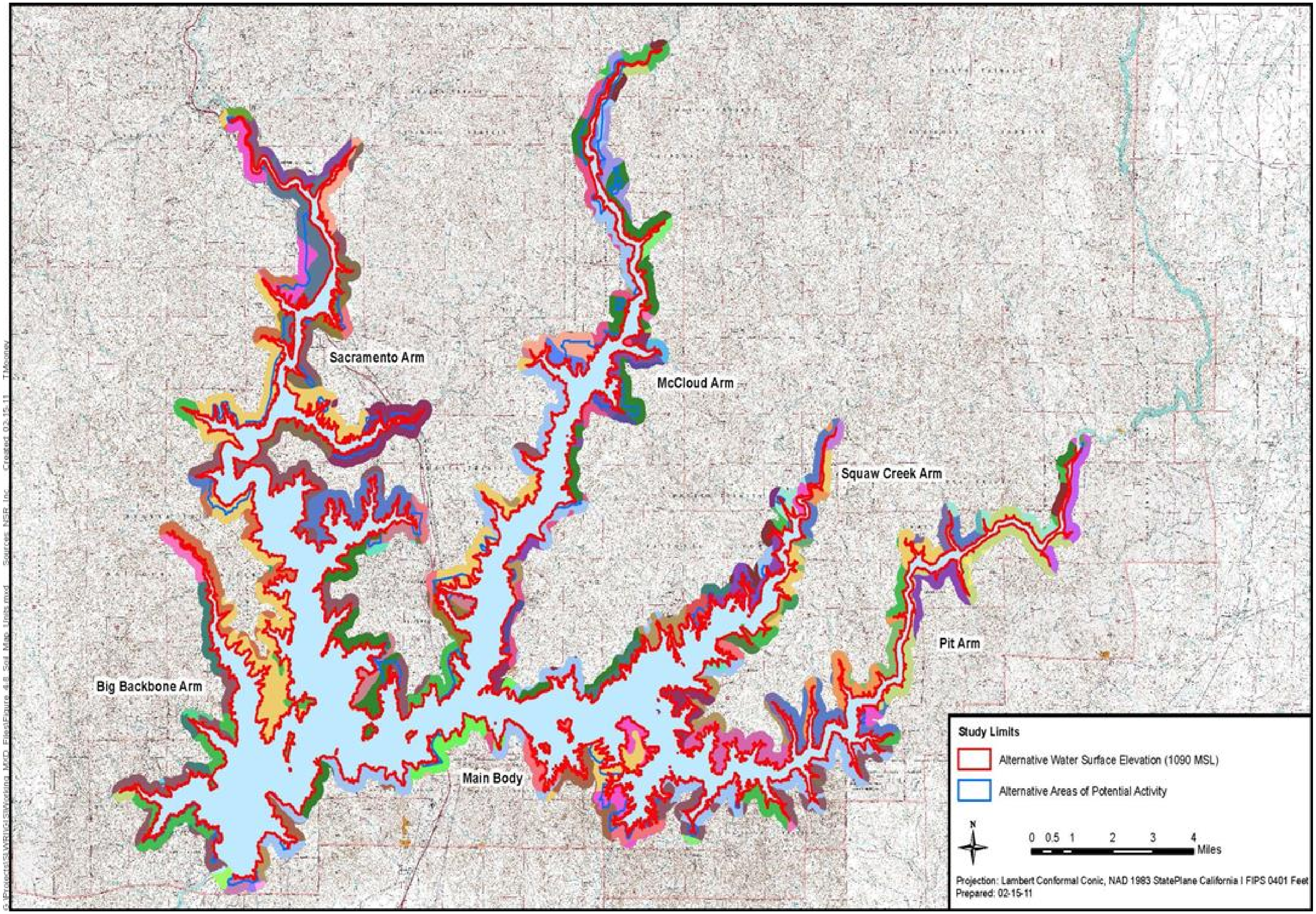


Figure 4-7. Soil Map Units – Shasta Lake and Vicinity

Table 4-8. Key to Soil Map Units – Shasta Lake and Vicinity

Map Unit, Map Unit Name
101, Holland-Goulding families association, 20 to 40 percent slopes.
102, Holland-Goulding families association, 40 to 60 percent slopes.
103, Holland-Goulding families association, 60 to 80 percent slopes.
104, Holland family-Holland family, deep complex, 20 to 40 percent slopes.
105, Holland family-Holland family, deep complex, 40 to 60 percent slopes.
107, Holland-Neuns families complex, 40 to 60 percent slopes.
109, Holland family, ashy, 0 to 20 percent slopes.
111, Holland, ashy-Leadmount families association, 0 to 20 percent slopes.
114, Holland, ashy-Washougal families complex, 25 to 65 percent slopes.
115, Holland family, deep, 0 to 20 percent slopes.
116, Holland family, deep, 20 to 40 percent slopes.
117, Holland family, deep, 40 to 60 percent slopes.
119, Holland family, deep-Holland families complex, 20 to 40 percent slopes.
120, Holland family, deep-Holland family complex, 40 to 60 percent slopes.
123, Holland, deep-Marpa families complex, 20 to 40 percent slopes.
127, Holland, deep-neuns families complex, 40 to 60 percent slopes.
133, Hugo family, 60 to 80 percent slopes.
139, Hugo-Neuns families complex, 60 to 80 percent slopes.
174, Marpa family, 20 to 40 percent slopes.
175, Marpa family, 40 to 60 percent slopes.
176, Marpa family, 60 to 80 percent slopes.
177, Marpa-Chawanakee families complex, 40 to 60 percent slopes.
178, Marpa-Goulding families association, 20 to 40 percent slopes.
179, Marpa-Goulding families association, 40 to 60 percent slopes.
18, Chaix family, 40 to 60 percent slopes.
180, Marpa-Goulding families association, 60 to 80 percent slopes.
182, Marpa-Holland, deep families complex, 20 to 40 percent slopes.
183, Marpa-holland, deep families complex, 40 to 60 percent slopes.
187, Marpa-Neuns families complex, 40 to 60 percent slopes.
188, Marpa-Neuns families complex, 60 to 80 percent slopes.
195, Millsholm family, 20 to 60 percent slopes.
203, Neuns family, 40 to 60 percent slopes.
204, Neuns family, 60 to 80 percent slopes.
209, Neuns-Goulding families association, 60 to 80 percent slopes.
214, Neuns-Holland, deep families complex, 40 to 80 percent slopes.
218, Neuns-Marpa families complex, 40 to 60 percent slopes.
219, Neuns-Marpa families complex, 60 to 80 percent slopes.
224, Neuns family-Typic Xerorthents association, 50 to 80 percent slopes.
228, Neuns family, deep-Neuns family complex, 40 to 70 percent slopes.
24, Chawanakee-Chaix families complex, 40 to 60 percent slopes.
250, Rock outcrop, limestone.

Table 4-8. Key to Soil Map Units – Shasta Lake and Vicinity (contd.)

Map Unit, Map Unit Name

- 251, Rock outcrop, metamorphic.
- 252, Rock outcrop, sedimentary.
- 259, Rock outcrop-Goulding family complex, 40 to 80 percent slopes.
- 27, Chawanakee family-Rock outcrop complex, 60 to 80 percent slopes.
- 35, Deadwood-Neuns families complex, 40 to 60 percent slopes.
- 61, Etsel family, 40 to 80 percent slopes.
- 79, Goulding family, 20 to 40 percent slopes.
- 80, Goulding family, 40 to 60 percent slopes.
- 81, Goulding family, 60 to 80 percent slopes
- 82, Goulding-Holland families association, 40 to 60 percent slopes.
- 83, Goulding-Marpa families association, 40 to 60 percent slopes.
- 85, Goulding family-Rock outcrop complex, 50 to 80 percent slopes
- 98, Holland family, 40 to 60 percent slopes.
- 99, Holland family, 60 to 80 percent slopes
- AtE2sh, Auburn very stony clay loam, 30 to 50 percent slopes, eroded
- AuF2sh, Auburn very rocky clay loam, 50 to 70 percent slopes, eroded
- BoF3sh, Boomer very stony clay loam, 50 to 70 percent slopes, severely eroded
- GeF2sh, Goulding very rocky loam, 50 to 70 percent slopes, eroded
- W, Water

Table 4-9. Areal Extent of Soil Map Units – Shasta Lake and Vicinity (Impoundment Area)

Map Unit	Map Unit Name	Acres	% of Total Subarea
18	Chaix family, 40–60% slopes	43.6	1.75%
27	Chawanakee family – Rock outcrop complex, 60–80% slopes	0.8	0.03%
35	Deadwood-Neuns families complex, 40–60% slopes	2.5	0.10%
61	Etsel family, 40–80% slopes	39.4	1.58%
79	Goulding family, 20–40% slopes	32.0	1.28%
80	Goulding family, 40–60% slopes	153.1	6.13%
81	Goulding family, 60–80% slopes	7.3	0.29%
82	Goulding-Holland families association, 40–60% slopes	45.3	1.81%
83	Goulding-Marpa families association, 40–60% slopes	118.5	4.74%
85	Goulding family – Rock outcrop complex, 50–80% slopes	10.8	0.43%
98	Holland family, 40–60% slopes	3.6	0.14%
99	Holland family, 60–80% slopes	8.4	0.34%
101	Holland-Goulding families association, 20–40% slopes	66.5	2.66%

Table 4-9. Areal Extent of Soil Map Units – Shasta Lake and Vicinity (Impoundment Area) (contd.)

Map Unit	Map Unit Name	Acres	% of Total Subarea
102	Holland-Goulding families association, 40–60% slopes	145.0	5.80%
103	Holland-Goulding families association, 60–80% slopes	4.6	0.18%
104	Holland family – Holland family, deep complex, 20–40% slopes	60.6	2.43%
105	Holland family – Holland family, deep complex, 40–60% slopes	215.3	8.62%
109	Holland family, ashy, 0–22% slopes	0.1	0.00%
111	Holland, ashy – Leadmount families association, 0–20% slopes	93.4	3.74%
114	Holland, ashy – Washougal families complex, 25–65% slopes	6.2	0.25%
115	Holland family, deep, 0–20% slopes	38.6	1.54%
116	Holland family, deep, 20–40% slopes	8.5	0.34%
117	Holland family, deep, 40–60% slopes	32.1	1.29%
119	Holland family, deep – Holland families complex 20–40% slopes	111.5	4.46%
120	Holland family, deep – Holland family complex, 40–60% slopes	70.4	2.82%
123	Holland, deep – Marpa families complex, 20–40% slopes	66.7	2.67%
127	Holland, deep – Neuns families complex, 40–60% slopes	4.1	0.16%
133	Hugo family, 60–80% slopes	5.2	0.21%
139	Hugo-Neuns families complex, 60–80% slopes	4.3	0.17%
174	Marpa family, 20–40% slopes	28.2	1.13%
175	Marpa family, 40–60% slopes	28.4	1.14%
177	Marpa-Chawanakee families complex, 40–60% slopes	47.1	1.89%
178	Marpa-Goulding families association, 20–40% slopes	74.7	2.99%
179	Marpa-Goulding families association, 40–60% slopes	309.8	12.40%
180	Marpa-Goulding families association, 60–80% slopes	10.2	0.41%
182	Marpa-Holland, deep families complex, 20–40% slopes	89.1	3.57%
183	Marpa-Holland, deep families complex, 40–60% slopes	162.4	6.50%
187	Marpa-Neuns families complex, 40–60% slopes	5.6	0.22%
188	Marpa-Neuns families complex, 60–80% slopes	0.2	0.01%
195	Millsholm family, 20–60% slopes	39.7	1.59%
203	Neuns family, 40–60% slopes	7.6	0.30%
204	Neuns family, 60–80% slopes	43.5	1.74%
209	Neuns-Goulding families association, 60–80% slopes	1.7	0.07%
214	Neuns-Holland, deep families complex, 40–80% slopes	8.5	0.34%
218	Neuns-Marpa families complex, 40–60% slopes	1.1	0.04%
219	Neuns-Marpa families complex, 60–80% slopes	23.9	0.96%
250	Rock outcrop, limestone	9.3	0.37%
251	Rock outcrop, metamorphic	0.0	0.00%
259	Rock outcrop – Goulding family complex, 40–80% slopes	0.5	0.02%
AtE2sh	Auburn very stony clay loam, 30–50% slopes, eroded	0.1	0.01%
BoF3sh	Boomer very stony clay loam, 50–70% slopes, severely eroded	7.4	0.30%
W	Water	200.7	8.03%

Table 4-10. Areal Extent of Soil Map Units – Shasta Lake and Vicinity (Relocation Areas)

Map Unit	Map Unit Name	Acres	% of Total Subarea
18	Chaix family, 40–60% slopes	48.6	1.46%
35	Deadwood-Neuns families complex, 40–60% slopes	1.5	0.04%
61	Etsel family, 40–80% slopes	42.2	1.26%
79	Goulding family, 20–40% slopes	50.4	1.51%
80	Goulding family, 40–60% slopes	179.3	5.37%
82	Goulding-Holland families association, 40–60% slopes	13.9	0.42%
83	Goulding-Marpa families association, 40–60% slopes	6.6	0.20%
85	Goulding family – Rock outrcrop complex, 50–80% slopes	14.6	44.00%
102	Holland-Goulding families association, 40–60% slopes	280.0	8.38%
103	Holland-Goulding families association, 60–80% slopes	2.0	0.06%
104	Holland family – Holland family, deep complex, 20–40% slopes	79.1	2.37%
105	Holland family – Holland family, deep complex, 40–60% slopes	170.9	5.12%
109	Holland family, ashy, 0–22% slopes	1.1	0.03%
111	Holland, ashy – Leadmount families association, 0–20% slopes	533.6	15.98%
114	Holland, ashy – Washougal families complex, 25–65% slopes	1.5	0.05%
115	Holland family, deep, 0–20% slopes	120.0	3.59%
117	Holland family, deep, 40–60% slopes	71.2	2.13%
119	Holland family, deep – Holland families complex 20–40% slopes	163.5	4.90%
120	Holland family, deep – Holland family complex, 40–60% slopes	28.6	0.86%
123	Holland, deep – Marpa families complex, 20–40% slopes	86.8	2.60%
174	Marpa family, 20–40% slopes	150.5	4.51%
175	Marpa family, 40–60% slopes	17.0	0.51%
177	Marpa-Chawanakee families complex, 40–60% slopes	3.1	0.09%
178	Marpa-Goulding families association, 20–40% slopes	107.6	3.22%
179	Marpa-Goulding families association, 40–60% slopes	545.8	16.34%
180	Marpa-Goulding families association, 60–80% slopes	11.7	0.35%
182	Marpa-Holland, deep families complex, 20–40% slopes	247.0	7.40%
183	Marpa-Holland, deep families complex, 40–60% slopes	167.2	5.01%
195	Millsholm family, 20–60% slopes	36.7	1.10%
204	Neuns family, 60–80% slopes	19.4	0.58%
250	Rock outcrop, limestone	43.3	1.30%
259	Rock outcrop – Goulding family complex, 40–80% slopes	20.1	0.60%
AtE2sh	Auburn very stony clay loam, 30–50% slopes, eroded	2.7	0.08%
BoF3sh	Boomer very stony clay loam, 50–70% slopes, severely eroded	43.6	1.30%
W	Water	28.6	0.86%

Soil Biomass Productivity Soil biomass productivity in the Shasta-Trinity National Forest (STNF) ranges from nonproductive to high (USFS 1994). Using Forest Service Site Class (FSSC) as a surrogate metric for soil biomass productivity, approximately 36 percent of the Shasta Lake and vicinity area is occupied by soils of low biomass productivity, about 39 percent by soils of moderate productivity, and about 13 percent by "nonproductive" soils and miscellaneous land types (e.g., rock outcrop). Soils of high biomass productivity are unlikely to occur in the Shasta Lake and vicinity area.

Soil Susceptibility to Erosion (Uplands) Interpretations of soil susceptibility to erosion are presented in Table 4-11 for the portion of the area between 1,070 feet and 1,090 feet above msl (Impoundment Area), and in Table 4-12 for the portion potentially disturbed by construction activities. Of the approximately 5,837 acres in the Shasta Lake and vicinity area, 5,377 acres (92 percent of total area) are assigned a hazard rating of severe.

Table 4-11. Summary of Soil Erosion Hazard – Shasta Lake and Vicinity (Impoundment Area)

Soil Erosion Hazard	Acres	% of Total Subarea)
Moderate	38.55	1.54%
Severe	2248.81	90.03%
Not Rated	210.00	8.41%

Table 4-12. Summary of Soil Erosion Hazard – Shasta Lake and Vicinity (Relocation Areas)

Soil Erosion Hazard	Acres	% of Total Subarea
Moderate	119.97	3.59%
Severe	3127.62	93.65%
Not Rated	92.01	2.76%

Soil Susceptibility to Erosion (Shoreline) There are more than 420 miles of shoreline around Shasta Lake. As described below under "Methods and Assumptions," a conceptual model was developed to quantify current erosion rates and predict future erosion rates (see Attachment 1, Shoreline Erosion Technical Memorandum).

Based on the model output, about 50 percent of the shoreline has a low erosion severity. The remaining shoreline has moderate (35 percent) to high (15 percent) erosion severity. Most of the shoreline that is exposed during routine drawdown periods (i.e., drawdown zone) has been subject to substantial erosion, and very little soil remains after more than 60 years of reservoir operations.

Soil Susceptibility to Subsidence Published interpretations of soil susceptibility to subsidence are generally not available for the Shasta Lake and vicinity area. The likelihood that subsidence would occur as a result of decomposition of soil organic matter is low because of the absence of soils derived from peaty or mucky parent materials. Similarly, the likelihood of subsidence caused by aquifer-system compaction is low because of the absence of significant, widespread groundwater withdrawal in the Shasta Lake and vicinity area. Land subsidence has the potential to occur in areas underlain by highly weatherable, carbonate-rich rocks (e.g., certain limestones), and in areas affected by underground construction.

Soil Susceptibility to Liquefaction Published interpretations of soil susceptibility to liquefaction are generally not available for the Shasta Lake and vicinity area. The likelihood that soil liquefaction would occur is low because of the absence of the necessary high-groundwater conditions in the Shasta Lake and vicinity area.

Soil Susceptibility to Expansion Published interpretations of soil susceptibility to expansion (i.e., shrinking and swelling) are generally not available for most of the Shasta Lake and vicinity area. The likelihood that expansive soils occur is low because the weathering products derived from the local bedrock typically contain low concentrations of “active” clays (e.g., montmorillonite).

Soil Suitability for On-site Application of Waste Material Published interpretations of soil suitability for on-site application of waste material (i.e., capability to support use of septic tanks or alternative wastewater disposal systems) are generally not available for the Shasta Lake and vicinity area. In general, soils in the Shasta Lake and vicinity area are poorly suited to these uses because of shallow soil depth, high rock content, and excessive slope.

Upper Sacramento River (Shasta Dam to Red Bluff)

The following section describes the susceptibility of soil in the upper Sacramento River portion of the primary study area to erosion (channel shoreline), erosion (wind), subsidence, liquefaction, and expansion.

Soils in the Sacramento River basin are divided into four physiographic groups: upland soils, terrace soils, valley land soils, and valley basin soils. Upland soils are prevalent in the hills and mountains of the region and are composed mainly of sedimentary sandstones, shales, and conglomerates originating from igneous rocks. Terrace and upland soils are predominant between Redding and Red Bluff; however, valley land soils border the Sacramento River through this area. Valley land and valley basin soils occupy most of the Sacramento Valley floor south of Red Bluff. Valley land soils consist of deep alluvial and aeolian soils that make up some of the best agricultural land in the state. The valley floor was once covered by an inland sea, and sediments were formed by deposits of marine silt followed by mild uplifting earth movements. After the main body of water disappeared, the Sacramento River began eroding and redepositing silt and sand in new alluvial fans.

Soil Susceptibility to Erosion (Channel Shoreline) Shasta and Keswick dams have a significant influence on sediment transport in the Sacramento River because they block sediment that would normally be transported downstream. The result has been a net loss of coarse sediment, including salmon spawning gravels, in the Sacramento River below Keswick Dam. In alluvial river sections, bank erosion and sediment deposition cause river channel migrations that are vital to maintaining instream and riparian habitats, but which can cause loss of agricultural lands and damage to roads and other structures.

Soil Susceptibility to Erosion (Wind) Soil erodibility, climatic factors, soil surface roughness, width of field, and quantity of vegetative coverage affect the susceptibility of soils to wind erosion. Wind erosion leaves the soils shallower and can remove organic matter and needed plant nutrients. In addition, blowing soil particles can damage plants, particularly young plants. Blowing soils also can cause off-site problems such as reduced visibility and increased allergic reaction to dust.

Soil Susceptibility to Subsidence Land subsidence in the Sacramento Valley is localized and concentrated in areas of overdraft from groundwater pumping. Land subsidence had exceeded 1 foot by 1973 in two main areas in the southwestern part of the valley near Davis and Zamora; however, additional subsidence since then has not been reported.

Soil Susceptibility to Expansion Most of Shasta County is characterized by moderately expansive soils with areas of low expansiveness in the South Central Region and southeastern corner of the county. Small scattered areas of highly expansive soils exist in the mountains of the Western Upland, French Gulch, and North East Shasta County planning areas. The hazard associated with expansive soils is that areas of varying moisture or soil conditions can differentially expand or shrink, causing stresses on structures that lead to cracking or settling. Effects of expansive soils on structures can be mitigated by requiring proper engineering design and standard corrective measures.

Lower Sacramento River and Delta

The following section describes the susceptibility of soil in the lower Sacramento River and Delta portion of the extended study area to erosion (channel shoreline), erosion (wind), subsidence, liquefaction, and expansion.

The soils of the Sacramento River basin are divided into four physiographic groups, as described above for the upper Sacramento River portion of the study area.

The soils of the Delta region vary primarily as a result of differences in geomorphological processes, climate, parent material, biological activity, topography, and time. The soils are divided into the following four general soil types:

- Delta organic soils and highly organic mineral soils
- Sacramento River and San Joaquin River deltaic soils
- Basin and basin rim soils
- Moderately well to well-drained valley, terrace, and upland soils

The Delta region contains soils primarily with the required physical and chemical soil characteristics, growing season, drainage, and moisture supply necessary to qualify as Prime Farmland. This includes 80–90 percent of the area of organic and highly organic mineral soils, Sacramento River and San Joaquin River deltaic soils, and basin and basin rim soils. Most of the remaining soils of the Delta region qualify as Farmland of Statewide Importance.

Soil Susceptibility to Erosion (Channel Shoreline) In the extended study area, the Sacramento River is a major alluvial river section that is active and sinuous, meandering across alluvial deposits within a wide meander belt. In alluvial river sections, bank erosion and sediment deposition cause migrations of the river channel. These migrations are extremely important in maintaining instream and riparian habitats, but also can cause loss of agricultural lands and damage to roads and other structures. Geologic outcroppings and human-made structures, such as bridges and levees, act as local hydraulic controls along the river. Bank protection, consisting primarily of rock riprap, has been placed along various sections of the Sacramento River to reduce erosion and river meandering.

The great quantities of sediment transported by the rivers into the Delta move primarily as suspended load. Of the estimated 5 million tons per year of sediment inflow into the Delta, about 80 percent originates from the Sacramento River and San Joaquin River drainages; the remainder is contributed by local streams. Approximately 15–30 percent of the sediment is deposited in the Delta; the balance moves into the San Francisco Bay system or out through CVP and SWP facilities.

Soil Susceptibility to Erosion (Wind) The Delta’s organic soils and highly organic mineral soils have wind erodibility ratings of 2–4 on a scale where 1 is most erodible and 8 is least erodible. The high wind erodibility of Delta soils is caused by the organic matter content of the soil. The rate of wind erosion is estimated at 0.1 inch per year.

Soil Susceptibility to Subsidence Subsidence of the Delta’s organic soils and highly organic mineral soils is attributable primarily to biochemical oxidation of organic soil material as a result of long-term drainage and flood protection. The highest rates of subsidence occur in the central Delta islands, where organic matter content in the soils is highest.

Development of the islands resulted in subsidence of the islands' interiors and greater susceptibility of the topsoil to wind erosion. Subsidence, as it relates to Delta islands, refers generally to the falling level of the land surface from primarily the oxidation of peat soil. Levee settlement may be partially caused by peat oxidation if land adjacent to levees is not protected from subsidence.

Soil Susceptibility to Expansion Soils in the lower Sacramento River and Delta portion of the extended study area vary from having low to high shrink-swell potential. In general, soils in the narrow corridor upstream along the Sacramento River have low shrink-swell potential according the U.S. Department of Agriculture's State Soil Geographic (STATSGO) Database Soil Surveys, with the exception of some soils with moderate shrink-swell potential near the Red Bluff Pumping Plant (NRCS 1995). Downstream, the shrink-swell potential of soils near the Delta is generally classified by the STATSGO Soil Surveys as "high." The hazard associated with expansive soils is that areas of varying moisture or soil conditions can differentially expand or shrink, causing stresses on structures that lead to cracking or settling. This hazard is identifiable through standard soil tests. Its effects on structures can be mitigated through the requirements of proper engineering design and standard corrective measures.

CVP/SWP Service Areas

As described above for the upper Sacramento River portion of the primary study area, soils in the CVP/SWP service areas are divided into four physiographic groups: valley land, valley basin, terrace land, and upland soils. According to the U.S. Department of Agriculture's STATSGO Database, soils within the CVP/SWP service areas consist of clay, loam, silt, and sand, some of which is gravelly. The CVP/SWP service areas also consist of unweathered and weathered bedrock that is evident through outcrops at the ground surface (NRCS 1995).

4.2 Regulatory Framework

The following section describes the Federal, State, and local regulatory setting for geological resources.

4.2.1 Federal

This section discusses the Federal regulatory setting for water quality, runoff, air quality, earthquakes, paleontological resources, and natural resources.

Clean Water Act

The Clean Water Act (CWA) includes provisions for reducing soil erosion for the protection of water quality. The CWA makes it unlawful for any person to discharge pollutants from a point source (including construction sites) into navigable waters, unless a permit has been obtained under its provisions. This pertains to construction sites where soil erosion and storm runoff and other pollutant discharges could affect downstream water quality.

National Pollutant Discharge Elimination System

The National Pollutant Discharge Elimination System process, established by the CWA, is intended to meet the goal of preventing or reducing pollutant runoff. Projects involving construction activities (e.g., clearing, grading, or excavation) with land disturbance greater than 1 acre must file a notice of intent with the applicable regional water quality control board (RWQCB) to indicate the intent to comply with the State General Permit for Storm Water Discharges Associated with Construction Activity (General Permit). This permit establishes conditions to minimize sediment and pollutant loading and requires preparation and implementation of a stormwater pollution prevention plan before construction.

Clean Air Act

The Clean Air Act also has provisions for reducing soil erosion relevant to air and water quality. On construction sites, exposed soil surfaces are vulnerable to wind erosion, and small soil particulates are carried into the atmosphere. Suspended particulate matter (consisting of PM_{10} and $PM_{2.5}$, as defined in Chapter 5, "Air Quality and Climate") is one of the six criteria air pollutants of the Clean Air Act.

Earthquake Hazards Reduction Act

In October 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act to "reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards and reduction program." To accomplish this, the act established the National Earthquake Hazards Reduction Program. The National Earthquake Hazards Reduction Program Act (NEHRPA) significantly amended this program in November 1990 by refining the description of agency responsibilities, program goals, and objectives. The NEHRPA designates the Federal Emergency Management Agency as the lead agency of the program and assigns it several planning, coordinating, and reporting responsibilities. Other NEHRPA agencies include the National Institute of Standards and Technology, the National Science Foundation, and U.S. Geological Survey.

Antiquities Act of 1906

Federal protection for significant paleontological resources would apply to the project if any construction or other related project impacts occurred on Federally owned or managed lands. Federal legislative protection for paleontological resources stems from the Antiquities Act of 1906 (Public Law 59-209; 16 U.S. Code 431 et seq.; 34 Stat. 225), which calls for protection of historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on federal land.

Federal Cave Resource Protection Act of 1988

Cave and karst landform resources are provided Federal protection under the Federal Cave Resource Protection Act of 1988. Although not a legally binding agreement, the Interagency Agreement for Collaboration and Coordination in Cave and Karst Resources signed by U.S. Department of the Interior and U.S. Department of Agriculture land management agencies provides guidelines for the management, research, conservation, and protection of these resources.

Shasta-Trinity National Forest Land and Resource Management Plan

The STNF Land and Resource Management Plan (LRMP) (USFS 1995) contains forest goals, standards, and guidelines designed to guide the management of the STNF. The following goals, standards, and guidelines related to geologic and seismic hazards and soils issues associated with the study area were excerpted from the STNF LRMP.

- Goals (LRMP, p. 4-5):
  - Maintain or improve soil productivity and prevent excessive surface erosion, mass wasting, and cumulative watershed impacts.
- Standard and Guidelines (LRMP, p. 4-25):
  - Determine the sensitivity of each 2nd or 3rd order watershed using soil, geologic, and streamflow characteristics.
  - Implement Forest Soil Quality Standards and Best Management Practices for areas identified as having highly erodible soils. Specifically, apply the special practices dealing with timber harvest, site preparation, and road construction in highly erodible soils.
  - Forest Soil Quality Standards in relation to ground cover, soil organic matter, and soil porosity will be used to protect soil productivity (as referenced in Appendix O of the LRMP).

U.S. Bureau of Land Management Resource Management Plan

The U.S. Department of the Interior, Bureau of Land Management (BLM) Resource Management Plan, which is its plan for managing federal lands in Shasta County, was amended by the 1994 Record of Decision for the Northwest Forest Plan (Final Supplemental EIS for Amendments to USFS and BLM Planning Documents within the Range of the Northern Spotted Owl). This amendment required preparation of watershed analyses prior to initiating BLM activities. As a party to the Northwest Forest Plan, BLM, like USFS, is also required to ensure that projects are consistent with the Aquatic Conservation Strategy.

Federal Minerals Management

Mineral development is permitted on all public lands not withdrawn from mineral entry. The U.S. Mining Laws (30 U.S. Code 21–54) confer statutory right to enter upon public lands in search of minerals. Regulations found in 36 Code of Federal Regulations 228, Subpart A, set forth rules and procedures to minimize adverse environmental impacts on national forest resources. Access for mineral exploration and development is generally unrestricted, subject to the mitigation of adverse impacts on surface resources.

Access for mineral exploration on STNF land is restricted in wildernesses, the “wild” portions of Wild and Scenic Rivers, botanical areas, Research Natural Areas, NRAs, and areas that have been withdrawn from mineral entry. Minerals in the Whiskeytown-Shasta-Trinity NRA are not locatable (minerals that may be acquired under the Mining Law of 1872, as amended), but they are leasable (USFS 1994).

Access for mineral-related activities to wilderness, the NRA, and other lands typically withdrawn from mineral entry is subject to valid existing rights. The type of access authorized must be consistent with the proposed use and of a type that would maintain the special character of the areas to the fullest extent possible.

The Federal lands within the Shasta Unit of the Whiskeytown-Shasta-Trinity NRA were withdrawn from mineral entry under the 1872 Mining Law by the NRA legislation, subject to valid existing rights. Five claims in the NRA predate the withdrawal. Currently, there are no approved operating plans for these five mining claims.

4.2.2 State

This section discusses the State regulatory setting for soil erosion, water quality, earthquakes, mining, air quality (related to asbestos), paleontological resources, and building design.

Porter-Cologne Act

State regulations, including the Porter-Cologne Act and California Fish and Game Code Section 1600, have provisions to reduce soil erosion. The Porter-Cologne Act established the State Water Resources Control Board and nine RWQCBs that regulate water quality. The RWQCBs carry out the National Pollutant Discharge Elimination System permitting process for point source discharges and the CWA Section 401 certification program.

California Fish and Game Code Section 1600

California Fish and Game Code Section 1600 requires notification for projects that are planned to occur in, or in close proximity to, a river, stream, or lake, or their tributaries. Applicants are to enter into a “streambed alteration agreement” with the California Department of Fish and Wildlife when a construction activity would (1) divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake; (2) use material from a streambed; or (3) result in the disposal of debris, waste, or other material containing crumbled, flaked, or ground pavement that could pass into a river, stream, or lake. The Federal government is not required to submit a Fish and Game Code 1600 permit; however, the same impacts will be addressed under CWA Section 401 and 404 permits.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code Section 2621 et seq.) was passed by the California Legislature to mitigate the hazard of surface faulting to structures. The act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. Local agencies must regulate most development in fault zones established by the State Geologist. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, cities and counties must require a geologic investigation to demonstrate that proposed buildings would not be constructed across active faults.

1990 Seismic Hazards Mapping Act

The 1990 Seismic Hazards Mapping Act (California Public Resources Code Sections 2690 through 2699.6) addresses strong ground shaking, liquefaction, landslides, or other ground failures as a result of earthquakes. This act requires statewide identification and mapping of seismic hazard zones, which would be used by cities and counties to adequately prepare the safety element of their general plans and protect public health and safety (California Geological Survey 2003). Local agencies are also required to regulate development in any seismic hazard zones, primarily through permitting. Permits for development projects are not issued until geologic investigations have been completed and mitigation measures have been developed to address identified issues.

Surface Mining and Reclamation Act of 1975

The Surface Mining and Reclamation Act of 1975 (California Public Resources Code Section 2710 et seq.) addresses surface mining and requires mitigation to reduce adverse impacts on public health, property, and the environment. The Surface Mining and Reclamation Act applies to anyone (including a government agency) that disturbs more than 1 acre or removes more than 1,000 cubic yards of material through surface mining activities, even if activities occur on Federally managed lands (CDMG 2006b). Local city and county "lead agencies" develop ordinances for permitting that provide the regulatory framework for mining and reclamation activities. The permit generally includes a permit to mine, a reclamation plan to return the land to a useable condition, and financial reports to ensure reclamation would be feasible. The State Mining and Geology Board reviews lead agency ordinances to ensure they comply with Surface Mining and Reclamation Act (CDMG 2006b).

Asbestos Airborne Toxic Control Measure for Construction, Grading, Quarrying, and Surface Mining Operations

The Asbestos Airborne Toxic Control Measure for Construction, Grading, Quarrying, and Surface Mining Operations (Title 17, California Code of Regulations (CCR) Section 93105 (17 CCR Section 93105)) contains the requirements for construction operations that would disturb any portion of an area that is located in a geographic ultramafic rock unit or that has naturally occurring asbestos, serpentine, or ultramafic rock. Construction or grading operations on property where the area to be disturbed is greater than 1 acre require that an asbestos dust mitigation plan be submitted and approved by the air quality management district before the start of construction. The asbestos dust mitigation plan must be implemented at the beginning and must be maintained throughout the operation. To receive an exemption from this asbestos airborne toxic control measure, a State-registered professional geologist must conduct a geologic evaluation of the property and determine that no serpentine or ultramafic rock is likely to be found in the area to be disturbed. This report must be presented to the executive officer or air pollution control officer of the air pollution control or air quality management district, who may then grant or deny the exemption.

Asbestos Airborne Toxic Control Measure for Surfacing Applications

The Asbestos Airborne Toxic Control Measure for Surfacing Applications (17 CCR Section 93106) applies to any person who produces, sells, supplies, offers for sale or supply, uses, applies, or transports any aggregate material extracted from property where any portion of the property is located in a geographic ultramafic rock unit or the material has been determined to be ultramafic rock, or serpentine, or material that has an asbestos content of 0.25 percent or greater. Unless exempt, the use, sale, application, or transport of material for surfacing is restricted, unless it has been tested using an approved asbestos bulk test method and determined to have an asbestos content that is less than 0.25 percent. Any recipient of such materials may need to be provided a receipt with the quantity of materials, the date of the sale, verification that the asbestos content is less than 0.25 percent, and a warning label. Anyone involved in the transportation of the material must keep copies of all receipts with the materials at all times.

California Public Resources Code Chapter 1.7

No State or local agency requires a paleontological collecting permit to allow for the recovery of fossil remains discovered as a result of construction-related earthmoving on State or private land in a project site. California Public Resources Code Chapter 1.7 (Archaeological, Paleontological, and Historical Sites), Section 5097.3, specifies that State agencies may undertake surveys, excavations, or other operations as necessary on State lands to preserve or record paleontological resources.

California Building Standards Code

The State of California provides minimum standards for building design through the California Building Standards Code (CBC) (see Title 24, Part 2, Table 18-1-B). Where no other building codes apply, Chapter 29 regulates excavation, foundations, and retaining walls. The CBC also applies to building design and construction in the State and is based on the Federal Uniform Building Code used widely throughout the country (generally adopted on a state-by-state or district-by-district basis). The CBC has been modified for California conditions with numerous more detailed and/or more stringent regulations.

The State's earthquake protection law (California Health and Safety Code, Section 19100 et seq.) requires that structures be designed to resist stresses produced by lateral forces caused by wind and earthquakes. Specific minimum seismic safety and structural design requirements are set forth in Chapter 16 of the CBC. The CBC identifies seismic factors that must be considered in structural design.

Chapter 18 of the CBC regulates the excavation of foundations and retaining walls, and Appendix Chapter A33 regulates grading activities, including drainage and erosion control, and construction on unstable soils such as expansive soils and liquefaction areas.

4.2.3 Regional and Local

The following section describes the regional and local regulatory setting for geological resources.

County General Plans

Section 65302(g) of the California Government Code requires that county general plans include an element that identifies and appraises seismic and geologic hazards.

Seismic hazards that must be addressed in this section include the following:

- Surface faulting
- Ground shaking
- Ground failure

Nonseismic hazards addressed include the following:

- Volcanoes
- Erosion
- Expansive soils

Local Guiding Ordinances

In addition to identifying and appraising seismic and geologic hazards, counties and municipalities in the project study area also commonly set requirements for grading and erosion control, including prevention of sedimentation or damage to off-site property. Usually these requirements are established via a grading ordinance, which is administered through issuance of grading permits. Grading permits typically require a vested map and the following information:

- Detailed grading plan
- Geological studies, if the project is located within an area prone to slippage, having highly erodible soils, or of known geologic hazards
- Detailed drainage or flood control information as required by the department of public works
- Final plan for development, if the project is located in a zone district that requires a final development plan
- Noise analysis, if the project is located in the vicinity of a high-noise-generating use

4.3 Environmental Consequences and Mitigation Measures

This section discusses environmental consequences on geology, geologic hazards, geomorphology, minerals, and soils associated with implementation of the project alternatives. It also describes potential mitigation measures associated with impacts on geology that are significant or potentially significant.

4.3.1 Methods and Assumptions

In general, the analysis presented in this section is qualitative and is based on general information on geology, geologic hazards, geomorphology, minerals, and soils, as reported in Section 4.1. Environmental consequences associated with geologic resources that could result from implementing alternatives were evaluated qualitatively based on expected construction methods; environmental commitments common to all action alternatives; and the locations, materials, and durations of project construction and related activities.

As described in following paragraphs, for the Shasta Lake and vicinity portion of the primary study area, more quantitative analyses were undertaken to address geomorphology (i.e., stream characteristics in watersheds that are adjacent and directly tributary to Shasta Lake) (also see Section 4.1.3) and shoreline erosion (also see Section 4.1.5).

Geomorphology

The analysis of fluvial characteristics of watersheds that are adjacent and directly tributary to Shasta Lake evaluated the impact of raising Shasta Dam on stream channel equilibrium, focusing on the balance between sediment transport capacity and channel stability. The average gradient and flow regime of a watercourse are often the variables that control the sediment transport capacity of a given stream channel. The flow regime of a stream is determined by the measure of the average flow of surface water. The analysis assumed that any stream that has a predicted average annual flow above 0.1 cubic feet per second (cfs) functions as a perennial stream, and any stream with a predicted flow of less than 0.1 cfs functions as an intermittent stream.

Typically, over time, streams reach a natural state of equilibrium based on their gradient and sediment transport capacity. Raising the water level of Shasta Lake may affect the equilibrium of watercourses that are controlled by the present reservoir level. Raising the dam may destabilize these streams by altering the length of stream that will be incorporated into the drawdown. Raising the dam will affect the gradient of adjacent watercourses by altering the length of the watercourse and the change in elevation due to seasonal fluctuations in lake water levels. This is the rationale behind analyzing the gradient and flow regime of watercourses that are adjacent and directly tributary to Shasta Lake.

The stream networks in the Shasta Lake and vicinity area were characterized using the Net Trace model generated in a geographic information system (GIS) environment. Net Trace was used because existing California and USFS stream layers lack the level of detail and necessary variables needed to assess the impact of raising the water level of Shasta Lake on stream channel equilibrium. Initially, sub-10-meter digital elevation models covering the Shasta Lake and vicinity were imported into GIS. Using the methods described in programs for digital elevation model analysis (Miller 2003), a surface stream network with user-selected attributes was created using Net Trace. The following characteristics were then calculated for each stream segment: drainage area, riparian area, length, flow direction (degrees), stream order, elevation, gradient statistics, mean precipitation, and mean annual stream flow (cfs).

To verify the accuracy of the Net Trace stream model, the measured bed gradient along surveyed transects on Squaw Creek and Big Backbone Creek was compared to the modeled gradient values calculated by Net Trace along the same transect. The combined average difference between the measured and modeled bed gradient was approximately 4.5 percent, meaning that the measured stream bed gradient is steeper than the modeled gradient. A sampling bias is believed to be the cause of the disparity. For example, 22 segments were surveyed along the Squaw Creek transect and used to determine the measured bed gradient; however, only 5 segments were available from the Net Trace model to calculate the gradient. Simply, the surveyed transects were measured at greater level of detail than were calculated in the Net Trace model.

Although the surveyed gradient values are more accurate than the modeled values, it would be impractical to survey every watercourse within a study area as large as that of the SLWRI. Because this study seeks to characterize the stream channel, a more reasonable approach was to compare the surveyed water surface gradient to the modeled values. This approach eliminates the topographic details of the streambed surface and measures the surface gradient of the stream over the entire transect. The combined average difference between the measured surface gradient and modeled bed gradient was about 2 percent, meaning the measured stream bed gradient is 2 percent steeper than the modeled gradient. Although this disparity is noteworthy, the modeled stream network is considered an accurate representation of the hydrologic system of the study area, and the lower gradient values produce a more conservative estimate of sediment transport within the system. These results suggest that the digital elevation model–generated stream network is accurate enough to be used as a measure of the potential impacts of raising Shasta Dam on stream channel equilibrium.

Using GIS, the Net Trace stream network was intersected with polygons representative of shoreline area affected through the inundation by each alternative. These intersections were completed for each arm of Shasta Lake. The total stream length and riparian area affected by the inundation were calculated for each arm and summarized to calculate the value for the entire shoreline of Shasta Lake. The affected stream length and riparian areas were also calculated in further detail for perennial and intermittent streams by stream-gradient categories of less than or greater than 10 percent.

Soil Erosion (Shoreline)

A conceptual model was developed to predict the rate and volume of shoreline erosion. The methods and assumptions used for the model are described in Attachment 1, “Shoreline Erosion Technical Memorandum.” The conceptual model represents the spatial and temporal components of shoreline erosion, and was developed as a framework for field investigations, quantifying present erosion rates, and predicting future erosion rates. The process-based model characterizes the primary causes of shoreline erosion and uses external erosion triggers to weight the relative erodibility of the shoreline. The model was developed using results from similar studies; available precipitation, wind, and lake level data; information concerning the engineering properties of the bedrock geology and soils; the shoreline and hillslope topography; measured erosion processes and rates from sequential historical aerial photographs; and field investigations. Because there were very few shoreline erosion studies for reservoirs as large as Shasta Lake to use as background and support for the analysis, readily available references were used to help characterize the process of shoreline erosion, verify the predicted shoreline erosion rates, and design mitigation measures.

The model divided the shoreline into two zones, which helped account for the episodic nature of erosional events. The nearshore zone is classified as the area above the 1,070-foot contour, and represents the “bathtub” ring around the reservoir. The drawdown zone is classified as the area between the 1,070-foot contour and the 1,020-foot contour. The latter contour was used to represent the drawdown level that typically occurs to meet USACE requirements for flood storage capacity. The nearshore zone is eroded by wave action when the reservoir is full. During drawdown periods, this zone erodes as a result of upland surface runoff, subsurface flow, and fluvial incision along stream channels and gullies.

To represent the temporal component of shoreline erosion, the model compartmentalizes shoreline development into three time steps. The first step lasts for about 15 years and is when most of the erosion occurs (Morris and Fan 1997). During this time, the inundated soils are fully saturated; as a result, they lose cohesion and are subject to rapid erosion, transport, and deposition. Shoreline exposed in the drawdown zone is typically eroded to bedrock or to resilient soil layers, leaving an exposed surface that supports little vegetation. Within this zone, stream channels and gullies rapidly incise the underlying soil and rock.

The second time step can last between about 0 and 150 years. During this time, stable shoreline topography is developing through a sequence of slope-forming events. For modeling purposes, the types of slope-forming events were classified by lithotopo unit because several common processes trigger and control erosion. The shoreline erosion survey data suggest that stable hillslopes are typically associated with shallow soils on coherent bedrock, forming steep topography (greater than 65 percent slope gradient). Unstable hillslopes are associated with deep soils on moderately steep areas (between 30 percent and 65 percent). Around Shasta Lake, stable shoreline formed rapidly during the first 15 years of lake management. Conversely, about 60 years later, unstable hillslopes are still responding to erosional forces and, in some locations, continue to erode at a very high rate (greater than 900 cubic yards/acre/year).

The third time step is used to represent a period when the shoreline slope is stable and soil shear strength remains greater than the shear stresses acting on the slope. During this time, the erosion rate continues to decrease and eventually equals the upslope erosion rates. The analysis assumes that most of the shoreline around Shasta Lake will become stable as the reservoir ages, and the data show that about half of the shoreline is presently stable.

4.3.2 Criteria for Determining Significance of Effects

An environmental document prepared to comply with NEPA must consider the context and intensity of the environmental consequences that would be caused by, or result from, the proposed action. Under NEPA, the significance of an environmental consequence is used solely to determine whether an EIS must be prepared. An environmental document prepared to comply with CEQA must identify the potentially significant environmental effects of a proposed project. A “[s]ignificant effect on the environment” means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project (State CEQA Guidelines, Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental effects (State CEQA Guidelines, Section 15126.4(a).

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

- Expose people or structures to potential substantial adverse effects, including the risk of loss, or injury, or death involving the following:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault
  - Strong seismic ground shaking
  - Seismic-related ground failure, including liquefaction
  - Landslides
- Result in substantial soil erosion or loss of topsoil
- Locate project facilities on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse
- Locate project facilities on expansive soil, as defined in Table 18-1-B of the Uniform Building Code, creating substantial risks to life or property
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for disposal of wastewater
- Result in the loss or availability of known mineral resources that would be of future value to the region

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

4.3.3 Topics Eliminated from Further Discussion

The topics of snow avalanches, expansive soil, and soil liquefaction are eliminated from the discussion of environmental consequences owing to the low likelihood of their occurrence as previously discussed (see Section 4.1.2 for snow avalanches and Section 4.15 for other eliminated topics).

Paleontological resources are not included in the discussion of environmental consequences. As described in Section 4.1.1, a small area of the fossiliferous Cretaceous Chico Formation occurs near Jones Valley Creek, a tributary to the Pit Arm, but this rock unit is not exposed along the shoreline of the lake, and falls outside the study subarea. Some outcrops of McCloud Limestone, especially in the vicinity of the McCloud River Bridge, also contain fossil corals and other microinvertebrates. Some areas underlain by limestone are likely to be disturbed regardless of the action alternative being considered. However, the fossils that compose the McCloud Limestone are well documented in the scientific literature, and it is unlikely that paleontological resources of scientific or cultural significance occur in this formation.

Paleontological resources have been eliminated from further discussion in the upper Sacramento River (Shasta Dam to Red Bluff), lower Sacramento River and Delta, and CVP/SWP service areas because no impacts are anticipated to these resources as a result of reoperation of the dam.

4.3.4 Direct and Indirect Effects

The following section describes the potential environmental consequences of the project, and impacts and mitigation measures.

No-Action Alternative

This section describes potential impacts that would occur under the NEPA No-Action Alternative. Under the No-Action Alternative, no additional Federal action would be taken to address water reliability issues or increase anadromous fish survival. Shasta Dam would not be modified, and the CVP would continue operating similar to the existing condition. No new construction would occur under the No-Action Alternative and the full pool elevation of the reservoir would remain at approximately 1,070 feet above msl.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake and vicinity portion of the primary study area.

Impact Geo-1 (No-Action): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption Under the No-Action Alternative, no new construction would occur and the full pool level would not be increased. Therefore, there would be no increase in the risk of geologic hazards to people or structures. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-2 (No-Action): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Under the No-Action Alternative, the full pool level would not be increased. Therefore, there would be no change to streams tributary to Shasta Lake. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-3 (No-Action): Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Under the No-Action Alternative, no new construction would occur and the full pool level would not be increased. Therefore, there would be no loss or diminished availability of known mineral resources that would be of future value to the region. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-4 (No-Action): Lost or Diminished Soil Biomass Productivity Under the No-Action Alternative, no new construction would occur and the full pool level would not be increased. Therefore, there would be no lost or diminished soil biomass productivity. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-5 (No-Action): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under the No-Action Alternative, the full pool level would not be increased. Therefore, there would be no increase in soil erosion or loss of topsoil due to shoreline processes. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-6 (No-Action): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes Under the No-Action Alternative, there would be no disturbance of upland landscape positions. Therefore, there would be no increase in soil erosion or loss of topsoil due to upland processes. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-7 (No-Action): Location on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence Under the No-Action Alternative, no new construction would occur and the full pool level would not be increased. Therefore, there would be no increase in the risk of land subsidence. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-8 (No-Action): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that Are Unsuited to Land Application of Waste Under the No-Action Alternative, no new construction would occur and the full pool level would not be increased. Therefore, there would be no increase in the risk of failure of septic tanks or alternative wastewater disposal systems. No impact would occur. Mitigation is not required for the No-Action Alternative.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes impacts on the upper Sacramento River portion of the primary study area.

Impact Geo-9 (No-Action): Substantial Increase in Channel Erosion and Meander Migration No Shasta Dam enlargement activities would be implemented, and no new water releases from the dam would occur as a result of the No-Action Alternative. The water releases from the dam would continue to vary based on time of year, water year types, and system conditions. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-10 (No-Action): Substantial Soil Erosion or Loss of Topsoil Due to Construction No Shasta Dam enlargement activities would be implemented, and no gravel augmentation activities would occur as a result of the No-Action Alternative. Therefore, no soil additional soil erosion would be anticipated on the banks along the river channel. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-11 (No-Action): Alteration of Fluvial Geomorphology Under the No-Action Alternative, no potential upper Sacramento River restoration activities would occur. Therefore, no changes in fluvial geomorphology would be anticipated. No impact would occur. Mitigation is not required for the No-Action Alternative.

Impact Geo-12 (No-Action): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under the No-Action Alternative, Shasta Dam operations would not change. Therefore, no changes in the fluvial geomorphology of downstream tributaries would be anticipated. No impact would occur. Mitigation is not required for the No-Action Alternative.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with the No-Action Alternative.

Impact Geo-13 (No-Action): Substantial Increase in Channel Erosion and Meander Migration No Shasta Dam enlargement activities would be implemented, and no new water releases from the dam would occur as a result of the No-Action Alternative. The water releases from the dam would continue to vary based on time of year, water year types, and system conditions. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

CVP/SWP Service Areas This section describes the impacts associated with the No-Action Alternative on the CVP/SWP service areas within the extended study area.

Impact Geo-14 (No-Action): Substantial Increase in Channel Erosion and Meander Migration No Shasta Dam enlargement activities would be implemented, and no new water releases from the dam would occur as a result of the No-Action Alternative. No changes in operations would occur under the No-Action Alternative. The water releases from the from Shasta Dam, Folsom Dam, and Oroville Dam would continue to vary based on time of year, water year types, and system conditions, but would not be anticipated to be outside of normal operating conditions. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

This section describes impacts associated with CP1, which focuses on increasing water supply reliability while contributing to increased anadromous fish survival by raising Shasta Dam 6.5 feet. The dam raise would increase the reservoir's full pool by 8.5 feet, and enlarge total storage space in the reservoir by 256,000 acre-feet. Section 2.3.8 in Chapter 2, "Alternatives" describes the construction activities and potential borrow sources associated with CP1.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake and vicinity portion of the primary study area.

Impact Geo-1 (CP1): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption Implementing CP1 has the potential to increase the exposure of structures and people to geologic hazards.

There are very few seismic hazard areas within the Shasta Lake and vicinity area. No active faults are known to be present within or immediately adjacent to the Shasta Lake and vicinity area, and there is a low risk of fault rupture (CDMG 2006a). According to Jennings (1994) and the California Department of Conservation, Division of Mines and Geology (1997), all known faults around the Shasta Lake and vicinity area are classified as inactive. (Inactive faults show no evidence of movement in the last 10,000 years (i.e., Holocene).) Because there are few active faults in close proximity to the Shasta Lake and vicinity area, the likelihood of strong seismic ground shaking also is low. Detailed, site-specific geologic and foundation investigations will be completed to develop design criteria to withstand reasonably probable seismic events. This impact would be less than significant.

Under CP1, the pool level increase would inundate 78 acres of mapped slope instability hazards (i.e., active and relict landslides, debris flows, inner gorge landscape positions, and complexes of these features). Relocation of infrastructure is proposed to occur in the vicinity of up to about 232 acres of mapped slope instability hazards. Inundation of bedrock and soils resulting from the increased pool elevation, and earthwork and vegetation removal associated with new construction, could reduce the stability of hillslopes prone to mass wasting. The existing relict and active mass wasting features may become less stable. The risks associated with increased slope instability due to the rise in pool elevation and relocation of infrastructure have been considered in formulating the description of CP1. Areas of known instability have been addressed via avoidance or through design measures intended to minimize the risk of increased instability. This impact would be less than significant.

Hazards associated with volcanic eruptions have a low probability of occurring within the Shasta Lake and vicinity area. Significant impacts resulting from eruptions in the Medicine Lake Highlands and at Lassen Peak are unlikely due to their distance from Shasta Lake and the lack of drainage connections. Eruptions of Mount Shasta are not likely to deposit lithic ash, lava flows, domes, or pyroclastic flows within the reservoir, and Mount Shasta is not likely to erupt large volumes of pumiceous ash. The danger from floods caused by eruptions is similar to that from floods having other origins, and would be mitigated via the proposed dam modifications (e.g., increased spillway capacity) and operational procedures. This impact would be less than significant.

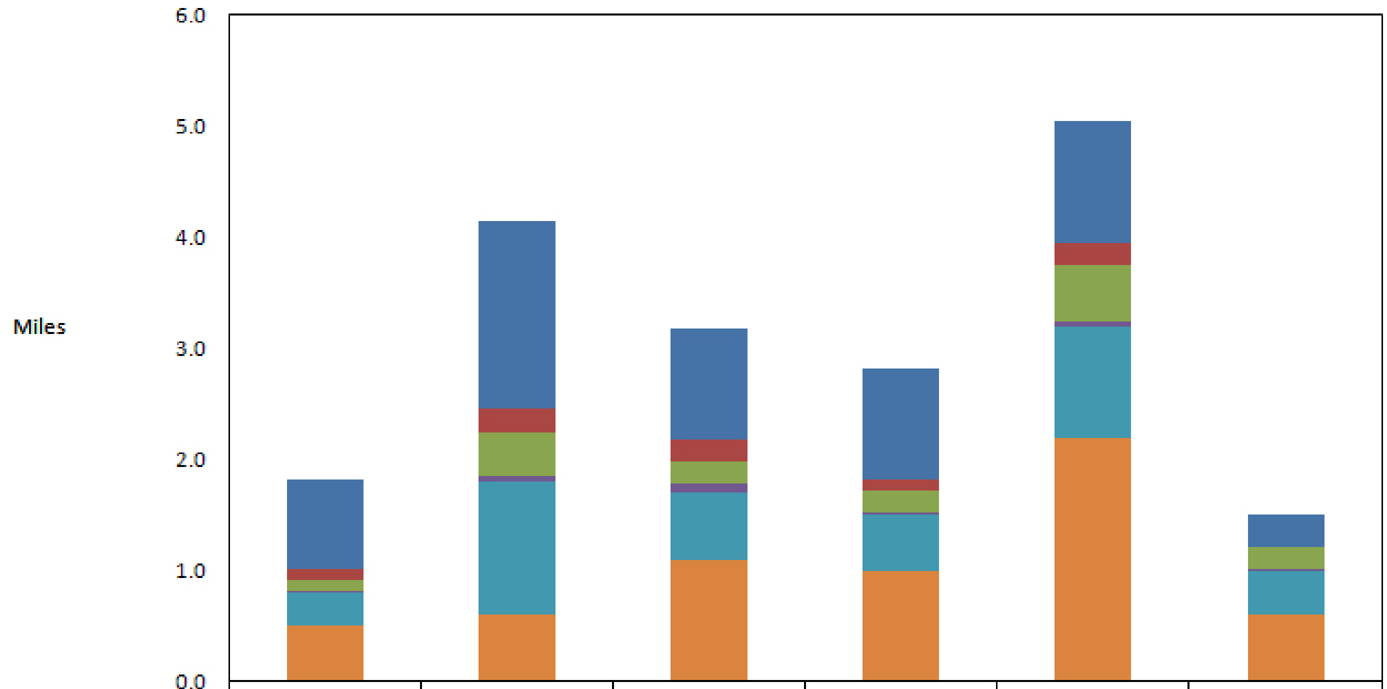
Similarly, the dangers from mudflows and seiche hazards are low, and would be mitigated via the proposed dam modifications (e.g., increased spillway capacity) and operational procedures. There are few seismic hazard areas within the Shasta Lake and vicinity area that would expose structures or people to geologic hazards. However, site-specific geologic and foundation investigations will be conducted to develop design criteria to withstand reasonably probable seismic events. In addition, areas of known instability around the perimeter of the lake shore have been addressed via avoidance or through design measures to minimize exposure of structures or people to slope instability. There is a low probability of hazards associated with volcanic eruptions within the Shasta Lake and vicinity area, but any potential for floods caused by eruptions is similar to that from floods having other origins and would be mitigated via the proposed dam modifications and operational procedures. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-2 (CP1): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Under CP1, stream channel equilibrium and geomorphology would be affected by an increase in full pool level. Lower gradient channels (less than 7 percent slope) with existing delta deposits would be affected more than higher gradient channels. It is likely that the delta deposits would expand both upstream and downstream as a result of this alternative. When the lake is full and regional flooding occurs, sediment transported from the uplands would be deposited as deltas at the confluence of the streams and lake. When the lake level is low during base-flow periods, stream channels within the inundation zone are likely to be channelized as they downcut into the Delta deposits. In the lower gradient channels, the stream type could shift to an unstable braided channel. This impact would be significant.

Inundation of lower gradient streams draining to Shasta Lake could result in long-term changes to channel equilibrium by changing the sediment transport capacity of the stream channels between 1,070 and 1,080 feet of elevation. CP1 could also destabilize the stream channels as a result of riparian vegetation loss on the lower and upper banks and a more mobile stream bed.

Based on a GIS-generated stream network, the total stream length inundated as a result of CP1 is estimated to be 18.5 miles (see Figure 4-8), which equates to about 0.7 percent of the total length of the streams in watersheds that are directly adjacent and contributory to Shasta Lake. Of the 18.5 miles inundated, about 6.2 miles are streams with a gradient of less than 7 percent.

The increase in full pool would affect streams by altering fluvial geomorphology and the hydrology of aquatic habitats as described above. This impact would be significant. Mitigation for this impact is proposed in Section 4.3.5.



	Big Backbone Creek	Main Body	McCloud River	Pit River	Sacramento River	Squaw Creek
Intermittent >10% Grade	0.8	1.7	1.0	1.0	1.1	0.3
Perennial >10% Grade	0.1	0.2	0.2	0.1	0.2	0.0
Intermittent 7-10% Grade	0.1	0.4	0.2	0.2	0.5	0.2
Perennial 7-10% Grade	0.02	0.05	0.08	0.02	0.05	0.01
Intermittent <7% Grade	0.3	1.2	0.6	0.5	1.0	0.4
Perennial <7% Grade	0.5	0.6	1.1	1.0	2.2	0.6

Figure 4-8. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP1

Impact Geo-3 (CP1): Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Significant quantities of cement, concrete sand and aggregate, and coarse aggregate would be needed under CP1. Cement Types I, II, III, and V are produced locally, but supplies are limited. Required quantities of concrete sand and aggregate are available from local commercial suppliers. The tonnage of sand anticipated to be needed is roughly more than 150 percent of the annual Shasta County production of sand and gravel. Embankment material (i.e., coarse aggregate) could be obtained from local sources, including from within Shasta Lake itself. Implementation of CP1 has the potential to diminish the availability of cement, and of concrete sand and aggregate, in the region. This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-4 (CP1): Lost or Diminished Soil Biomass Productivity Under CP1, soil productivity would be lost due to periodic inundation caused by increasing the full pool elevation and by construction including relocation of infrastructure. Using Equivalent FSSC as a surrogate metric for soil biomass productivity, implementation of CP1 would result in loss of the following acreages by productivity rank: moderate productivity – 1,954.6 acres; low productivity – 1,604.5 acres; nonproductive – 565 acres.

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-5 (CP1): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under CP1, the area of shoreline that would be periodically inundated would be about 1,229 acres. Substantial soil erosion and loss of topsoil would result. This impact would be significant.

The inundated area would be subjected to shoreline erosional processes. For the first 15 years after the dam raise, the average rate of shoreline erosion would increase substantially, from 90 cubic yards per acre per year to about 300 cubic yards per acre per year. For the first time step (i.e., 15 years), the total average annual volume of potential shoreline erosion from CP1 would be about 421,000 cubic yards per year. Within 60 years of the dam raise, the average annual volume is predicted to decrease to 107,000 cubic yards per year.

Sediment delivery from shoreline erosion would likely be greatest in the Sacramento Arm, the eastern portion of the Main Body of the lake, and the McCloud Arm. These three arms are predicted to deliver more than 66,000 cubic yards per year for the first 15 years after the dam raise. Within 60 years of the dam raise, the average rate for these arms is predicted to decrease to 19,000 cubic yards per year. The western portion of the Main Body of Shasta Lake and the Backbone Creek Arm are predicted to have the lowest shoreline erosion rates, resulting in a 15-year average annual potential erosion volume of less than

26,000 cubic yards per year. The Pit Arm is predicted to produce about 50,000 cubic yards per year and the Squaw Creek Arm about 35,000 cubic yards per year.

Assuming the available vegetation removal prescriptions between the 1,070-foot and 1,080-foot contours, for the first time step (i.e., 15 years after the raising of Shasta Dam), there would be about 421,000 cubic yards per year of shoreline erosion. After about 15–20 years, depending on climatic variability, the new shoreline would form and would start to stabilize. Total reservoir erosion is predicted to decrease by 70 percent between 15 and 60 years after the dam raise. The wetter the climate cycle, the more rapidly the shoreline is predicted to form.

The analysis also calculated the 15-year erosion volume using the prescribed vegetation treatments and modeled higher erosion rates for shoreline with partial and complete vegetation removal. The Big Backbone, Squaw Creek, and Pit arms would have very little vegetation removal, which would not affect the short-term rate of shoreline erosion. The Main Body and the Sacramento and McCloud arms would have substantial amounts of vegetation removal, which would result in higher short-term erosion rates. For these arms, areas treated by vegetation removal represent about half of the total predicted erosion.

Soil erosion due to shoreline processes is estimated to be 421,000 cubic yards per year, assuming the available vegetation removal prescriptions between 1,070-foot and 1,080-foot contours would occur in the first 15 years after the raising of Shasta Dam. This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-6 (CP1): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes Interpretations of soil susceptibility to erosion are presented in Table 4-12 for the portion of the area potentially disturbed by construction activities. Up to approximately 3,340 acres in the upland portion of the Shasta Lake and vicinity area could be disturbed, and up to 3,128 acres (94 percent of total area) are assigned a hazard rating of severe. A severe rating indicates that significant erosion is expected, and that extensive erosion-control measures are needed. This impact would be less than significant.

Construction-related erosion will be avoided and minimized via implementation of the storm water pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans will address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement best management practices for erosion and sediment control. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-7 (CP1): Location of Project Facilities on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence Of the approximately 3,340 acres in the upland portion of the Shasta Lake and vicinity area, 175.5 acres (5.3 percent of total area) occupy landscape positions underlain by limestone. Land subsidence has potential to occur in areas underlain by certain limestones, and in areas affected by underground construction. Detailed, site-specific geologic and foundation investigations will be completed to inform project design as to how to avoid potential subsidence from these causes. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-8 (CP1): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that Are Unsuited to Land Application of Waste In general, soils in the Shasta Lake and vicinity area are poorly suited to use as septic tank leach fields or alternative waste disposal systems due to shallow soil depth, high rock content, and excessive slope. Relocated wastewater facilities would be designed and constructed to satisfy the conditions of the Shasta County Environmental Health Division Sewage Disposal System Permit. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes impacts on the upper Sacramento River portion of the primary study area associated with CP1.

Impact Geo-9 (CP1): Substantial Increase in Channel Erosion and Meander Migration This impact would be similar to Impact Geo-9 (No-Action). However, by altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, this alternative would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream stream erosion and change downstream geomorphologic characteristics. However, the frequency and duration of high-flow events resulting from this action are expected to be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase. This impact would be less than significant.

Reductions of stream bedload contribution are greatest during high-flow events. Bed and bank conditions in streams and rivers are created, maintained, and destroyed by natural geomorphic processes whose rates and patterns are regulated through complex interactions of flow, sediment transport, and properties of the channel and floodplain (including slope, erodibility, and morphology). Because large fluvial systems, such as the Sacramento River and its floodplain, are affected by the interaction of a wide variety of geomorphic processes, quantifying and understanding how they evolve can be complex. The legacy of land and water use in a region adds to the complexity, modulating factors such as flow, sediment supply, and floodplain erodibility, thus affecting the dynamics of riverine and floodplain characteristics.

High-flow events can mobilize and scour gravel stored in the channel bed, routing the sediment downstream. In the alluvial reaches of unregulated rivers, the sediment scoured from a local reach is generally replaced by sediment transported from upstream, supplied from tributaries, or recruited from storage in riverbanks. There may be short-term or local changes in the amount of gravel stored in a channel bed due to episodic sediment delivery (e.g., mass wasting events in the watershed) or extreme flow events. However, over a broader time span, unregulated rivers generally achieve a balance between sediment supply and routing so that in-channel sediment storage is maintained.

The first significant natural source of sediment to the Sacramento River is nearly 30 miles (48 kilometers) downstream from Keswick Dam at Cottonwood Creek (River Mile 273.5). Tributaries between Keswick Dam and Cottonwood Creek contribute little sediment to the mainstem because they drain small basins of erosion-resistant material or, as is the case for Clear Creek, are themselves regulated by dams and are affected by aggregate mining. Much of the upper Sacramento River (i.e., from River Mile 302 to approximately River Mile 273.5) is bounded by erosion-resistant bedrock and terrace deposits, such that bank erosion is not fast enough, relative to in-channel transport, to provide a significant source of coarse sediment. In other words, the rate of supply from erosion of banks due to meander migration in the upper river is minimal.

Meander migration and bank erosion occur by two processes: progressive channel migration, in which flows erode banks incrementally, and episodic meander-bend cutoff, in which the channel avulses to a completely new course. Cutoffs may be partial or complete, depending on initial meander bend geometry and the resistance of bank and floodplain materials to erosion, among other factors. Complete cutoffs are often referred to as “chute cutoffs.” Partial cutoffs are sometimes also referred to as “neck cutoffs” in geomorphology texts and literature. While progressive migration and episodic cutoff can generally be thought of as distinct (i.e., mutually exclusive) processes, they are nevertheless interrelated because they simultaneously regulate and are affected by sinuosity and other channel characteristics.

An erosion and sediment control plan would be implemented, as described in Section 2.3.2, “Environmental Commitments Common to All Action Alternatives,” in Chapter 2, “Alternatives,” to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant. Mitigation for this impact is not needed. However, mitigation for this impact is proposed in Section 4.3.5 to further reduce the impact.

Impact Geo-10 (CP1): Substantial Soil Erosion or Loss of Topsoil Due to Construction With implementation of CP1, no gravel augmentation activities or construction activities would occur at potential upper Sacramento River restoration sites. Therefore, no additional soil erosion would be anticipated on the banks along the river channel. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-11 (CP1): Alteration of Fluvial Geomorphology With implementation of CP1, no potential upper Sacramento River restoration activities would occur. Therefore, no changes in fluvial geomorphology would be anticipated. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-12 (CP1): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under CP1, the fluvial geomorphology of downstream tributaries would not be affected by changes in Sacramento River stage attributed to Shasta Dam operations. By altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, CP1 would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River. Small increases in Sacramento River stage may occur with implementation of CP1. However, the frequency and duration of high-flow events resulting from CP1 implementation are expected to be reduced as compared to existing conditions with current operations. This impact would be less than significant.

Where they occur, geomorphic changes (headcutting, channel incisement, etc.) in major tributaries in Cow, Clear and Cottonwood creeks has been directly attributed to the presence of dams (on Clear Creek) and past and current instream gravel mining on the tributaries themselves. Geomorphic changes at these major tributaries have not been linked with Shasta Dam operations. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with CP1.

Impact Geo-13 (CP1): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP1 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. With implementation of CP1, there would be a potential reduction in high-flow events. Therefore, increases in Sacramento River flow would be limited and effects on reservoirs and rivers in the extended study area would be attenuated and dissipated by the large number of these water bodies, as well as flood bypasses in the extended study area. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), but would take place in the lower Sacramento River and Delta where the effects of increases in Sacramento River flow would be limited and effects on reservoirs and rivers would be attenuated and dissipated. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CVP/SWP Service Areas This section describes impacts on the CVP/SWP service areas within the extended study area associated with CP1.

Impact Geo-14 (CP1): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP1 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Changes in water operations in the CVP/SWP service areas could potentially result in small changes in flow in the American and Feather rivers, as a result of operations at Folsom Dam and Oroville Dam. However, changes in flow affecting these reservoirs and rivers in the extended study area would be within the normal range of conditions and would not be expected to result in an increase in channel erosion or meander migration. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), but would be associated with the CVP/SWP service areas that extend along the Sacramento River. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

This section describes impacts associated with CP2, which focuses on enlarging Shasta Dam and Reservoir by raising Shasta Dam 12.5 feet. The dam raise would increase the reservoir's full pool by 14.5 feet, and enlarge total storage space in the reservoir by 443,000 acre-feet. Section 2.3.8 in Chapter 2, "Alternatives" describes the construction activities and potential borrow sources associated with CP2.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake portion of the primary study area.

Impact Geo-1 (CP2): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption Implementing CP2 has the potential to increase the exposure of structures and people to geologic hazards similar to CP1. For the same reasons as apply to CP1, impacts resulting from seismic conditions would be less than significant for CP2.

Under CP2, the pool level increase would inundate 110 acres of mapped slope instability hazards. Relocation of infrastructure under CP2 would occur in the vicinity of mapped slope instability hazards to a similar but greater extent than under CP1 (up to about 232 acres). For the same reasons as apply to CP1, impacts resulting from slope instability hazards would be less than significant for CP2.

For the same reasons as apply to CP1, impacts resulting from hazards associated with volcanic eruptions would be less than significant for CP2.

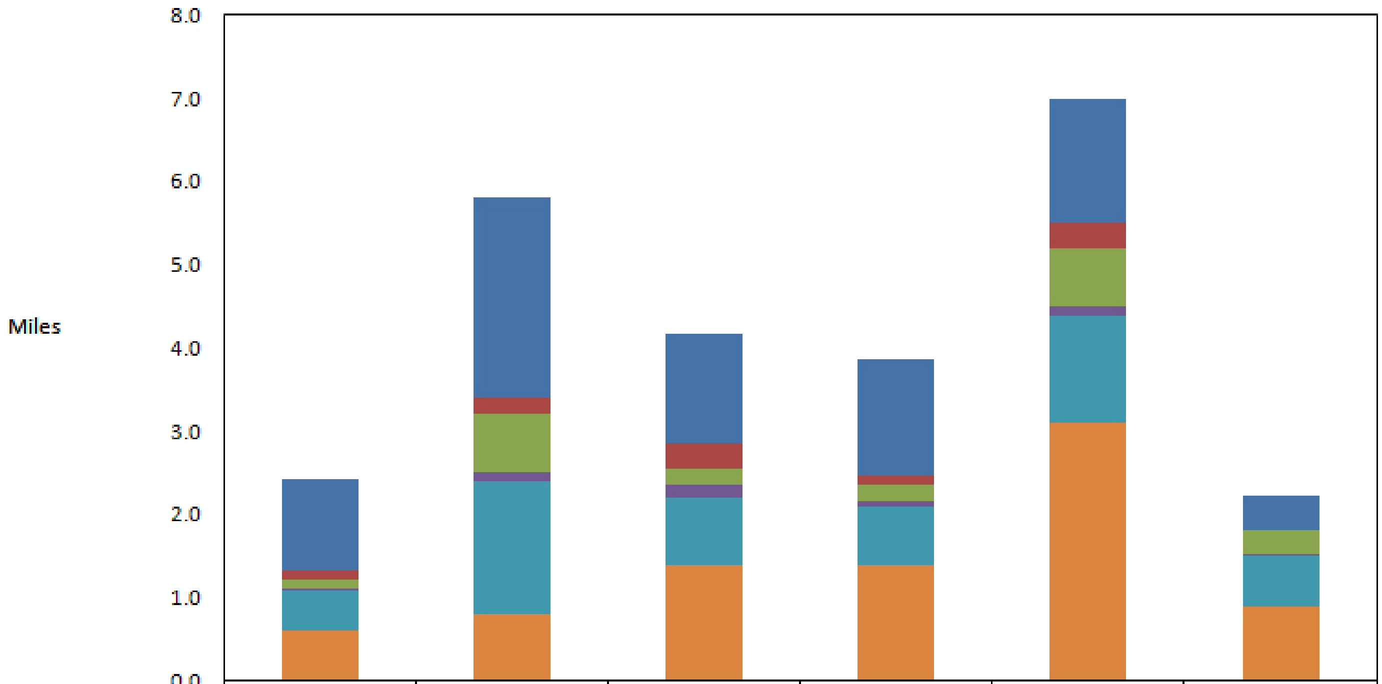
There are few seismic hazard areas within the Shasta Lake and vicinity area that would expose structures or people to geologic hazards. However, site-specific geologic and foundation investigations will be conducted to develop design criteria to withstand reasonably probable seismic events. In addition, areas of known instability around the perimeter of the lake shore have been addressed via avoidance or through design measures to minimize exposure of structures or people to slope instability. There is a low probability of hazards associated with volcanic eruptions within the Shasta Lake and vicinity area, but any potential for floods caused by eruptions is similar to that from floods having other origins and would be mitigated via the proposed dam modifications and operational procedures. This impact would be less than significant for CP2. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-2 (CP2): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Like CP1, under CP2 stream channel equilibrium and geomorphology would be affected by an increase in full pool level. Inundation of lower gradient streams draining to Shasta Lake could result in long-term changes to channel equilibrium by changing the sediment transport capacity of the stream channels between 1,070 and 1,084 feet of elevation. This impact would be significant.

Based on a GIS-generated stream network, the total stream length inundated as a result of CP2 would be 25.5 miles (see Figure 4-9), which equates to about 0.9 percent of the total length of the streams in watersheds that are directly adjacent and contributory to Shasta Lake. Of the 25.5 miles inundated, about 8.2 miles are streams with a gradient less than 7 percent.

The increase in full pool would affect streams by altering fluvial geomorphology and the hydrology of aquatic habitats as described above. This impact would be significant. Mitigation for this impact is proposed in Section 4.3.5.

Impact Geo-3 (CP2): Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Implementing CP2 has the same potential as CP1 to diminish the availability in the region of cement, and of concrete sand and aggregate. For the same reasons as apply to CP1, this impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.



	Big Backbone Creek	Main Body	McCloud River	Pit River	Sacramento River	Squaw Creek
Intermittent >10% Grade	1.1	2.4	1.3	1.4	1.5	0.4
Perennial >10% Grade	0.1	0.2	0.3	0.1	0.3	0.0
Intermittent 7-10% Grade	0.1	0.7	0.2	0.2	0.7	0.3
Perennial 7-10% Grade	0.02	0.1	0.16	0.06	0.1	0.02
Intermittent <7% Grade	0.5	1.6	0.8	0.7	1.3	0.6
Perennial <7% Grade	0.6	0.8	1.4	1.4	3.1	0.9

Figure 4-9. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP2

Impact Geo-4 (CP2): Lost or Diminished Soil Biomass Productivity Like CP1, under CP2 soil productivity would be lost due to periodic inundation caused by increasing the full pool elevation and by construction including relocation of infrastructure. Using Equivalent FSSC as a surrogate metric for soil biomass productivity, implementation of CP2 would result in loss of the following acreages by productivity rank: moderate productivity, 2,128 acres; low productivity, 1,751 acres; nonproductive, 638 acres.

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-5 (CP2): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under CP2, the area of shoreline that would be inundated would be about 1,734 acres. Substantial soil erosion and loss of topsoil would result. This impact would be significant.

For the first 15 years after the dam raise, the average rate of shoreline erosion would increase substantially, from 90 cubic yards per acre per year to about 300 cubic yards per acre per year. For the first time step (i.e., 15 years), the total average annual volume of potential shoreline erosion from CP2 would be about 549,000 cubic yards per year. Within 60 years of the dam raise, the average annual volume is predicted to decrease to 150,000 cubic yards per year.

Sediment delivery from shoreline erosion would likely be greatest in the Sacramento Arm, the eastern portion of the Main Body of the lake, and the McCloud Arm. These three arms are predicted to deliver more than 90,000 cubic yards per year for the first 15 years after the dam raise. Within 60 years of the dam raise, the average rate for these arms is predicted to decrease to 27,000 cubic yards per year. The western portion of the Main Body and the Backbone Creek Arm are predicted to have the lowest shoreline erosion rates, a 15-year average annual potential erosion volume of less than 43,000 cubic yards per year. The Pit Arm is predicted to produce about 67,000 cubic yards per year and the Squaw Creek Arm about 63,000 cubic yards per year.

Assuming the available vegetation removal prescriptions between the 1,070-foot and 1,084-foot contours, for the first time step (i.e., 15 years after the raising of Shasta Dam), there would be about 549,000 cubic yards per year of shoreline erosion. After about 15–20 years, depending on climatic variability, the new shoreline would form and would start to stabilize. Total reservoir erosion is predicted to decrease by 70 percent between 15 and 60 years after the dam raise. The wetter the climate cycle, the more rapidly the shoreline is predicted to form.

The analysis also calculated the 15-year erosion volume using the prescribed vegetation treatments and modeled higher erosion rates for shoreline with partial and complete vegetation removal. The Big Backbone, Squaw Creek, and

Pit arms would have very little vegetation removal, which would not affect the short-term rate of shoreline erosion. The Main Body of Shasta Lake and the Sacramento River and McCloud arms would have substantial amounts of vegetation removal, which would result in higher short-term erosion rates. For these arms, areas treated by vegetation removal represent about half of the total predicted erosion.

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-6 (CP2): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes CP2 is similar to CP1 with respect to its potential to cause substantial soil erosion or loss of topsoil due to upland processes. The area disturbed by construction activities under CP2 is roughly the same as the area disturbed under CP1, up to approximately 3,340 acres. Of this area, up to approximately 3,128 acres are assigned a hazard rating of severe. For the same reasons as apply to CP1, this impact would be less than significant for CP2, because construction-related erosion will be avoided and minimized via implementation of the storm water pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans will address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement best management practices for erosion and sediment control. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-7 (CP2): Location of Project Facilities on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence CP2 is similar to CP1 with respect to its potential to cause or be affected by subsidence. For the same reasons as apply to CP1, this impact would be less than significant for CP2, because detailed, site-specific geologic and foundation investigations will be completed to inform project design as to how to avoid potential subsidence from these causes. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-8 (CP2): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that are Unsuited to Land Application of Waste CP2 is similar to CP1 with respect to its potential to cause or be affected by failure of septic tanks or alternative wastewater disposal systems due to soils that are unsuited to land application of waste. For the same reasons as apply to CP1, this impact would be less than significant for CP2, because relocated wastewater facilities would be designed and constructed to satisfy the conditions of the Shasta County Environmental Health Division Sewage Disposal System Permit. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes the impacts on the upper Sacramento River portion of the primary study area associated with CP2.

Impact Geo-9 (CP2): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP2 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. However, by altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, this alternative would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream stream erosion and change downstream geomorphologic characteristics. However, the frequency and duration of high-flow events resulting from this action are expected to be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, “Environmental Commitments Common to All Action Alternatives,” in Chapter 2, “Alternatives,” to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be slightly greater under CP2. This impact would be less than significant. Mitigation for this impact is not needed. However, mitigation for this impact is proposed in Section 4.3.5 to further reduce the impact.

Impact Geo-10 (CP2): Substantial Soil Erosion or Loss of Topsoil Due to Construction With implementation of CP2, no gravel augmentation activities would occur. Therefore, no soil additional soil erosion would be anticipated on the banks along the river channel. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-11 (CP2): Alteration of Fluvial Geomorphology With implementation of CP2, no potential upper Sacramento River restoration activities would occur. Therefore, no changes in fluvial geomorphology would be anticipated. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-12 (CP2): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under CP2, the fluvial geomorphology of downstream tributaries would not be affected by changes in Sacramento River stage attributed to Shasta Dam operations. By altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, CP2 would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River. Small increases in Sacramento River stage may occur with implementation of CP2. However, the frequency and duration of high-flow events resulting from CP2 implementation are expected to be reduced as compared to existing conditions with current operations.

Where they occur, geomorphic changes (headcutting, channel incisement, etc.) in major tributaries in Cow, Clear and Cottonwood creeks has been directly attributed to the presence of dams (on Clear Creek) and past and current instream gravel mining on the tributaries themselves. Geomorphic changes at these major tributaries have not been linked with Shasta Dam operations. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with CP2.

Impact Geo-13 (CP2): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP2 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. With implementation of CP2, there would be a potential reduction in high-flow events. Therefore, increases in Sacramento River flow would be limited and effects on reservoirs and rivers in the extended study area would be attenuated and dissipated by the large number of these water bodies, as well as by flood bypasses in the extended study area. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be slightly greater under CP2. However, the effects of increases in Sacramento River flow in the extended study area would be limited and effects on reservoirs and rivers would be attenuated and dissipated. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CVP/SWP Service Areas This section describes impacts on the CVP/SWP service areas within the extended study area associated with CP2.

Impact Geo-14 (CP2): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP2 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Changes in water operations in the CVP/SWP service areas could potentially result in small changes in flow in the American and Feather rivers, as a result of operations at Folsom Dam and Oroville Dam. However, changes in flow affecting these reservoirs and rivers in the extended study area would be within the normal range of conditions and would not be expected to result in an increase in channel erosion or meander migration. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be slightly greater under CP2. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

This section describes impacts associated with CP3, which focuses on the greatest practical enlargement of Shasta Dam and Reservoir consistent with the goals of the 2000 CALFED Bay-Delta Program Record of Decision (CALFED 2000b). CP3 was formulated for the primary purposes of increased agricultural water supply reliability and increased anadromous fish survival by raising Shasta Dam 18.5 feet. The dam raise would raise the reservoir's full pool by 20.5 feet, and enlarge total storage space in the reservoir by 5.19 million acre-feet. Section 2.3.8 in Chapter 2, "Alternatives" describes the construction activities and potential borrow sources associated with CP3.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake portion of the primary study area for CP3.

Impact Geo-1 (CP3): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption
Implementing CP3 has the potential to increase the exposure of structures and people to geologic hazards similar to CP1. For the same reasons as apply to CP1, impacts resulting from seismic conditions would be less than significant for CP3.

Under CP3, the pool level increase would inundate 173 acres of mapped slope instability hazards (i.e., active and relict landslides, debris slides, and inner gorge landscape positions). Relocation of infrastructure under CP3 would occur in the vicinity of mapped slope instability hazards to a similar but greater extent than under CP2 (up to about 232 acres). For the same reasons as apply to CP1, impacts resulting from slope instability hazards would be less than significant for CP3.

For the same reasons as apply to CP1, impacts resulting from hazards associated with volcanic eruptions would be less than significant for CP3.

There are few seismic hazard areas within the Shasta Lake and vicinity area that would expose structures or people to geologic hazards. However, site-specific geologic and foundation investigations will be conducted to develop design criteria to withstand reasonably probable seismic events. In addition, areas of known instability around the perimeter of the lake shore have been addressed via avoidance or through design measures to minimize exposure of structures or people to slope instability. There is a low probability of hazards associated with volcanic eruptions within the Shasta Lake and vicinity area, but any potential for floods caused by eruptions is similar to that from floods having other origins and would be mitigated via the proposed dam modifications and operational procedures. This impact would be less than significant for CP3. Mitigation for this impact is not needed, and thus not proposed.

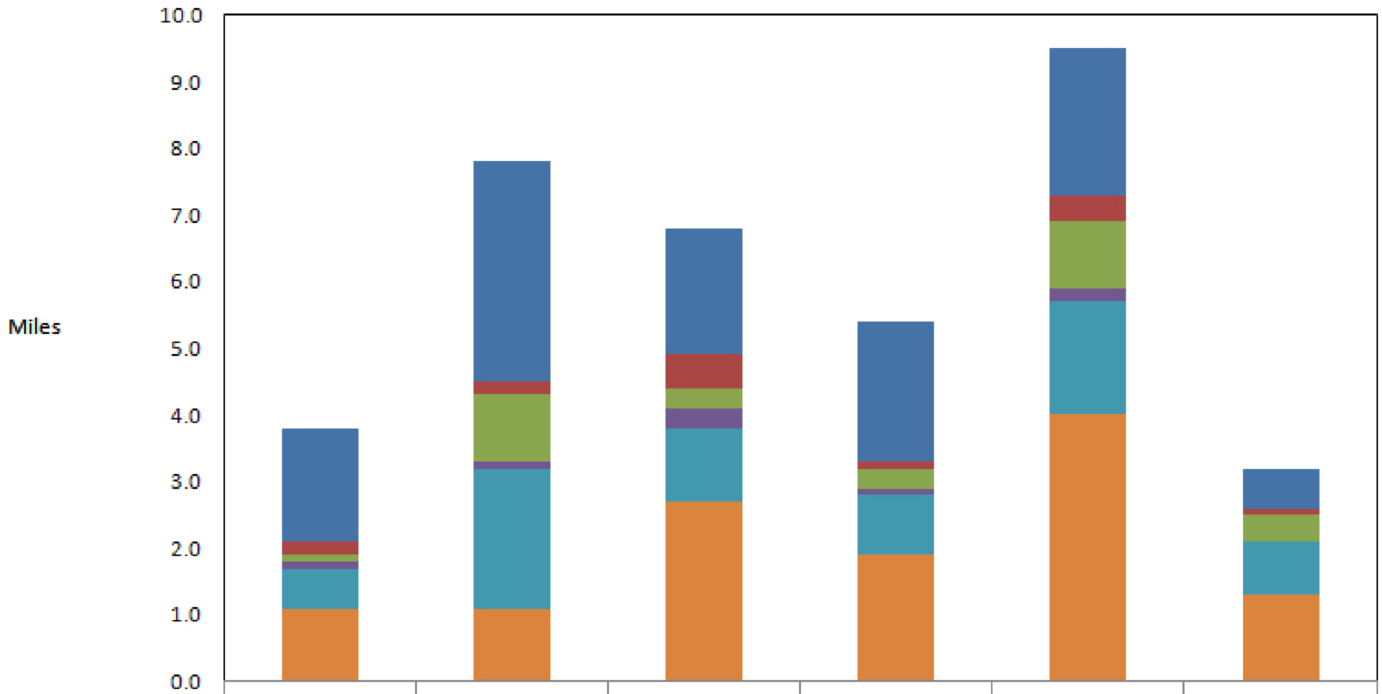
Impact Geo-2 (CP3): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Similar to CP1, under CP3 stream channel equilibrium and geomorphology would be affected by an increase in full pool level. Inundation of lower gradient streams draining to Shasta Lake could result in long-term changes to channel equilibrium by changing the sediment transport capacity of the stream channels between 1,070 and 1,090 feet of elevation. This impact would be significant.

Based on a GIS-generated stream network, the total stream length inundated as a result of CP3 would be 36.5 miles (see Figure 4-10), which equates to about 1.3 percent of the total length of the streams in watersheds that are directly adjacent and contributory to Shasta Lake. Of the 36.5 miles inundated, about 12.1 miles are streams with a gradient less than 7 percent.

The increase in full pool would affect streams by altering fluvial geomorphology and the hydrology of aquatic habitats as described above. This impact would be significant. Mitigation for this impact is proposed in Section 4.3.5.

Impact Geo-3 (CP3): Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Implementing CP3 has the same potential as CP1 to diminish the availability in the region of cement, and of concrete sand and aggregate. For the same reasons as apply to CP1, this impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-4 (CP3): Loss or Diminished Soil Biomass Productivity Like CP1, under CP3 soil productivity would be lost due to periodic inundation caused by increasing the full pool elevation and by construction including relocation of infrastructure. Using Equivalent FSSC as a surrogate metric for soil biomass productivity, implementation of CP3 would result in loss of the following acreages by productivity rank: moderate productivity – 2,301 acres; low productivity – 2,092 acres; nonproductive – 760 acres.



	Big Backbone Creek	Main Body	McCloud River	Pit River	Sacramento River	Squaw Creek
Intermittent >10% Grade	1.7	3.3	1.9	2.1	2.2	0.6
Perennial >10% Grade	0.2	0.2	0.5	0.1	0.4	0.1
Intermittent 7-10% Grade	0.1	1.0	0.3	0.3	1.0	0.4
Perennial 7-10% Grade	0.1	0.1	0.3	0.1	0.2	0.0
Intermittent <7% Grade	0.6	2.1	1.1	0.9	1.7	0.8
Perennial <7% Grade	1.1	1.1	2.7	1.9	4.0	1.3

Figure 4-10. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP3, CP4, and CP5

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-5 (CP3): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under CP3, the area of shoreline that would be inundated would be about 2,498 acres. Substantial soil erosion and loss of topsoil would result. This impact would be significant.

For the first 15 years after the dam raise, the average rate of shoreline erosion would increase substantially, from 90 cubic yards per acre per year to about 300 cubic yards per acre per year. For the first time step (i.e., 15 years), the total average annual volume of potential shoreline erosion from CP3 would be about 767,000 cubic yards per year. Within 60 years of the dam raise, the average annual volume is predicted to decrease to 216,000 cubic yards per year.

Sediment delivery from shoreline erosion would likely be greatest in the Sacramento Arm, the eastern portion of the Main Body of the lake, and the McCloud Arm. These three arms are predicted to deliver more than 140,000 cubic yards per year for the first 15 years after the dam raise. Within 60 years of the dam raise, the average rate for these arms is predicted to decrease to 39,000 cubic yards per year. The western portion of the Main Body and the Backbone Creek Arm are predicted to have the lowest shoreline erosion rates, a 15-year average annual potential erosion volume of less than 57,000 cubic yards per year. The Pit Arm is predicted to produce about 99,000 cubic yards per year and the Squaw Creek Arm about 68,000 cubic yards per year.

Assuming the available vegetation removal prescriptions between the 1,070-foot and 1,090-foot contours, for the first time step (i.e., 15 years after the raising of Shasta Dam), there would be about 767,000 cubic yards per year of shoreline erosion. After about 15–20 years, depending on climatic variability, the new shoreline would form and would start to stabilize. Total reservoir erosion is predicted to decrease by 70 percent between 15 and 60 years after the dam raise. The wetter the climate cycle, the more rapidly the shoreline is predicted to form.

The analysis also calculated the 15-year erosion volume using the prescribed vegetation treatments and modeled higher erosion rates for shoreline with partial and complete vegetation removal. The Big Backbone, Squaw Creek, and Pit arms would have very little vegetation removal, which would not affect the short-term rate of shoreline erosion. The Main Body and the Sacramento and McCloud arms would have substantial amounts of vegetation removal, which would result in higher short-term erosion rates. For these arms, areas treated by vegetation removal represent about half of the total predicted erosion.

Soil erosion due to shoreline processes is estimated to be 767,000 cubic yards per year, assuming the available vegetation removal prescriptions between

1,070-foot and 1,090-foot contours would occur in the first 15 years after the raising of Shasta Dam. This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-6 (CP3): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes CP3 is similar to CP1 with respect to its potential to cause substantial soil erosion or loss of topsoil due to upland processes. The area disturbed by construction activities under CP3 is about 3,340 acres. Of this area, approximately 3,128 acres are assigned a hazard rating of severe. For the same reasons as apply to CP1, this impact would be less than significant for CP3, because construction-related erosion will be avoided and minimized via implementation of the stormwater pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans will address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement best management practices for erosion and sediment control. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-7 (CP3): Location of Project Facilities on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence CP3 is similar to CP1 with respect to its potential to cause or be affected by subsidence. For the same reasons as apply to CP1, this would be less than significant for CP3, because detailed, site-specific geologic and foundation investigations will be completed to inform project design as to how to avoid potential subsidence from these causes. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-8 (CP3): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that are Unsuited to Land Application of Waste CP3 is similar to CP1 with respect to its potential to cause or be affected by failure of septic tanks or alternative wastewater disposal systems due to soils that are unsuited to land application of waste. For the same reasons as apply to CP1, this would be less than significant for CP3, because relocated wastewater facilities would be designed and constructed to satisfy the conditions of the Shasta County Environmental Health Division Sewage Disposal System Permit. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes impacts on the upper Sacramento River portion of the primary study area associated with CP3.

Impact Geo-9 (CP3): Potential Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP3 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. However, by altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, this alternative would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream stream erosion and change downstream geomorphologic characteristics. However, the frequency and duration of high-flow events resulting from this action are expected to be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, "Environmental Commitments Common to All Action Alternatives," in Chapter 2, "Alternatives," to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be greater under CP3. This impact would be less than significant. Mitigation for this impact is not needed. However, mitigation for this impact is proposed in Section 4.3.5 to further reduce the impact.

Impact Geo-10 (CP3): Substantial Soil Erosion or Loss of Topsoil Due to Construction Under CP3, no gravel augmentation activities would occur. Therefore, no soil additional soil erosion would be anticipated on the banks along the river channel. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-11 (CP3): Alteration of Fluvial Geomorphology Under CP3, no potential upper Sacramento River restoration activities would occur. Therefore, no changes in fluvial geomorphology would be anticipated. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-12 (CP3): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under CP3, the fluvial geomorphology of downstream tributaries would not be affected by changes in Sacramento River stage attributed to Shasta Dam operations. By altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, CP3 would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River. Small increases in Sacramento River stage may occur with implementation of CP3. However, the frequency and duration of high-flow events resulting from CP3 implementation are expected to be reduced as compared to existing conditions with current operations. This impact would be less than significant.

Where they occur, geomorphic changes (headcutting, channel incisement, etc.) in major tributaries in Cow, Clear and Cottonwood creeks has been directly attributed to the presence of dams (on Clear Creek) and past and current instream gravel mining on the tributaries themselves. Geomorphic changes at these major tributaries have not been linked with Shasta Dam operations. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with CP3.

Impact Geo-13 (CP3): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP3 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Under CP1, there would be a potential reduction in high-flow events. Therefore, increases in Sacramento River flow would be limited and effects on reservoirs and rivers in the extended study area would be attenuated and dissipated by the large number of these water bodies, as well as by flood bypasses in the extended study area. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be greater under CP3. However, the effects of increases in Sacramento River flow in the extended study area would be limited and effects on reservoirs and rivers would be attenuated and dissipated. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CVP/SWP Service Areas This section describes impacts on the CVP/SWP service areas within the extended study area associated with CP3.

Impact Geo-14 (CP3): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP3 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Changes in water operations in the CVP/SWP service areas could potentially result in small changes in flow in the American and Feather rivers, as a result of operations at Folsom Dam and Oroville Dam. However, changes in flow affecting these reservoirs and rivers in the extended study area would be within the normal range of conditions and would not be expected to result in an increase in channel erosion or meander migration. This impact would be less than significant.

This impact would be very similar to Impact Geo-9 (CP1), except the modification of flow regimes would be slightly greater under CP3. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus With Water Supply Reliability

This section describes impacts associated with CP4, which focuses on increasing the volume of cold water available to the Shasta Dam temperature control device through reservoir reoperations, and on raising Shasta Dam by raising Shasta Dam 18.5 feet. The dam raise would increase the reservoir's full pool by 20.5 feet, and enlarge total storage space by 634,000 acre-feet. This additional storage space would expand the Shasta Lake cold-water supply available to the temperature control device by 378,000 acre-feet, a feature that would help regulate cooler water temperatures in the upper Sacramento River. Section 2.3.8 in Chapter 2, "Alternatives" describes the construction activities and potential borrow sources associated with CP4.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake portion of the primary study area for CP4.

Impact Geo-1 (CP4): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption Implementing CP4 has the potential to increase the exposure of structures and people to geologic hazards similar to CP1. For the same reasons as apply to CP1, impacts resulting from seismic conditions would be less than significant for CP4.

Like CP3, under CP4, the pool level increase would inundate 173 acres of mapped slope instability hazards. Relocation of infrastructure under CP4 would occur in the vicinity of mapped slope instability hazards to the same extent as under CP3 (up to about 232 acres). For the same reasons as apply to CP1, impacts resulting from slope instability hazards would be less than significant for CP4.

For the same reasons as apply to CP1, impacts resulting from hazards associated with volcanic eruptions would be less than significant for CP4.

There are few seismic hazard areas within the Shasta Lake and vicinity area that would expose structures or people to geologic hazards. However, site-specific geologic and foundation investigations will be conducted to develop design criteria to withstand reasonably probable seismic events. In addition, areas of known instability around the perimeter of the lake shore have been addressed via avoidance or through design measures to minimize exposure of structures or people to slope instability. There is a low probability of hazards associated with volcanic eruptions within the Shasta Lake and vicinity area, but any potential for floods caused by eruptions is similar to that from floods having other origins and would be mitigated via the proposed dam modifications and operational procedures. This impact would be less than significant for CP4. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-2 (CP4): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Like CP3, under CP4 stream channel equilibrium and geomorphology would be affected by an increase in full pool level. Inundation of lower gradient streams draining to Shasta Lake could result in long-term changes to channel equilibrium by changing the sediment transport capacity of the stream channels between 1,070 and 1,090 feet of elevation. This impact would be significant.

Based on a GIS-generated stream network, the total stream length inundated as a result of CP4 would be the same as for CP3, about 36.5 miles (see Figure 4-10). This value equates to about 1.3 percent of the total length of the streams in watersheds that are directly adjacent and contributory to Shasta Lake. Of the 36.5 miles inundated, about 12.1 miles are streams with a gradient less than 7 percent.

The increase in full pool would affect streams by altering fluvial geomorphology and the hydrology of aquatic habitats as described above. This impact would be significant. Mitigation for this impact is proposed in Section 4.3.5.

Impact Geo-3 (CP4): Loss or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Implementing CP4 has the same potential as CP1 to diminish the availability in the region of cement, and of concrete sand and aggregate. For the same reasons as apply to CP1, this impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-4 (CP4): Lost or Diminished Soil Biomass Productivity Like CP3, under CP4 soil productivity would be lost due to periodic inundation caused by increasing the full pool elevation and by construction including relocation of infrastructure. The acreages of these losses would be the same as those reported for CP3.

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-5 (CP4): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under CP4, the area of shoreline that would be inundated would be the same as the area reported under CP3, about 2,498 acres. Substantial soil erosion and loss of topsoil would result. The previous descriptions of the time steps and associated volumes of soil lost due to shoreline processes under CP3 also apply to CP4. This impact would be significant.

Soil erosion due to shoreline processes is estimated to be 767,000 cubic yards per year, assuming the available vegetation removal prescriptions between 1,070-foot and 1,090-foot contours would occur in the first 15 years after the raising of Shasta Dam. This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-6 (CP4): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes CP4 is similar to CP3 with respect to its potential to cause substantial soil erosion or loss of topsoil due to upland processes. The area disturbed by construction activities under CP4 is roughly the same as the area disturbed under CP3, about 3, 340 acres. Of this area, approximately 3,128 acres are assigned a hazard rating of severe. For the same reasons as apply to CP1, this impact would be less than significant for CP4, because construction-related erosion will be avoided and minimized via implementation of the storm water pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans will address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement best management practices for erosion and sediment control. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-7 (CP4): Location of Project Facilities on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence CP4 is similar to CP1 with respect to its potential to cause or be affected by subsidence. For the same reasons as apply to CP1, this impact would be less than significant for CP4, because detailed, site-specific geologic and foundation investigations will be completed to inform project design as to how to avoid potential subsidence from these causes. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-8 (CP4): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that are Unsuited to Land Application of Waste CP4 is similar to CP1 with respect to its potential to cause or be affected by failure of septic tanks or alternative wastewater disposal systems due to soils that are unsuited to land application of waste. For the same reasons as apply to CP1, this impact would be less than significant for CP4, because relocated wastewater facilities would be designed and constructed to satisfy the conditions of the Shasta County Environmental Health Division Sewage Disposal System Permit. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes impacts on the upper Sacramento River portion of the primary study area associated with CP4.

Impact Geo-9 (CP4): Potential Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP4 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. However, by altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, this alternative would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream stream erosion and change downstream geomorphologic characteristics. However, the frequency and duration of high-flow events resulting from this action are expected to be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, "Environmental Commitments Common to All Action Alternatives," in Chapter 2, "Alternatives," to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant.

This impact would be the same as Impact Geo-9 (CP1) and would be less than significant. Mitigation for this impact is not needed. However, mitigation for this impact is proposed in Section 4.3.5 to further reduce the impact.

Impact Geo-10 (CP4): Substantial Soil Erosion or Loss of Topsoil Due to Construction CP4 involves replenishing spawning gravel in the Upper Sacramento River between Keswick Dam and Red Bluff Pumping Plant. Implementation of these activities could potentially contribute to soil erosion or loss of topsoil from clearing, grading, and grubbing activities required while constructing roadways to access the new spawning gravel sites. In addition, soil erosion could also potentially occur at sites where clearing and grubbing of the river bank would be required to allow the gravel to be placed on the river bank for recruitment. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, "Environmental Commitments Common to All Action Alternatives," in Chapter 2, "Alternatives," to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-11 (CP4): Alteration of Fluvial Geomorphology Under CP4, riparian, floodplain, and side-channel habitat restoration would be constructed at one or a combination of potential locations along the upper Sacramento River. Descriptions of restoration measures for six potential sites, referred to collectively as upper Sacramento River restoration sites, are detailed in the Downstream Restoration Technical Memorandum. Stream restoration activities could potentially cause changes in fluvial geomorphology that could result in channelized or unstable braided streams, depending on the gradient of the channel and specific restoration activities. However, restoration of habitat through planting of native vegetation would stabilize channel banks. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-12 (CP4): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under CP4, the fluvial geomorphology of downstream tributaries would not be affected by changes in Sacramento River stage attributed to Shasta Dam operations. By altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, CP4 would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River. Small increases in Sacramento River stage may occur with implementation of CP4. However, the frequency and duration of high-flow events resulting from CP4 implementation are expected to be reduced as compared to existing conditions with current operations. This impact would be less than significant.

Where they occur, geomorphic changes (headcutting, channel incisement, etc.) in major tributaries in Cow, Clear and Cottonwood creeks has been directly attributed to the presence of dams (on Clear Creek) and past and current instream gravel mining on the tributaries themselves. Geomorphic changes at these major tributaries have not been linked with Shasta Dam operations. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with CP4.

Impact Geo-13 (CP4): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP4 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Under CP1, there would be a potential reduction in high-flow events. Therefore, increases in Sacramento River flow would be limited and effects on reservoirs and rivers in the extended study area would be attenuated and dissipated by the large number of these water bodies, as well as by flood bypasses in the extended study area. This impact would be less than significant.

This impact would be similar to Impact Geo-9 (CP1) and would be less than significant.

Effects of increases in Sacramento River flow in the extended study area would be limited and effects on reservoirs and rivers would be attenuated and dissipated. Mitigation for this impact is not needed, and thus not proposed.

CVP/SWP Service Areas This section describes impacts on the CVP/SWP service areas within the extended study area associated with CP4.

Impact Geo-14 (CP4): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP4 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Changes in water operations in the CVP/SWP service areas could potentially result in small changes in flow in the American and Feather rivers, as a result of operations at Folsom Dam and Oroville Dam. However, changes in flow affecting these reservoirs and rivers in the extended study area would be within the normal range of conditions and would not be expected to result in an increase in channel erosion or meander migration. This impact would be less than significant.

This impact would be the same as Impact Geo-9 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP5 – 18.5-Foot Dam Raise, Combination Plan

This section describes impacts associated with CP5, which includes raising Shasta Dam 18.5 feet. This alternative also includes (1) implementing environmental restoration features along the lower reaches of major tributaries to Shasta Lake, (2) constructing shoreline fish habitat around Shasta Lake, and (3) constructing additional and/or improved recreation features at various locations around Shasta Lake to increase the value of the recreational experience. The dam raise would increase the reservoir's full pool elevation by 20.5 feet to about 1,090 feet above msl, and enlarge total storage space by 634,000 acre-feet. Section 2.3.8 in Chapter 2, "Alternatives" describes the construction activities and potential borrow sources associated with CP5.

Shasta Lake and Vicinity This section describes impacts on the Shasta Lake portion of the primary study area for CP5.

Impact Geo-1 (CP5): Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruption Implementing CP5 has the potential to increase the exposure of structures and people to geologic hazards similar to CP1. For the same reasons as apply to CP1, impacts resulting from seismic conditions would be less than significant for CP5.

Like CP3, under CP5, the pool level increase would inundate 173 acres of mapped slope instability hazards. Relocation of infrastructure under CP5 would occur in the vicinity of mapped slope instability hazards to a similar but greater extent than under CP4 (up to about 232 acres). For the same reasons as apply to CP1, impacts resulting from slope instability hazards would be less than significant for CP5.

For the same reasons as apply to CP1, impacts resulting from hazards associated with volcanic eruptions would be less than significant for CP5.

There are few seismic hazard areas within the Shasta Lake and vicinity area that would expose structures or people to geologic hazards. However, site-specific geologic and foundation investigations will be conducted to develop design criteria to withstand reasonably probable seismic events. In addition, areas of known instability around the perimeter of the lake shore have been addressed via avoidance or through design measures to minimize exposure of structures or people to slope instability. There is a low probability of hazards associated with volcanic eruptions within the Shasta Lake and vicinity area, but any potential for floods caused by eruptions is similar to that from floods having other origins and would be mitigated via the proposed dam modifications and operational procedures. This impact would be less than significant for CP5. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-2 (CP5): Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats Like CP3, under CP5 stream channel equilibrium and geomorphology would be affected by an increase in full pool level. Inundation of lower gradient streams draining to Shasta Lake could result in long-term changes to channel equilibrium by changing the sediment transport capacity of the stream channels between 1,070 and 1,090 feet of elevation. This impact would be significant.

Based on a GIS-generated stream network, the total stream length inundated as a result of CP5 would be the same as for CP3, about 36.5 miles (see Figure 4-10). This value equates to about 1.3 percent of the total length of the streams in watersheds that are directly adjacent and contributory to Shasta Lake. Of the 36.5 miles inundated, about 12.1 miles are streams with a gradient less than 7 percent.

The increase in full pool would affect streams by altering fluvial geomorphology and the hydrology of aquatic habitats as described above. This impact would be significant. Mitigation for this impact is proposed in Section 4.3.5.

Impact Geo-3 (CP5): Lost or Diminished Availability of Known Mineral Resources that Would Be of Future Value to the Region Implementing CP5 has the same potential as CP1 to diminish the availability in the region of cement, concrete sand, and aggregate. For the same reasons that apply to CP1, this impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-4 (CP5): Lost or Diminished Soil Biomass Productivity Like CP3, under CP5 soil productivity would be lost due to periodic inundation caused by increasing the full pool elevation and by construction including relocation of infrastructure. The acreages of these losses would be the same as those reported for CP3.

This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-5 (CP5): Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes Under CP5, the area of shoreline that would be inundated would be the same as the area reported under CP3, about 2,498 acres. Substantial soil erosion and loss of topsoil would result. The previous descriptions of the time steps and associated volumes of soil lost due to shoreline processes under CP3 also apply to CP5.

Soil erosion due to shoreline processes is estimated to be 767,000 cubic yards per year, assuming the available vegetation removal prescriptions between 1,070-foot and 1,090-foot contours would occur in the first 15 years after the raising of Shasta Dam. This impact would be significant. Mitigation for this impact is not proposed in Section 4.3.5 because no feasible mitigation is available to reduce the impact to a less-than-significant level.

Impact Geo-6 (CP5): Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes CP5 is similar to CP3 with respect to its potential to cause substantial soil erosion or loss of topsoil due to upland processes. The area disturbed by construction activities under CP5 is roughly the same as the area disturbed under CP3, about 3,340 acres. Of this area, approximately 3,128 acres are assigned a hazard rating of severe. For the same reasons as apply to CP1, this impact would be less than significant for CP5, because construction-related erosion will be avoided and minimized via implementation of the storm water pollution prevention plans (i.e., erosion and sediment control plans, including site revegetation) that are a part of the environmental commitments common to all action alternatives. These plans will address the necessary local jurisdiction requirements regarding erosion control and site revegetation, and would implement best management practices for erosion and sediment control. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-7 (CP5): Location of Project Facilities on a Geologic Unit or Soil that Is Unstable, or that Would Become Unstable as a Result of the Project, and Potentially Result in Subsidence CP5 is similar to CP1 with respect to its potential to cause or be affected by subsidence. For the same reasons as apply to CP1, this impact would be less than significant for CP5, because detailed, site-specific geologic and foundation investigations will be completed to inform project design as to how to avoid potential subsidence from these causes. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-8 (CP5): Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that are Unsuited to Land Application of Waste

CP5 is similar to CP1 with respect to its potential to cause or be affected by failure of septic tanks or alternative wastewater disposal systems due to soils that are unsuited to land application of waste. For the same reasons as apply to CP1, this impact would be less than significant for CP5, because relocated wastewater facilities would be designed and constructed to satisfy the conditions of the Shasta County Environmental Health Division Sewage Disposal System Permit. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff) This section describes impacts on the upper Sacramento River portion of the primary study area associated with CP5.

Impact Geo-9 (CP5): Potential Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP5 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. However, by altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, this alternative would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River and potentially several other reservoirs and downstream waterways. Alterations to river flows could potentially change downstream stream erosion and change downstream geomorphologic characteristics. However, the frequency and duration of high-flow events resulting from this action are expected to be reduced as compared to existing conditions with current operations. Therefore, downstream erosion would not be anticipated to increase. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, “Environmental Commitments Common to All Action Alternatives,” in Chapter 2, “Alternatives,” to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant.

Because Shasta Dam and Reservoir operations would be the same for CP3 and CP5, this impact would be the same as Impact Geo-9 (CP3) and would be less than significant. Mitigation for this impact is not needed. However, mitigation for this impact is proposed in Section 4.3.5 to further reduce the impact.

Impact Geo-10 (CP5): Substantial Soil Erosion or Loss of Topsoil Due to Construction CP5 involves replenishing spawning gravel in the Upper Sacramento River between Keswick Dam and Red Bluff Pumping Plant. Implementation of these activities could potentially contribute to soil erosion or loss of topsoil from clearing, grading, and grubbing activities required while constructing roadways to access the new spawning gravel sites. In addition, soil erosion could also potentially occur at sites where clearing and grubbing of the river bank would be required to allow the gravel to be placed on the river bank for recruitment. An erosion and sediment control plan would be implemented, as described in Section 2.3.2, “Environmental Commitments Common to All

Action Alternatives," in Chapter 2, "Alternatives," to control any short-term and long-term erosion and sedimentation effects of construction activities. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-11 (CP5): Alteration of Fluvial Geomorphology Under CP5, riparian, floodplain, and side-channel habitat restoration would be constructed at one or a combination of potential locations along the upper Sacramento River. Descriptions of restoration measures for six potential sites, referred to collectively as upper Sacramento River restoration sites, are detailed in the Downstream Restoration Technical Memorandum. Stream restoration activities could potentially cause changes in fluvial geomorphology that could result in channelized or unstable braided streams depending on the gradient of the channel and specific restoration activities. However, restoration of habitat through planting of native vegetation would stabilize channel banks. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact Geo-12 (CP5): Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations Under CP5, the fluvial geomorphology of downstream tributaries would not be affected by changes in Sacramento River stage attributed to Shasta Dam operations. By altering storage and operations at Shasta Lake as compared to the No-Action Alternative and existing conditions, CP5 would change the maximum pool elevation and seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento River. Small increases in Sacramento River stage may occur with implementation of CP5. However, the frequency and duration of high-flow events resulting from CP5 implementation are expected to be reduced as compared to existing conditions with current operations. This impact would be less than significant.

Where they occur, geomorphic changes (headcutting, channel incisement, etc.) in major tributaries in Cow, Clear and Cottonwood creeks has been directly attributed to the presence of dams (on Clear Creek) and past and current instream gravel mining on the tributaries themselves. Geomorphic changes at these major tributaries have not been linked with Shasta Dam operations. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta This section describes impacts on the lower Sacramento River and Delta portions of the extended study area associated with CP5.

Impact Geo-13 (CP5): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP5 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. With implementation of CP1, there would be a potential reduction in high-flow events. Therefore, increases in Sacramento River flow would be limited and effects on reservoirs and rivers in the extended study area would be attenuated and dissipated by the large number of these water bodies, as well as by flood bypasses in the extended study area. This impact would be less than significant.

Because Shasta Dam and Reservoir operations would be the same for CP3 and CP5, this impact would be the same as Impact Geo-13 (CP3) and would be less than significant. Effects of increases in Sacramento River flow in the extended study area would be limited and effects on reservoirs and rivers would be attenuated and dissipated. Mitigation for this impact is not needed, and thus not proposed.

CVP/SWP Service Areas This section describes impacts on the CVP/SWP service areas within the extended study area associated with CP5.

Impact Geo-14 (CP5): Substantial Increase in Channel Erosion and Meander Migration It is not anticipated that implementation of CP5 would lead to increased channel erosion and meander migration as compared to the No-Action Alternative and existing conditions. Changes in water operations in the CVP/SWP service areas could potentially result in small changes in flow in the American and Feather rivers, as a result of operations at Folsom Dam and Oroville Dam. However, changes in flow affecting these reservoirs and rivers in the extended study area would be within the normal range of conditions and would not be expected to result in an increase in channel erosion or meander migration. This impact would be less than significant.

Because Shasta Dam and Reservoir operations would be the same for CP3 and CP5, this impact would be the same as Impact Geo-9 (CP3) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

4.3.5 Mitigation Measures

This section discusses mitigation measures for each significant impact described in the environmental consequences section, as presented in Table 4-13.

Table 4-13. Summary of Mitigation Measures for Geology, Geomorphology, Minerals, and Soils

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Geo-1: Exposure of Structures and People to Geologic Hazards Resulting from Seismic Conditions, Slope Instability, and Volcanic Eruptions	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-2: Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats	LOS before Mitigation	NI	S	S	S	S	S
	Mitigation Measure	None required.	Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-3: Loss or Diminished Availability of Known Mineral Resources That Would Be of Future Value to the Region	LOS before Mitigation	NI	S	S	S	S	S
	Mitigation Measure	None required.	No feasible mitigation is available to reduce impact.				
	LOS after Mitigation	NI	SU	SU	SU	SU	SU
Impact Geo-4: Lost or Diminished Soil Biomass Productivity	LOS before Mitigation	NI	S	S	S	S	S
	Mitigation Measure	None required	No feasible mitigation is available to reduce impact.				
	LOS after Mitigation	NI	SU	SU	SU	SU	SU
Impact Geo-5: Substantial Soil Erosion or Loss of Topsoil Due to Shoreline Processes	LOS before Mitigation	NI	S	S	S	S	S
	Mitigation Measure	None required	No feasible mitigation is available to reduce impact.				
	LOS after Mitigation	NI	SU	SU	SU	SU	SU

Table 4-13. Summary of Mitigation Measures for Geology, Geomorphology, Minerals, and Soils (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Geo-6: Substantial Soil Erosion or Loss of Topsoil Due to Upland Processes	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-7: 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 Subsidence	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-8: Failure of Septic Tanks or Alternative Wastewater Disposal Systems Due to Soils that are Unsuited to Land Application of Waste	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-9: Substantial Increase in Channel Erosion and Meander Migration	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	Mitigation Measure Geo-9: Implement Channel Sensitive Water Release Schedules.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-10: Substantial Soil Erosion or Loss of Topsoil Due to Construction	LOS before Mitigation	NI	NI	NI	NI	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	LTS	LTS

Table 4-13. Summary of Mitigation Measures for Geology, Geomorphology, Minerals, and Soils (contd.)

Impact		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact Geo-11: Alteration of Fluvial Geomorphology	LOS before Mitigation	NI	NI	NI	NI	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	LTS	LTS
Impact Geo-12: Alteration of Downstream Tributary Fluvial Geomorphology Due to Shasta Dam Operations	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-13: Substantial Increase in Channel Erosion and Meander Migration (Lower Sacramento River and Delta)	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact Geo-14: Substantial Increase in Channel Erosion and Meander Migration (CVP/SWP Service Areas)	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS

Key:
CVP = Central Valley Project
LOS = level of significance
LTS = less than significant
NI = No Impact
PS = potentially significant
S = significant
SU = significant and unavoidable
SWP = State Water Project

No-Action Alternative

No mitigation measures are required for this alternative.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply

No mitigation is required for Impact Geo-1 (CP1), Impacts Geo-6 (CP1) through Geo-8 (CP1), and Impacts Geo-10 (CP1) through Geo-14 (CP1). No feasible mitigation measures are available at the time of preparation of this DEIS to reduce Impacts Geo-3 (CP1) through Geo-5 (CP1) to a less-than-significant level. Therefore, Impacts Geo-3 (CP1), Geo-4 (CP1), and Geo-5 (CP1) would be significant and unavoidable.

Mitigation is provided below for other impacts of CP1 on geology, geomorphology, minerals, and soils. No mitigation is required for Impact Geo-9 (CP1), but mitigation is provided to further reduce this less-than-significant impact.

Mitigation Measure Geo-2 (CP1): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact The loss of 18.5 miles of intermittent and perennial streams (including 6.2 miles of streams with a gradient less than 7 percent) will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Geo-2 (CP1) to a less-than-significant level.

Mitigation Measure Geo-9 (CP1): Implement Channel-Sensitive Water Release Schedules Dam operators will establish water release schedules that would maintain flow levels equal to or similar to current operating conditions. Under a sound water release regime, single event flows would remain at levels similar to the existing condition, although the frequency and duration of these flows could increase. This potential increase in frequency and duration would not be considered significant provided that single event flow levels do not exceed current operating conditions. Implementation of this mitigation measure would reduce Impact Geo-9 (CP1) to a less-than-significant level.

In wet years, CP1 would decrease potential channel erosion and meander migration compared to the existing condition, because of the dam’s ability to store more water than is currently possible. Greater storage capacity would provide dam operators more flexibility in timing and amount of water that would be released during wet years, decreasing the need for large releases when the dam is at or near capacity. This impact would be less than significant after implementation of channel-sensitive water release schedules.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply
No mitigation is required for Impact Geo-1 (CP2), Impacts Geo-6 (CP2) through Geo-8 (CP2), and Impacts Geo-10 (CP2) through Geo-14 (CP2). No feasible mitigation measures are available at the time of preparation of this DEIS to reduce Impacts Geo-3 (CP2) through Geo-5 (CP2) to a less-than-significant level. Therefore, Impacts Geo-3 (CP2), Geo-4 (CP2), and Geo-5 (CP2) would be significant and unavoidable.

Mitigation is provided below for other impacts of CP2 on geology, geomorphology, minerals, and soils. No mitigation is required for Impact Geo-9 (CP2), but mitigation is provided to further reduce this less-than-significant impact.

Mitigation Measure Geo-2 (CP2): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact The loss of 25.5 miles of intermittent and perennial streams (including 8.2 miles of streams with a gradient less than 7 percent) will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Geo-2 (CP2) to a less-than-significant level.

Mitigation Measure Geo-9 (CP2): Implement Channel-Sensitive Water Release Schedules This mitigation measure is identical to Mitigation Measure Geo-9 (CP1). Implementation of this mitigation measure would reduce Impact Geo-9 (CP2) to a less-than-significant level.

In wet years, CP2 would decrease potential channel erosion and meander migration compared to the existing condition, because of the dam's ability to retain more water than is currently possible. Greater storage capacity would provide dam operators more flexibility in the timing and amount of water that would be released during wet years, decreasing the need for large releases when the dam is at or near capacity. This impact would be less than significant after implementation of channel-sensitive water release schedules.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

No mitigation is required for Impact Geo-1 (CP3) and Impacts Geo-6 (CP3) through Geo-8 (CP3), and Impacts Geo-10 (CP3) through Geo-14 (CP3). No feasible mitigation measures are available at the time of preparation of this DEIS to reduce Impacts Geo-3 (CP3) through Geo-5 (CP3) to a less-than-significant level. Therefore, Impacts Geo-3 (CP3), Geo-4 (CP3), and Geo-5 (CP3) would be significant and unavoidable.

Mitigation is provided below for other impacts of CP3 on geology, geomorphology, minerals, and soils. No mitigation is required for Impact Geo-9 (CP3), but mitigation is provided to further reduce this less-than-significant impact.

Mitigation Measure Geo-2 (CP3): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact The loss of 36.5 miles of intermittent and perennial streams (including 12.1 miles of streams with a gradient less than 7 percent) will be mitigated by compensating for the impact by replacing or providing substitute resources or environments. Compensation will be accomplished by restoring and enhancing the aquatic functions of existing, degraded aquatic habitats in or near the Shasta Lake and vicinity area. Examples of techniques that may be used include channel and bank stabilization, channel redirection, channel reconstruction, culvert replacement and elimination of barriers to fish passage, and enhancement of habitat physical structure (e.g., placement of woody debris, rocks). The nature and extent of the restoration and enhancement activities will be based on an assessment of the ecological functions that are lost as a consequence of implementing this alternative. Implementation of this mitigation measure would reduce Impact Geo-2 (CP3) to a less-than-significant level.

Mitigation Measure Geo-9 (CP3): Implement Channel-Sensitive Water Release Schedules This mitigation measure is identical to Mitigation Measure Geo-9 (CP1). Implementation of this mitigation measure would Impact Geo-9 (CP3) to a less-than-significant level.

In wet years, CP3 would decrease potential channel erosion and meander migration compared to the existing condition, because of the dam’s ability to retain more water than is currently possible. More retention capacity would provide dam operators more flexibility in the timing and amount of water that would be released during wet years, decreasing the need for large releases when the dam is at or near capacity. This impact would be less than significant after implementation of channel-sensitive water release schedules.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus With Water Supply Reliability

No mitigation is required for Impact Geo-1 (CP4), Impacts Geo-6 (CP4) through Geo-8 (CP4), and Impacts Geo-10 (CP4) through Geo-14 (CP4). No feasible mitigation measures are available at the time of preparation of this DEIS to reduce Impacts Geo-3 (CP4) through Geo-5 (CP4) to a less-than-significant level. Therefore, Impacts Geo-3 (CP4), Geo-4 (CP4), and Geo-5 (CP4) would be significant and unavoidable.

Mitigation is provided below for other impacts of CP4 on geology, geomorphology, minerals, and soils. No mitigation is required for Impact Geo-9 (CP4), but mitigation is provided to further reduce this less-than-significant impact.

Mitigation Measure Geo-2 (CP4): Replace Lost Ecological Functions of Aquatic Habitats By Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is identical to Mitigation Measure Geo-2 (CP3). Implementation of this mitigation measure would reduce Impact Geo-2 (CP4) to a less-than-significant level.

Mitigation Measure Geo-9 (CP4): Implement Channel-Sensitive Water Release Schedules This mitigation measure is identical to Mitigation Measure Geo-9 (CP1). Implementation of this mitigation measure would reduce Impact Geo-9 (CP4) to a less-than-significant level. Mitigation Measure Geo-9 (CP4) would also provide mitigation for the less-than-significant impacts Geo-10 (CP4) and Geo-11 (CP4).

In wet years, CP4 would decrease potential channel erosion and meander migration compared to the existing condition, because of the dam’s ability to retain more water than is currently possible. More retention capacity would provide dam operators more flexibility in the timing and amount of water that would be released during wet years, decreasing the need for large releases when the dam is at or near capacity. This impact would be less than significant after implementation of channel-sensitive water release schedules.

CP5 – 18.5-Foot Dam Raise, Combination Plan

No mitigation is required for Impact Geo-1 (CP5), Impacts Geo-6 (CP5) through Geo-8 (CP5), and Impacts Geo-10 (CP5) through Geo-14 (CP5). No feasible mitigation measures are available at the time of preparation of this DEIS to reduce Impacts Geo-3 (CP5) through Geo-5 (CP5) to a less-than-significant level. Therefore, Impacts Geo-3 (CP5), Geo-4 (CP5), and Geo-5 (CP5) would be significant and unavoidable.

Mitigation is provided below for other impacts of CP5 on geology, geomorphology, minerals, and soils. No mitigation is required for Impact Geo-9 (CP5), but mitigation is provided to further reduce this less-than-significant impact.

Mitigation Measure Geo-2 (CP5): Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact This mitigation measure is identical to Mitigation Measure Geo-2 (CP3). Implementation of this mitigation measure would reduce Impact Geo-2 (CP5) to a less-than-significant level.

Mitigation Measure Geo-9 (CP5): Implement Channel-Sensitive Water Release Schedules This mitigation measure is identical to Mitigation Measure Geo-9 (CP1). Implementation of this mitigation measure would reduce Impact Geo-9 (CP5) to a less-than-significant level. Mitigation Measure Geo-9 (CP5) would also provide mitigation for the less-than-significant Impacts Geo-10 (CP5) and Geo-11 (CP5).

In wet years, CP5 would decrease potential channel erosion and meander migration compared to the existing condition, because of the dam's ability to retain more water than is currently possible. More retention capacity would provide dam operators more flexibility in the timing and amount of water that would be released during wet years, decreasing the need for large releases when the dam is at or near capacity. This impact would be less than significant after implementation of channel-sensitive water release schedules.

4.3.6 Cumulative Effects

Chapter 3, "Considerations for Describing the Affected Environment and environmental Consequences," discusses overall cumulative impacts of the project alternatives, including the relationship to the CALFED Bay-Delta Program Programmatic EIS/EIR cumulative impacts analysis, qualitative and quantitative assessment, past and future actions in the study area, and significance criteria.

This section provides an analysis of overall cumulative impacts of the project alternatives with other past, present, and reasonably foreseeable future projects producing related impacts. For both the primary and extended study areas, a number of factors could substantially affect geology, soils and erosion, mineral resources, and geomorphology as an outcome of present and future actions. These actions may result in either a beneficial or adverse impact. However, there is a high level of uncertainty regarding potential effects of the reasonably foreseeable future actions. Therefore, geology, soils and erosion, mineral resources, and geomorphology are expected to remain in similar conditions to existing conditions, with the exception of potential effects associated with future climate change, as described below.

The effects of climate change on operations at Shasta Lake could potentially result in changes to downstream geomorphology. As described in the Climate Change Projection Appendix, climate change could result in higher reservoir releases in the future because of an increase in winter and early-spring inflow into the lake from high-intensity storm events. The change in reservoir releases could be necessary to manage for flood events resulting from these potentially larger storms. The potential increase in releases from the reservoir could lead to long-term changes in downstream channel equilibrium.

The effects of increased monthly inflow into Shasta Lake in winter and early spring could also potentially result in changes to stream channel equilibrium and geomorphology upstream from the lake and at the point where the streams meet the lake.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

As discussed in Section 4.3.4 above, CP1 could result in several localized project-level impacts related to (1) exposure of structures and people to geologic hazards (less than significant); (2) alteration of fluvial geomorphology and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion from shoreline processes (significant and unavoidable); (4) soil erosion from upland processes (less than significant); (5) location of project features on unstable geologic or soil units (less than significant); and (6) the suitability of soils for wastewater disposal systems (less than significant). As with many types of geologic impacts, these project-level impacts are localized and would not contribute to any cumulative impacts.

Also discussed in Section 4.3.4 above, CP1 could result in regional impacts related to a diminished availability of cement, concrete sand, and aggregate and a loss of soil productivity. When taken together with reasonable foreseeable future projects in the region, CP1 could contribute to significant cumulative impacts related to these mineral and soil biomass resources. Mitigation is not available for either of these impacts; therefore, these cumulative impacts would be significant and unavoidable.

As stated previously, effects of climate change on operations at Shasta Lake could include a higher frequency of high-flow events, potentially resulting in changes to geomorphology. Although implementation of CP1 could potentially diminish these effects through additional storage capacity of the reservoir available after construction, it is not expected to result in long-term changes to channel equilibrium downstream from Shasta Dam. In addition, potential impacts associated with channel meander and erosion under CP1 would be less than significant in the Shasta Lake and vicinity portion of the study area, the upper Sacramento River portion of the primary study area, and the extended study area. When added to the anticipated effects of climate change, raising Shasta Dam would not have a significant cumulative effect.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

As discussed in Section 4.3.4 above, CP2 could result in several localized project-level impacts related to (1) exposure of structures and people to geologic hazards (less than significant); (2) alteration of fluvial geomorphology and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion from shoreline processes (significant and unavoidable); (4) soil erosion from upland processes (less than significant); (5) location of project features on unstable geologic or soil units (less than significant); and (6) the suitability of soils for wastewater disposal systems (less than significant). As with many types of geologic impacts, these project-level impacts are localized and would not contribute to any cumulative impacts.

Also discussed in Section 4.3.4 above, CP2 could result in regional impacts related to a diminished availability of cement, concrete sand, and aggregate and a loss of soil productivity. When taken together with reasonable foreseeable future projects in the region, therefore, CP2 could contribute to significant cumulative impacts related to these mineral and soil biomass resources. Mitigation is not available for either of these impacts; therefore, these cumulative impacts would be significant and unavoidable.

As stated previously, effects of climate change on operations at Shasta Lake could include a higher frequency of high-flow events, potentially resulting in changes to geomorphology. Although implementation of CP2 could potentially diminish these effects through additional storage capacity of the reservoir available after construction, it is not expected to result in long-term changes to channel equilibrium downstream from Shasta Dam. In addition, potential impacts associated with channel meander and erosion under CP2 would be less than significant in the Shasta Lake and vicinity portion of the study area, the upper Sacramento River portion of the primary study area, and the extended study area. When added to the anticipated effects of climate change, raising Shasta Dam would not have a significant cumulative effect.

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

As discussed in Section 4.3.4 above, CP3 could result in several localized project-level impacts related to (1) exposure of structures and people to geologic hazards (less than significant); (2) alteration of fluvial geomorphology and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion from shoreline processes (significant and unavoidable); (4) soil erosion from upland processes (less than significant); (5) location of project features on unstable geologic or soil units (less than significant); and (6) the suitability of soils for wastewater disposal systems (less than significant). As with many types of geologic impacts, these project-level impacts are localized and would not contribute to any cumulative impacts.

Also discussed in Section 4.3.4 above, CP3 could result in regional impacts related to a diminished availability of cement, concrete sand, and aggregate and a loss of soil productivity. When taken together with reasonable foreseeable future projects in the region, therefore, CP3 could contribute to significant cumulative impacts related to these mineral and soil biomass resources. Mitigation is not available for either of these impacts; therefore, these cumulative impacts would be significant and unavoidable.

As stated previously, effects of climate change on operations at Shasta Lake could include a higher frequency of high-flow events, potentially resulting in changes to geomorphology. Although implementation of CP3 could potentially diminish these effects through additional storage capacity of the reservoir available after construction, it is not expected to result in long-term changes to channel equilibrium downstream from Shasta Dam. In addition, potential impacts associated with channel meander and erosion under CP3 would be less than significant in the Shasta Lake and vicinity portion of the study area, the upper Sacramento River portion of the primary study area, and the extended study area. When added to the anticipated effects of climate change, raising Shasta Dam would not have a significant cumulative effect.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus With Water Supply Reliability

As discussed in Section 4.3.4 above, CP4 could result in several localized project-level impacts related to (1) exposure of structures and people to geologic hazards (less than significant); (2) alteration of fluvial geomorphology and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion from shoreline processes (significant and unavoidable); (4) soil erosion from upland processes (less than significant); (5) location of project features on unstable geologic or soil units (less than significant); and (6) the suitability of soils for wastewater disposal systems (less than significant). As with many types of geologic impacts, these project-level impacts are localized and would not contribute to any cumulative impacts.

Also discussed in Section 4.3.4 above, CP4 could result in regional impacts related to a diminished availability of cement, concrete sand, and aggregate and a loss of soil productivity. When taken together with reasonable foreseeable future projects in the region, therefore, CP4 could contribute to significant cumulative impacts related to these mineral and soil biomass resources. Mitigation is not available for either of these impacts; therefore, these cumulative impacts would be significant and unavoidable.

As stated previously, effects of climate change on operations at Shasta Lake could include a higher frequency of high-flow events, potentially resulting in changes to geomorphology. Although implementation of CP4 could potentially diminish these effects through additional storage capacity of the reservoir available after construction, it is not expected to result in long-term changes to channel equilibrium downstream from Shasta Dam. In addition, potential impacts associated with channel meander and erosion under CP4 would be less than significant in the Shasta Lake and vicinity portion of the study area, the upper Sacramento River portion of the primary study area, and the extended study area. When added to the anticipated effects of climate change, raising Shasta Dam would not have a significant cumulative effect.

CP5 – 18.5-Foot Dam Raise, Combination Plan

As discussed in Section 4.3.4 above, CP5 could result in several localized project-level impacts related to (1) exposure of structures and people to geologic hazards (less than significant); (2) alteration of fluvial geomorphology and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion from shoreline processes (significant and unavoidable); (4) soil erosion from upland processes (less than significant); (5) location of project features on unstable geologic or soil units (less than significant); and (6) the suitability of soils for wastewater disposal systems (less than significant). As with many types of geologic impacts, these project-level impacts are localized and would not contribute to any cumulative impacts.

Also discussed in Section 4.3.4 above, CP5 could result in regional impacts related to a diminished availability of cement, concrete sand, and aggregate and a loss of soil productivity. When taken together with reasonable foreseeable future projects in the region, therefore, CP5 could contribute to significant cumulative impacts related to these mineral and soil biomass resources. Mitigation is not available for either of these impacts; therefore, these cumulative impacts would be significant and unavoidable.

As stated previously, effects of climate change on operations at Shasta Lake could include a higher frequency of high-flow events, potentially resulting in changes to geomorphology. Although implementation of CP5 could potentially diminish these effects through additional storage capacity of the reservoir available after construction, it is not expected to result in long-term changes to channel equilibrium downstream from Shasta Dam. In addition, potential impacts associated with channel meander and erosion under CP5 would be less than significant in the Shasta Lake and vicinity portion of the study area, the upper Sacramento River portion of the primary study area, and the extended study area. When added to the anticipated effects of climate change, raising Shasta Dam would not have a significant cumulative effect.

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Chapter 5
Air Quality and Climate

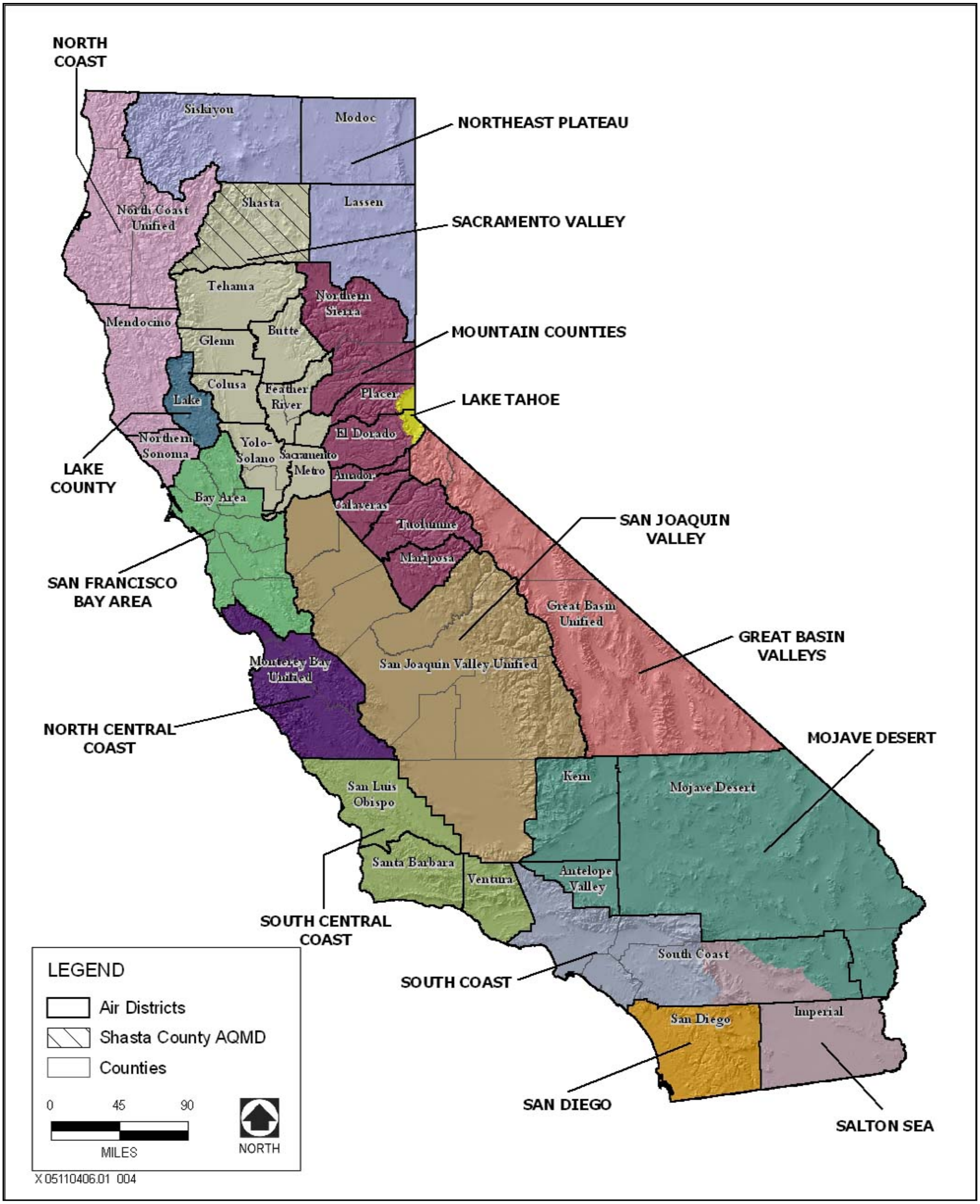
5.1 Affected Environment

This section describes existing air quality conditions in the primary study area for the dam and reservoir modifications proposed under SLWRI action alternatives. The climate and the emissions of criteria air pollutants and toxic air contaminants (TAC) at Shasta Lake and vicinity and the upper Sacramento River from Shasta Dam to Red Bluff are described. In addition, the attainment status of Shasta County relative to national and State air quality standards is summarized.

The primary study area for air quality analysis has two components – local and regional. The local area is the area immediately surrounding Shasta Dam and Shasta Lake where project construction would occur. Regionally, Shasta and Tehama counties are located in the Northern Sacramento Valley Air Basin (NSVAB), a subarea of the Sacramento Valley Air Basin (SVAB). The SVAB also includes all of Butte, Colusa, Glenn, Sacramento, Sutter, Yolo, and Yuba counties; the western portion of Placer County; and the eastern portion of Solano County. Figure 5-1 depicts the locations of these air basins, highlighting the Shasta County Air Quality Management District (SCAQMD) area. The NSVAB includes the seven counties located in the northern portion of the Sacramento Valley: Butte, Colusa, Glenn, Shasta, Sutter, Tehama, and Yuba.

The SLWRI would not include any construction or operational activities in the extended study area (the lower Sacramento River and Delta and the CVP and SWP service areas) that would affect air quality. Therefore, this section only minimally discusses air quality conditions in the extended study area. Details about conditions in the extended study area are available in the *Air Quality and Climate Technical Report*.

This section also summarizes current climate change effects of greenhouse gas (GHG) emissions on what is referred to in this chapter as the "global study area."



Source: ARB 2004

Figure 5-1. Air Basins in California, Including the SCAQMD Area

5.1.1 Regional Climate in the Primary Study Area

The NSVAB is bounded on the north and west sides by the Coast Ranges and on the east side by the southern portion of the Cascade Range and the northern portion of the Sierra Nevada. These mountain ranges provide a substantial physical barrier to locally created air pollution, as well as pollution transported northward on prevailing winds from the Sacramento metropolitan area (NSVPAD 2010). The valley is often subject to inversion layers that, coupled with geographic barriers and high summer temperatures, create high potential for air pollution problems.

5.1.2 Criteria Air Pollutants

Concentrations of the following air pollutants are used as indicators of ambient air quality conditions: ozone, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), respirable and fine particulate matter (PM_{10} and $PM_{2.5}$), and lead. Because these are the most prevalent air pollutants known to be deleterious to human health, they are commonly referred to as “criteria air pollutants.”

Each criteria air pollutant is described briefly below. A more in-depth discussion is provided in the *Air Quality and Climate Technical Report*.

Ozone

Ozone is a photochemical oxidant and the primary component of smog. Ozone is not directly emitted into the air, but is formed through complex chemical reactions between precursor emissions of reactive organic gases (ROG) and oxides of nitrogen (NO_X) in the presence of sunlight. ROG are volatile organic compounds (VOC). ROG emissions result primarily from incomplete combustion and the evaporation of chemical solvents and fuels. NO_X are a group of gaseous compounds of nitrogen and oxygen that results from the combustion of fuels.

Ozone located in the lower atmosphere is a major health and environmental concern. Meteorology and terrain play a major role in ozone formation. Low wind speeds or stagnant air coupled with warm temperatures and clear skies provide the optimum conditions for ozone formation. Therefore, summer is the peak ozone season. Ozone is a regional pollutant that often affects large areas. Ozone concentrations over or near urban and rural areas reflect an interplay of emissions of ozone precursors, transport, meteorology, and atmospheric chemistry (Godish 2004).

Carbon Monoxide

CO is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels, primarily from mobile (transportation) sources. Approximately 77 percent of the nation’s CO emissions are from mobile sources. The other 23 percent consist of CO emissions from wood-burning stoves, incinerators, and industrial sources. The highest concentrations are generally associated with cold, stagnant weather conditions that occur during winter. In contrast to ozone, which is a regional pollutant, CO causes problems on a local scale.

Nitrogen Dioxide

NO_2 is a brownish, highly reactive gas that is present in all urban environments. The major human-made sources of NO_2 are combustion devices, such as boilers, gas turbines, and mobile and stationary combustion engines. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system (EPA 2010a). The combined emissions of NO and NO_2 are referred to as NO_X, which are reported as equivalent NO_2. Because NO_2 is formed and depleted by reactions associated with ozone, the NO_2 concentration in a particular geographical area may not be representative of the local NO_X emission sources.

Sulfur Dioxide

SO_2 is produced by such stationary sources as coal and oil combustion, steel mills, refineries, and pulp and paper mills. SO_2 is a respiratory irritant. On contact with the moist mucous membranes, SO_2 produces sulfurous acid.

Particulate Matter

Respirable particulate matter with an aerodynamic diameter of 10 micrometers or less is referred to as PM_{10}. PM_{10} consists of particulate matter emitted directly into the air, such as fugitive dust, soot, and smoke from mobile and stationary sources, construction operations, fires, and natural windblown dust, and particulate matter formed in the atmosphere by condensation and/or transformation of SO_2 and ROG. $PM_{2.5}$ includes a subgroup of finer particles that have an aerodynamic diameter of 2.5 micrometers or less (EPA 2011a).

Lead

Lead is a metal found naturally in the environment and in manufactured products. The major sources of lead emissions have historically been mobile and industrial sources. As a result of the phase-out of leaded gasoline, metal processing is currently the primary source of lead emissions. The highest levels of lead in air are generally found near lead smelters. Other stationary sources are waste incinerators, utilities, and lead-acid battery manufacturers.

5.1.3 Monitoring Station Data and Criteria Pollutant Attainment Area Designations

Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to Red Bluff)

Concentrations of criteria air pollutants are measured at several monitoring stations in Shasta County. The Redding Health Department and Shasta Lake stations are the closest stations to the project construction area with recent data for ozone and particulate matter. In general, the ambient air quality measurements from these stations are representative of the study area's air quality. Table 5-1 summarizes the air quality data from the most recent 3 years. The data are compared with the ambient air quality standards as noted below. Refer to Table 5-2 for a full listing of all ambient all quality standards.

Table 5-1. Summary of Annual Ambient Air Quality Data (2009 – 2011)

	2009	2010	2011
Ozone			
Redding Health Department Monitoring Station			
California maximum concentration (1-hour/8-hour average, ppm)	0.084/0.069	0.077/0.065	0.073/0.065
Number of days State 1-hour/8-hour standard exceeded	0/0	0/0	0/0
Number of days national 1-hour/8-hour standard exceeded	0/0	0/0	0/0
Fine Particulate Matter ($PM_{2.5}$)			
Redding Health Department Monitoring Station			
California maximum concentration ($\mu g/m^3$)	20.2	10.7	18.8
Number of days national standard exceeded (measured[a])	0	0	0
Respirable Particulate Matter (PM_{10})			
Redding Health Department Monitoring Station			
Maximum concentration ($\mu g/m^3$)	32.6	23.8	34.2
Number of days State standard exceeded (measured/calculated[a])	0/0	*/0	0/0
Number of days national standard exceeded (measured/calculated[a])	0/0	0/0	0/0
Shasta Lake Monitoring Station			
Maximum concentration ($\mu g/m^3$)	32.2	28.3	30.7
Number of days State standard exceeded (measured/calculated[a])	0/0	*/0	0/0
Number of days national standard exceeded (measured/calculated[a])	0/0	0/0	0/0

Source: ARB 2012

Note:
[a] Measured days are those days that an actual measurement was greater than the level of the State daily standard or the national daily standard. Measurements are typically collected every 6 days. Calculated days are the estimated number of days that a measurement would have been greater than the level of the standard had measurements been collected every day. The number of days above the standard is not necessarily the number of violations of the standard for the year.

Key:
* = insufficient data available to determine value.
µg/m3 = micrograms per cubic meter
$PM_{2.5}$ = fine particulate matter with an aerodynamic diameter of 2.5 micrometers or less
PM_{10} = respirable particulate matter with an aerodynamic diameter of 10 micrometers or less
ppm = parts per million

Table 5-2. Ambient Air Quality Standards and Designations

Pollutant	Averaging Time	California Standards [b,c]	California Attainment Status (Shasta County) [d]	National Standards [a] Primary [c,e]	National Standards Secondary [c,f]	National Attainment Status (Shasta County) [g]
Ozone	1-hour	0.09 ppm (180 µg/m^3)	N (Moderate)	*Note h*	Same as primary standard	–
	8-hour	0.070 ppm	–	0.075 ppm (147 µg/m^3)		U/A
Carbon monoxide	1-hour	20 ppm (23 mg/m^3)	U	35 ppm (40 mg/m^3)	–	U/A
	8-hour	9 ppm (10 mg/m^3)		9 ppm (10 mg/m^3)		
	8-hour (Lake Tahoe)	6 ppm (7 mg/m^3)	–	–	–	–
Nitrogen dioxide (NO_2)	Annual Arithmetic Mean	0.030 ppm (57 µg/m^3)	–	0.053 ppm (100 µg/m^3) [i]	Same as primary standard	U/A
	1-hour	0.18 ppm (339 µg/m^3)	A	0.100 ppm (188 µg/m^3) [i]		–
Sulfur dioxide (SO_2)	24-hour	0.04 ppm (105 µg/m^3)	A	–	–	U
	3-hour	–	–	–	0.5 ppm (1300 µg/m^3)[j]	
	1-hour	0.25 ppm (655 µg/m^3)	A	0.075 ppm (196 µg/m^3) [j]	–	–
Respirable particulate matter (PM_{10})	Annual Arithmetic Mean	20 µg/m^3	N	–	Same as primary standard	U/A
	24-hour	50 µg/m^3		150 µg/m^3 [f]		
Fine particulate matter ($PM_{2.5}$)	Annual Arithmetic Mean	12 µg/m^3	U	15 µg/m^3	Same as primary standard	U/A
	24-hour	–	–	35 µg/m^3		
Lead [k]	30-day Average	1.5 µg/m^3	A	–	–	–
	Calendar Quarter	–		1.5 µg/m^3	Same as primary standard	A
	Rolling 3 Month Average	–		0.15 µg/m^3		
Sulfates	24-hour	25 µg/m^3	A	No national standards		
Hydrogen sulfide	1-hour	0.03 ppm (42 µg/m^3)	U			
Vinyl chloride [k]	24-hour	0.01 ppm (26 µg/m^3)	U/A			
Visibility-reducing particle matter	8-hour	Extinction coefficient of 0.23 per kilometer—visibility of 10 mi or more	U			

Table 5-2. Ambient Air Quality Standards and Designations (contd.)

Sources: ARB 2010a, 2010b; EPA 2011b

Notes:

[a] National standards (other than ozone, particulate matter, and those based on annual averages or annual arithmetic means) are not to be exceeded more than once a year. The ozone standard is attained when the fourth highest 8-hour concentration in a year, averaged over 3 years, is equal to or less than the standard. The PM10 24-hour standard is attained when 99 percent of the daily concentrations, averaged over 3 years, are equal to or less than the standard. The PM2.5 24-hour standard is attained when 98 percent of the daily concentrations, averaged over 3 years, are equal to or less than the standard. Contact the U.S. Environmental Protection Agency (EPA) for further clarification and current Federal policies.

[b] California standards for ozone, CO (except Lake Tahoe), SO_2 (1- and 24-hour), NO_2, particulate matter, and visibility-reducing particles are values that are not to be exceeded. All others are not to be equaled or exceeded. California ambient air quality standards are listed in the Table of Standards in Section 70200 of Title 17 of the California Code of Regulations.

[c] Concentration expressed first in units in which it was promulgated (i.e., parts per million (ppm) or micrograms per cubic meter ($\mu g/m^3$)). Equivalent units given in parentheses are based upon a reference temperature of 25 degrees Celsius (°C) and a reference pressure of 760 torr. Most measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 torr; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

[d] Unclassified (U): A pollutant is designated unclassified if the data are incomplete and do not support a designation of attainment or nonattainment.

Attainment (A): A pollutant is designated attainment if the State standard for that pollutant was not violated at any site in the area during a 3-year period.

Nonattainment (N): A pollutant is designated nonattainment if there was a least one violation of a State standard for that pollutant in the area.

Nonattainment/Transitional (NT): A subcategory of the nonattainment designation. An area is designated nonattainment/transitional to signify that the area is close to attaining the standard for that pollutant.

[e] National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

[f] National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

[g] Nonattainment (N): Any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant.

Attainment (A): Any area that meets the national primary or secondary ambient air quality standard for the pollutant.

Unclassifiable (U): Any area that cannot be classified on the basis of available information as meeting or not meeting the national primary or secondary ambient air quality standard for the pollutant.

[h] The 1-hour ozone national ambient air quality standard was revoked on June 15, 2005, for all areas in California.

[i] To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 0.100 part per million (ppm) (effective January 22, 2010). Note that the EPA standards are in units of parts per billion (ppb). California standards are in units of ppm. To directly compare the national standards to the California standards, the units can be converted from ppb to ppm. In this case, the national standards of 53 ppb and 100 ppb are identical to 0.053 ppm and 0.100 ppm, respectively.

[j] On June 2, 2010, EPA established a new 1-hour SO_2 standard, effective August 23, 2010, which is based on the 3-year average of the annual 99th percentile of 1-hour daily maximum concentrations. EPA also proposed a new automated Federal Reference Method (FRM) using ultraviolet technology, but will retain the older pararosaniline methods until the new FRM have adequately permeated State monitoring networks. EPA also revoked both the existing 24-hour SO_2 standard of 0.14 ppm and the annual primary SO_2 standard of 0.030 ppm, effective August 23, 2010.

The secondary SO_2 standard was not revised at that time; however, the secondary standard is undergoing a separate review by EPA. Note that the new standard is in ppb. California standards are in ppm. To directly compare the new primary national standard to the California standard the units can be converted to ppm. In this case, the national standard of 75 ppb is identical to 0.075 ppm.

[k] The California Air Resources Board has identified lead and vinyl chloride as toxic air contaminants with no threshold of exposure for adverse health effects determined. These actions allow for the implementation of control measures at levels below the ambient concentrations specified for these pollutants.

Key:

$\mu g/m^3$ = micrograms per cubic meter

mg/m^3 = milligrams per cubic meter

ppm = parts per million

The monitoring data are used to designate areas according to their attainment status for criteria air pollutants. The purpose of these designations is to identify those areas with air quality problems and thereby initiate planning efforts for improvement. The three basic designation categories are "nonattainment," "attainment," and "unclassified (see notes in Table 5-2 for full definitions)." "Unclassified" is used in an area that cannot be classified on the basis of available information as meeting or not meeting the standards. In addition, the California designations include a subcategory of the nonattainment designation, "nonattainment-transitional," that is given to nonattainment areas that are progressing and nearing attainment. The most current attainment designations for Shasta County are shown in Table 5-2 for each criteria air pollutant.

Lower Sacramento River and Delta

The lower Sacramento River and Delta areas are within the SVAB and the San Joaquin Valley Air Basin. As described in greater detail in the *Air Quality and Climate Technical Report*, these basins are Federal and State nonattainment areas for ozone, PM_{10}, and $PM_{2.5}$.

CVP/SWP Service Areas

The CVP and SWP service areas extend beyond the Central Valley into the San Francisco Bay Area, North Central Coast, South Central Coast, and Mountain Counties air basins. Federal and State ozone attainment designations for all California counties and air basins are provided in the *Air Quality and Climate Technical Report*. All counties in California south of Shasta County, with the exception of Lake, Sonoma, Tuolumne, and Mariposa counties, are State nonattainment areas for PM_{10} (ARB 2010a).

5.1.4 Toxic Air Contaminants in the Primary Study Area

TACs, or in Federal terms hazardous air pollutants (HAP), are air pollutants that may cause or contribute to an increase in mortality or in serious illness, or that may pose a hazard to human health. TACs are usually present in minute quantities in the ambient air; however, their high toxicity or health risk may pose a threat to public health even at low concentrations. Of the TACs for which data are available in California, diesel particulate matter (diesel PM), naturally occurring asbestos, benzene, 1,3-butadiene, acetaldehyde, carbon tetrachloride, hexavalent chromium, para-dichlorobenzene, formaldehyde, methylene chloride, and perchloroethylene pose the greatest known health risks. Dioxins are also considered to pose substantial health risk and diesel PM poses the greatest health risk. Current facilities permitted by SCAQMD in the project vicinity are Lehigh Southwest Cement Company, Mountain Gate Quarry, Knauf Insulation, and Sierra Pacific Industries.

5.1.5 Global Study Area

Atmospheric GHGs play a critical role in determining the earth's surface temperature. Solar radiation enters the earth's atmosphere from space. Prominent GHGs contributing to the greenhouse effect are carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, chlorofluorocarbons, and sulfur hexafluoride. Sources of GHG emissions associated with existing operations include vehicles used for operation and maintenance of the dam and recreation areas, vehicles used by recreational visitors, and fossil fuel–powered boats on Shasta Lake. Human-caused emissions of these GHGs that exceed natural ambient concentrations are responsible for intensifying the greenhouse effect and have led to a trend of unnatural warming of the earth's climate, known as global climate change or global warming (Ahrens 2003).

To provide a method of quantifying GHG emissions, the standard unit of CO_2e, or CO_2 equivalent, was developed. The definition of CO_2e is "The quantity of a given GHG multiplied by its total global warming potential (GWP). This is the standard unit for comparing the degree of warming that can be caused by GHGs" (CCAR 2009). The GWP of a GHG is dependent on the lifetime, or persistence, of the gas molecule in the atmosphere compared to CO_2. The GWP of methane is 23; the GWP of nitrous oxide is 296. Therefore, methane and nitrous oxide are more potent GHGs than CO_2. Expressing emissions in CO_2e takes the contributions of all GHG emissions to the greenhouse effect and converts them to a single unit equivalent to the effect that would occur if only CO_2 were being emitted. The most common quantity unit for CO_2e is million metric tons (MMT). In some reports, CO_2e is written as CO_2e, and million metric tons is written as MMT CO_2e.

Climate change is a global phenomenon. GHGs are global pollutants, unlike criteria air pollutants and TACs, which are pollutants of regional and local concern. Whereas pollutants with localized air quality effects have relatively short atmospheric lifetimes (about 1 day), GHGs have long atmospheric lifetimes (1 year to several thousand years). GHGs persist in the atmosphere for long enough time periods to be dispersed around the globe. Although the exact lifetime of any particular GHG molecule is dependent on multiple variables and cannot be pinpointed, it is understood that more CO_2 is emitted into the atmosphere than is sequestered by ocean uptake, vegetation, and other forms of sequestration. Of the total annual human-caused CO_2 emissions, approximately 54 percent is sequestered through ocean uptake, uptake by Northern Hemisphere forest regrowth, and other terrestrial sinks within a year, whereas the remaining 46 percent of human-caused CO_2 emissions remains stored in the atmosphere (Seinfeld and Pandis 1998).

Effects of GHGs are borne globally, as opposed to localized air quality effects of criteria air pollutants and TACs. The quantity of GHGs that it takes to ultimately result in climate change is not precisely known; suffice it to say that the quantity is enormous, and no single project alone would be expected to measurably contribute to a noticeable incremental change in the global average temperature, or to global, local, or micro climate. From the standpoint of CEQA, GHG effects related to global climate change are inherently cumulative.

Please see the *Air Quality and Climate Technical Report* for a discussion of GHG feedback mechanisms and uncertainty.

5.2 Regulatory Framework

Air quality in Shasta County is regulated by such agencies as the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (ARB), and SCAQMD. Each of these agencies develops rules, regulations, policies, and/or goals to comply with applicable legislation. Although EPA regulations may not be superseded, both State and local regulations may be more stringent.

5.2.1 Federal

Criteria Air Pollutants

At the Federal level, EPA implements national air quality programs. EPA's air quality mandates are drawn primarily from the Federal Clean Air Act (CAA), which was enacted in 1970 and most recently amended in 1990.

The CAA required EPA to establish primary and secondary national ambient air quality standards, as shown in Table 5-2. The CAA also required each state to prepare an air quality control plan referred to as a State implementation plan (SIP). The Federal Clean Air Act Amendments of 1990 (CAAA) added requirements for states with nonattainment areas to revise their SIPs to incorporate additional control measures to reduce air pollution. The SIP is modified periodically to reflect the latest emissions inventories, planning documents, and rules and regulations of the air basins as reported by their jurisdictional agencies. EPA reviews all SIPs to determine whether they conform to the mandates of CAA and its amendments, and whether implementation will achieve air quality goals. If EPA determines a SIP to be inadequate, a Federal implementation plan that imposes additional control measures may be prepared for the nonattainment area. Failure to submit an approvable SIP or to implement the plan within the mandated time frame may result in the application of sanctions to transportation funding and stationary air pollution sources in the air basin.

Hazardous Air Pollutants

Air quality regulations also focus on TACs, or in Federal parlance, HAPs. In general, for those TACs that may cause cancer, there is no concentration that does not present some risk. In other words, there is no threshold level below which adverse health effects may not be expected to occur. This contrasts with the criteria air pollutants, for which acceptable levels of exposure can be determined and for which the ambient standards have been established (Table 5-2). Instead, EPA and ARB regulate HAPs and TACs, respectively, through statutes and regulations that generally require the use of the maximum available control technology or best available control technology for toxics to limit emissions. These statutes and regulations establish the regulatory framework for TACs.

EPA has programs for identifying and regulating HAPs. Title III of the CAAA directed EPA to promulgate national emissions standards for HAPs. National emissions standards for HAPs vary depending on the pollutant source type. The national emissions standards for HAPs for major stationary sources of HAPs could therefore be different than those for area sources. Major sources are defined as stationary sources with potential to emit more than 10 tons per year of any HAP or more than 25 tons per year of any combination of HAPs; all other sources are considered area sources. The emissions standards were to be promulgated in two phases. In the first phase (1992 to 2000), EPA developed technology-based emission standards designed to produce the maximum emission reduction achievable. These standards are generally referred to as requiring maximum available control technology. For area sources, the standards may be different, based on generally available control technology. In the second phase (2001 to 2008), EPA was required to promulgate health risk–based emissions standards, where deemed necessary, to address risks remaining after implementation of the technology-based national emission standards for HAPs standards.

The CAAA also required EPA to promulgate vehicle or fuel standards containing reasonable requirements that control toxic emissions of benzene and formaldehyde at a minimum. Performance criteria were established to limit mobile-source emissions of toxics, including benzene, formaldehyde, and 1,3-butadiene. In addition, Section 219 required the use of reformulated gasoline in selected areas with the most severe ozone nonattainment conditions to further reduce mobile-source emissions.

General Conformity

The 1990 amendments to CAA Section 176 require EPA to promulgate rules to ensure that Federal actions conform to the appropriate SIP. These rules are known as the General Conformity Rule (40 Code of Federal Regulations Parts 51.850–51.860 and 93.150–93.160). Any Federal agency responsible for an action in a nonattainment/maintenance area must determine whether that action conforms to the applicable SIP or is exempt from General Conformity Rule requirements.

Shasta County, where the proposed action would occur, is neither a nonattainment area nor a maintenance area for the national ambient air quality standards. Therefore, the General Conformity Rule is not applicable to the project.

Greenhouse Gases

Mandatory Greenhouse Gas Reporting Rule On September 22, 2009, EPA released its final Greenhouse Gas Reporting Rule (Reporting Rule). The Reporting Rule is a response to the fiscal year 2008 Consolidated Appropriations Act (House Bill 2764; Public Law 110-161), which required EPA to develop "… mandatory reporting of greenhouse gases above appropriate thresholds in all sectors of the economy…." The Reporting Rule applies to most entities that emit 25,000 metric tons (MT) CO_2e or more per year. Since 2010, facility owners have been required to submit an annual GHG emissions report with detailed calculations of facility GHG emissions. The Reporting Rule also mandates recordkeeping and administrative requirements for EPA to verify annual GHG emissions reports.

U.S. Environmental Protection Agency Endangerment and Cause or Contribute Findings On December 7, 2009, the EPA Administrator signed two distinct findings regarding GHGs under Section 202(a) of the CAA:

- **Endangerment Finding –** The current and projected concentrations of the six key well-mixed GHGs – CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride – in the atmosphere threaten the public health and welfare of current and future generations.

- **Cause or Contribute Finding –** The combined emissions of these well-mixed GHGs from new motor vehicles and new motor vehicle engines contribute to GHG pollution, which threatens public health and welfare.

Council on Environmental Quality Draft NEPA Guidelines Because of uneven treatment of climate change under NEPA, the International Center for Technology Assessment, Natural Resources Defense Council, and Sierra Club filed a petition with the Council on Environmental Quality (CEQ) in March 2008. The petition requested that climate change analyses be included in all Federal environmental review documents. In October 2009, President Barack Obama signed Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance.” The goal of this executive order is “to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of GHGs a priority for Federal agencies” (FedCenter 2011).

In response to the petition and subsequent Executive Order 13514, CEQ issued guidance on including GHG emissions and climate change impacts in environmental review documents under NEPA. CEQ’s guidance (issued February 18, 2010) suggests that Federal agencies consider opportunities to reduce GHG emissions caused by proposed Federal actions, adapt their actions to climate change impacts throughout the NEPA process, and address these issues in the agencies’ NEPA procedures. The following are the two main factors to consider when addressing climate change in environmental documentation:

- The effects of a proposed action and alternative actions on GHG emissions

- The impacts of climate change on a proposed action or alternatives

CEQ notes that "significant" national policy decisions with "substantial" GHG impacts require analysis of their GHG effects. That is, the GHG effects of a Federal agency's proposed action must be analyzed if the action would cause "substantial" annual direct emissions; would implicate energy conservation or reduced energy use or GHG emissions; or would promote cleaner, more efficient renewable-energy technologies. Qualitative or quantitative information on GHG emissions that is useful and relevant to the decision should be used when deciding among alternatives.

CEQ states that if a proposed action would cause direct annual emissions of more than 25,000 MT CO_2e, a quantitative and qualitative assessment may be meaningful to decision makers and the public. If annual direct emissions would be less than 25,000 MT CO_2e, Federal agencies are encouraged to consider whether the action's long-term emissions should receive similar analysis.

Greenhouse Gas Permitting Requirements on Large Industrial Facilities

On May 13, 2010, EPA issued the Prevention of Significant Deterioration and Title V Greenhouse Gas Tailor Rule (EPA 2010a). This final rule sets thresholds for GHG emissions that define when permits under the New Source Review Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities.

The rule establishes a schedule that will initially focus permitting programs on the largest sources and then expands to cover the largest sources of GHG that may not have been previously covered by the CAA for other pollutants (EPA 2010b). During Step 1, from January 2, 2011 to June 30, 2011, only sources currently subject to the PSD permitting program (i.e., those that are newly-constructed or modified in a way that significantly increases emissions of a pollutant other than GHGs) would be subject to permitting requirements for their GHG emissions under PSD; and, for these projects, only GHG increases of 75,000 tons (68,039 MT) per year or more of total GHG, on a CO_2e basis, would need to determine the Best Available Control Technology for their GHG emissions. Similarly for the operating permit program, only sources currently subject to the program (i.e., newly constructed or existing major sources for a pollutant other than GHGs) would be subject to Title V requirements for GHG. During this time, no sources would be subject to Clean Air Act permitting requirements due solely to GHG emissions.

Step 2 will build on Step 1. During Step 2, from July 1, 2011 to June 30, 2013, PSD permitting requirements will cover for the first time new construction projects that emit GHG emissions of at least 100,000 tons (90,718 MT) per year even if they do not exceed the permitting thresholds for any other pollutant. Modifications at existing facilities that increase GHG emissions by at least 75,000 tons (68,039 MT) per year will be subject to permitting requirements, even if they do not significantly increase emissions of any other pollutant. In Step 2, operating permit requirements will, for the first time, apply to sources based on their GHG emissions even if they would not apply based on emissions of any other pollutant. Facilities that emit at least 100,000 tons (90,718 MT) per year of CO_2e will be subject to Title V permitting requirements.

As part of this rule, EPA also commits to undertake another rulemaking, to begin in 2011 and conclude no later than July 1, 2012. That action will consist of an additional Step 3 for phasing in GHG permitting. Step three, if established, will not require permitting for sources with GHG emissions below 50,000 tons (45,359 MT) per year.

5.2.2 State

ARB coordinates and oversees State and local air pollution control programs in California and implements the California Clean Air Act (CCAA).

Criteria Air Pollutants

The CCAA, which was adopted in 1988, required ARB to establish California ambient air quality standards (Table 5-2). The CCAA requires that all local air districts in the state endeavor to achieve and maintain California ambient air quality standards by the earliest practical date. The act specifies that local air districts should particularly focus on reducing emissions from transportation and area-wide sources, and authorizes districts to regulate indirect sources. Among ARB's other responsibilities are to oversee local air district compliance with California and Federal laws; approve local air quality plans; submit SIPs to EPA; monitor air quality; determine and update area designations and maps; and set emissions standards for new mobile sources, consumer products, small utility engines, off-road vehicles, and fuels.

Toxic Air Contaminants

TACs in California are regulated primarily through the Tanner Air Toxics Act (Assembly Bill (AB) 1807 (Statutes of 1983)) and the Air Toxics Hot Spots Information and Assessment Act (AB 2588 (Statutes of 1987)). AB 1807 sets forth a formal procedure for ARB to designate substances as TACs. Research, public participation, and scientific peer review must be completed before ARB can designate a substance as a TAC. To date, ARB has identified more than 21 TACs and has adopted EPA's list of HAPs as TACs. Most recently, diesel PM was added to the ARB list of TACs.

Once a TAC is identified, ARB adopts an airborne toxics control measure for sources that emit that particular TAC. If a safe threshold exists for a substance at which there is no toxic effect, the control measure must reduce exposure below that threshold. If there is no safe threshold, the measure must incorporate best available control technology to minimize emissions.

AB 2588 requires facilities that emit toxic substances above a specified level to do all of the following:

- Prepare a toxic emissions inventory

- Prepare a risk assessment if emissions are significant
- Notify the public of significant risk levels
- Prepare and implement risk reduction measures

Greenhouse Gases

Various statewide initiatives to reduce California's contribution to GHG emissions have raised awareness that, even though the various contributors to and consequences of global climate change are not yet fully understood, global climate change is under way, and real potential exists for severe adverse environmental, social, and economic effects in the long term. The most relevant laws and orders are discussed in more detail below.

California Environmental Quality Act and SB 97 CEQA requires lead agencies to consider the reasonably foreseeable adverse environmental effects of projects they are considering for approval. GHG emissions have the potential to adversely affect the environment because they contribute to global climate change. In turn, global climate change has the potential to raise sea levels, affect rainfall and snowfall, and affect habitat.

Senate Bill 97 Senate Bill (SB) 97 was enacted in August 2007 as part of the State budget negotiations and is codified at Section 21083.05 of the California Public Resources Code. SB 97 directs the Governor's Office of Planning and Research (OPR) to propose guidance in the State CEQA Guidelines "for the mitigation of GHG emissions or the effects of GHG emissions." SB 97 directed OPR to develop text for the State CEQA Guidelines by July 2009. This legislation also directed the State Resources Agency (now Natural Resources Agency) – the agency charged with adopting the State CEQA Guidelines – to certify and adopt such guidelines by January 2010. In April 2009, OPR prepared draft CEQA Guidelines amendments and submitted them to the Natural Resources Agency (see below). On July 3, 2009, the Natural Resources Agency began the rulemaking process established under the Administrative Procedure Act.

The Natural Resources Agency recommended amendments for GHGs to fit within the existing CEQA framework for environmental analysis, which calls for lead agencies to determine baseline conditions and levels of significance and evaluate mitigation measures. The amendments to the State CEQA Guidelines do not identify a threshold of significance for GHG emissions, nor do they prescribe assessment methodologies or specific mitigation measures. The amendments encourage lead agencies to consider many factors in performing a CEQA analysis, but preserve the discretion that CEQA grants lead agencies to make their own determinations based on substantial evidence.

Section 15064.4, "Determining the Significance of Impacts from Greenhouse Gas Emissions," of the State CEQA Guidelines encourages lead agencies to consider three factors to assess the significance of GHG emissions:

1. Will the project increase or reduce GHGs as compared to the baseline?

2. Will the project's GHG emissions exceed the lead agency's threshold of significance?

3. Does the project comply with regulations or requirements to implement a statewide, regional, or local GHG reduction or mitigation plan?

These questions are addressed in Section 5.3.

Section 15064.4 also recommends that lead agencies make a good-faith effort, based on available information, to describe, calculate, or estimate the amount of GHG emissions associated with a project.

Section 15126.4, "Consideration and Discussion of Mitigation Measures Proposed to Minimize Significant Effects," of the State CEQA Guidelines lists considerations for lead agencies related to feasible mitigation measures to reduce GHG emissions. Among those considerations are the following:

- Project features, project design, or other measures that are incorporated into the project to substantially reduce energy consumption or GHG emissions

- Compliance with the requirements in a previously approved plan or mitigation program to reduce or sequester GHG emissions, when the plan or program provides specific requirements that will avoid or substantially lessen the potential impacts of the project

- Measures that sequester carbon or carbon-equivalent emissions

Section 15126.4 also specifies that where mitigation measures are proposed to reduce GHG emissions through off-site actions or purchase of carbon offsets, these mitigation measures must be part of a reasonable plan of mitigation that the relevant agency commits itself to implementing.

In addition, as part of the amendments and additions to the State CEQA Guidelines, a new set of environmental checklist questions (VII. Greenhouse Gas Emissions) was added to Appendix G of the State CEQA Guidelines. The new set asks whether a project would do either of the following:

a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

b) Conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of greenhouse gases?

Preliminary Draft Staff Proposal: Recommended Approaches for Setting Interim Significance Thresholds for Greenhouse Gases under CEQA CEQA gives discretion to lead agencies to establish thresholds of significance based on individual circumstances. To assist in that exercise, and because OPR believes the unique nature of GHGs warrants investigation of a statewide threshold of significance for GHG emissions, OPR asked ARB technical staff to recommend a methodology for setting thresholds of significance. In October 2008, ARB released *Preliminary Draft Staff Proposal: Recommended Approaches for Setting Interim Significance Thresholds for Greenhouse Gases under the California Environmental Quality Act* (ARB 2008). This draft proposal included a conceptual approach for thresholds associated with industrial, commercial, and residential projects. For nonindustrial projects, the steps to presuming a less than significant climate change impact generally involve analyzing whether the project meets the following criteria (ARB 2008):

- Is exempt under existing statutory or categorical exemptions
- Complies with a previously approved plan or target
- Meets specified minimum performance standards
- Falls below an as-yet-unspecified annual emissions level

The performance standards focus on construction activities, energy and water consumption, generation of solid waste, and transportation. For industrial projects, the draft proposal recommends a tiered analysis procedure similar to the procedure for analyzing nonindustrial projects. However, for industrial projects a quantitative limit for less than significant impacts is established at approximately 7,000 MT CO_2e per year. These standards have not yet been adopted or finalized as a basis for evaluating the significance of a project's contribution to climate change.

Overall, as directed by SB 97, the Natural Resources Agency adopted Amendments to the CEQA Guidelines for GHGs emissions on December 30, 2009. On February 16, 2010, the Office of Administrative Law approved the Amendments, and filed them with the Secretary of State for inclusion in the California Code of Regulations. The Amendments became effective on March 18, 2010.

Executive Order S-3-05 Executive Order S-3-05 made California the first state to formally establish GHG emissions reduction goals. Executive Order S-3-05 includes the following GHG emissions reduction targets for California:

- By 2010, reduce GHG emissions to 2000 levels.

- By 2020, reduce GHG emissions to 1990 levels.
- By 2050, reduce GHG emissions to 80 percent below 1990 levels.

The final emission target of 80 percent below 1990 levels would put the state's emissions in line with estimates of the required worldwide reductions needed to bring about long-term climate stabilization and avoidance of the most severe impacts of climate change (IPCC 2007).

Executive Order S-3-05 also dictated that the Secretary of the California Environmental Protection Agency coordinate oversight of efforts to meet these targets with all of the following:

- The Secretaries of the Business, Transportation, and Housing Agency; California Department of Food and Agriculture; and California Natural Resources Agency
- The Chairpersons of ARB and the California Energy Commission
- The President of the California Public Utilities Commission

This group was subsequently named the Climate Action Team.

As laid out in Executive Order S-3-05, the Climate Action Team has submitted biannual reports to the Governor and State legislature describing progress made toward reaching the targets. The Climate Action Team is finalizing its second biannual report on the effects of climate change on California's resources.

Assembly Bill 32 In 2006, California passed the California Global Warming Solutions Act of 2006 (AB 32; California Health and Safety Code, Sections 38500 et seq.). AB 32 further details and puts into law the midterm GHG reduction target established in Executive Order S-3-05 – reduce GHG emissions to 1990 levels by 2020. AB 32 also identifies ARB as the State agency responsible for the design and implementation of emissions limits, regulations, and other measures to meet the target.

The statute lays out the schedule for each step of the regulatory development and implementation, as follows:

- By June 30, 2007, ARB had to publish a list of early-action GHG emission reduction measures.
- Before January 1, 2008, ARB had to identify the current level of GHG emissions by requiring statewide reporting and verification of GHG emissions from emitters and identify the 1990 levels of California GHG emissions.

- By January 1, 2010, ARB had to adopt regulations to implement the early-action measures.

In December 2007, ARB approved the 2020 GHG emission limit (1990 level) of 427 MMT CO_2e. The 2020 target requires the reduction of 169 MMT CO_2e, or approximately 30 percent below California's projected "business-as-usual" 2020 emissions of 596 MMT CO_2e.

Also in December 2007, ARB adopted mandatory reporting and verification regulations pursuant to AB 32. The regulations became effective January 1, 2009, with the first reports covering 2008 emissions. The mandatory reporting regulations require reporting for major facilities, those that generate more than 25,000 MT CO_2e per year. To date ARB has met all of the statutorily mandated deadlines for promulgation and adoption of regulations.

Climate Change Scoping Plan In December 2008, ARB adopted its Climate Change Scoping Plan, which contains the main strategies California will implement to achieve reduction of approximately 118 MMT of CO_2e, or approximately 22 percent from the state's projected 2020 emission level of 545 MMT of CO_2e under a business-as-usual scenario (this is a reduction of 47 MMT CO_2e, or almost 10 percent, from 2008 emissions). ARB's original 2020 projection was 596 MMT CO_2e, but this revised 2020 projection takes into account the economic downturn that occurred in 2008 (ARB 2011). In August 2011, the Scoping Plan was re-approved by ARB, and includes the Final Supplement to the Scoping Plan Functional Equivalent Document, which further-examined various alternatives to Scoping Plan measures. The Scoping Plan also includes ARB-recommended GHG reductions for each emissions sector of the state's GHG inventory. ARB estimates the largest reductions in GHG emissions to be achieved by implementing the following measures and standards (ARB 2011):

- improved emissions standards for light-duty vehicles (estimated reductions of 26.1 MMT CO_2e),
- the Low-Carbon Fuel Standard (15.0 MMT CO_2e),
- energy efficiency measures in buildings and appliances (11.9 MMT CO_2e), and
- a renewable portfolio and electricity standards for electricity production (23.4 MMT CO_2e).

ARB has not yet determined what amount of GHG reductions it recommends from local government operations; however, the Scoping Plan does state that land use planning and urban growth decisions will play an important role in the state's GHG reductions because local governments have primary authority to plan, zone, approve, and permit how land is developed to accommodate population growth and the changing needs of their jurisdictions. (Meanwhile, ARB is also developing an additional protocol for community emissions.) ARB further acknowledges that decisions on how land is used will have large impacts on the GHG emissions that will result from the transportation, housing, industry, forestry, water, agriculture, electricity, and natural gas emission sectors. The Scoping Plan states that the ultimate GHG reduction assignment to local government operations is to be determined (ARB 2008). With regard to land use planning, the Scoping Plan expects approximately 3.0 MMT CO_2e will be achieved associated with implementation of SB 375, which is discussed further below (ARB 2011).

Executive Order S-13-08 Executive Order S-13-08, issued November 14, 2008, directs the California Natural Resources Agency, DWR, OPR, the California Energy Commission, the State Water Resources Control Board, the California Department of Parks and Recreation, and California’s coastal management agencies to participate in planning and research activities to advance California’s ability to adapt to the effects of climate change. The order specifically directs agencies to work with the National Academy of Sciences to initiate the first California sea-level-rise assessment and to review and update the assessment every 2 years after completion; immediately assess the vulnerability of California’s transportation system to sea level rise; and to develop a climate change adaptation strategy for California.

California Climate Change Adaptation Strategy Developed through cooperation and partnership among multiple State agencies, the 2009 *California Climate Adaptation Strategy* summarizes the best known science on climate change effects. The strategy describes effects of climate change on seven specific sectors—public health, biodiversity and habitat, ocean and coastal resources, water management, agriculture, forestry, and transportation and energy infrastructure—and recommends ways to manage against those threats.

Governor’s Office of Planning and Research Technical Advisory In June 2008, OPR published a technical advisory on CEQA and climate change to provide interim advice to lead agencies regarding the analysis of GHGs in environmental documents (OPR 2008). The advisory encourages lead agencies to identify and quantify the GHGs that could result from a proposed project, analyze impacts of those emissions to determine whether they would be significant, and identify feasible mitigation measures or alternatives that would reduce adverse impacts to a less than significant level. The advisory recognized that OPR would develop, and the Natural Resources Agency would adopt, amendments to the State CEQA Guidelines pursuant to SB 97. (See “California Environmental Quality Act and SB 97,” above.)

The advisory provides OPR’s perspective on the emerging role of CEQA in addressing climate change and GHG emissions. It recognizes that approaches and methodologies for calculating GHG emissions and determining their significance are rapidly evolving. OPR concludes in the technical advisory that climate change is ultimately a cumulative impact, and that no individual project could have a significant impact on global climate. Thus, projects must be analyzed with respect to the incremental impact of the project when added to other past, present, and reasonably foreseeable probable future projects. OPR recommends that lead agencies undertake an analysis, consistent with available guidance and current CEQA practice, to determine cumulative significance (OPR 2008).

The technical advisory points out that neither CEQA nor the State CEQA Guidelines prescribe thresholds of significance or particular methodologies for performing an impact analysis. “This is left to lead agency judgment and discretion, based upon factual data and guidance from regulatory agencies and other sources where available and applicable” (OPR 2008). OPR states that “the global nature of climate change warrants investigation of a statewide threshold of significance for GHG emissions” (OPR 2008). Until such a standard is established, OPR advises that each lead agency should develop its own approach to performing an analysis for projects that generate GHG emissions (OPR 2008).

OPR sets out the following process for evaluating GHG emissions. First, agencies should determine whether GHG emissions may be generated by a proposed project, and if so, quantify or estimate the emissions by type or source. Calculation, modeling, or estimation of GHG emissions should include the emissions associated with vehicular traffic, energy consumption, water usage, and construction activities (OPR 2008).

Agencies should then assess whether the emissions are “cumulatively considerable” even though a project’s GHG emissions may be individually limited. OPR states: “Although climate change is ultimately a cumulative impact, not every individual project that emits GHGs must necessarily be found to contribute to a significant cumulative impact on the environment” (OPR 2008). Individual lead agencies may undertake a project-by-project analysis, consistent with available guidance and current CEQA practice (OPR 2008).

Finally, if the lead agency determines that emissions are a cumulatively considerable contribution to a significant cumulative impact, the lead agency must investigate and implement ways to mitigate the emissions (OPR 2008). OPR (2008) states:

> *Mitigation measures will vary with the type of project being contemplated, but may include alternative project designs or locations that conserve energy and water, measures that reduce vehicle miles traveled by fossil-fueled vehicles, measures that contribute to established regional or programmatic mitigation strategies, and measures that sequester carbon to offset the emissions from the project.*

OPR concludes that "A lead agency is not responsible for wholly eliminating all GHG emissions from a project; the CEQA standard is to mitigate to a level that is "less than significant" (OPR 2008). Attachment 3 to the technical advisory includes a list of GHG reduction measures that can be applied on a project-by-project basis.

California Air Pollution Officers Association In January 2008, the California Air Pollution Control Officers Association issued a "white paper" on evaluating and addressing GHGs under CEQA (CAPCOA 2008). This resource guide was prepared to support local governments as they develop their climate change programs and policies. Though not a guidance document, the paper provides information about key elements of CEQA GHG analyses, including a survey of different approaches to setting quantitative significance thresholds. The following are some of the thresholds discussed:

- Zero (all emissions are significant)
- 900 MT CO_2e per year (90 percent market capture for residential and nonresidential discretionary development)
- 10,000 MT CO_2e per year (potential ARB mandatory reporting level for cap-and-trade program)
- 25,000 MT CO_2e per year (ARB's mandatory reporting level for the statewide emissions inventory)
- Unit-based thresholds, based on identifying thresholds for each type of new development and quantifying significance by a 90 percent capture rate

5.2.3 Regional and Local

Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to Red Bluff)

Shasta County Air Quality Management District SCAQMD is the primary local agency regulating air quality for all of Shasta County. SCAQMD attains and maintains air quality conditions in Shasta County through a comprehensive program of planning, regulation, enforcement, technical innovation, and promotion of the understanding of air quality issues. The clean-air strategy of SCAQMD is to prepare plans and programs for the attainment of ambient air quality standards, adopt and enforce rules and regulations, and issue permits for stationary sources. SCAQMD also inspects stationary sources, responds to citizen complaints, monitors ambient air quality and meteorological conditions, and implements other programs and regulations required by the CAA, CAAA, and CCAA.

Rules and Regulations All projects in Shasta County are subject to SCAQMD rules and regulations in effect at the time of construction. Specific rules applicable to the project may include the following:

- **Rule 2:1A: Permits Required –** Any person who is building, erecting, altering, or replacing any article, machine, equipment or other contrivance, or multicomponent system including same, portable or stationary and who is not exempt under Section 42310 of the California Health and Safety Code, the use of which may cause the issuance of air contaminants, shall first obtain written authority for such construction from the Air Pollution Control Officer.

- **Rule 2:7: Conditions for Open Burning –** All material to be burned must be arranged so that it will burn with a minimum of smoke and must be reasonably free of dirt, soil, and visible surface moisture. All vegetative wastes to be burned shall be ignited only with approved ignition devices and shall be free of tires, illegal residential waste, tar paper, construction debris, and combustible and flammable waste. No burning shall cause emissions to be transported into smoke sensitive areas. No burning shall be conducted when such burns, in conjunction with present or predicted meteorology, could cause or contribute to a violation of an ambient air quality standard.

- **Rule 3:15: Cutback and Emulsified Asphalt –** A person shall not manufacture, sell, offer for sale, use, or apply for paving, construction, or maintenance of parking lots, driveways, streets, or highways any rapid- or medium-cure cutback asphalt, slow-cure cutback asphalt material that contains more than 0.5 percent by volume VOCs that boil at 500 degrees Fahrenheit (260 degrees Celsius) or less, or any emulsified asphalt material that contains more than 3.0 percent by volume of VOCs that evaporate at 500 degrees Fahrenheit (260 degrees Celsius) or less.

- **Rule 3:16: Fugitive, Indirect, or Nontraditional Sources –** The Air Pollution Control Officer may place reasonable conditions upon any source, as delineated below, that will mitigate the emissions from such sources to below a level of significance or to a point that such emissions no longer constitute a violation of Health and Safety Code Sections 41700 and/or 41701: fugitive sources, indirect sources, and nontraditional sources.

- **Rule 3:22: Asbestos –** No person shall use or apply serpentine material for surfacing in California unless the material has been tested using ARB Test Method 435 and determined to have an asbestos content of 5 percent or less. A written receipt or other record documenting the asbestos content shall be retained by any person who uses or applies serpentine material for at least 7 years from the date of use or application, and shall be provided to the Air Pollution Control Officer, or his or her designate, for review upon request.

- **Rule 3:31: Architectural Coatings** – The developer or contractor is required to use coatings that comply with the VOC content limits specified in the rule.

Criteria Pollutants SCAQMD has adopted pollutant emission thresholds and mitigation requirements that are used in the analysis of project impacts. The thresholds and mitigation requirements are discussed below in Section 5.3.2, "Criteria for Determining Significance of Effects."

Attainment Plan Air quality planning in the NSVAB has been undertaken on a joint basis by the air districts in seven counties. The current plan, the *Northern Sacramento Valley Planning Area 2009 Triennial Air Quality Attainment Plan* (AQAP), is an update of plans prepared in 1994, 1997, 2000, 2003, and 2006. The purpose of the plan is to achieve and maintain healthful air quality throughout the air basin. The 2009 AQAP addresses the progress made in implementing the 2006 plan and proposes modifications to the strategies necessary to attain the California ambient air quality standards for the 1-hour ozone standard at the earliest practicable date. The 2012 update is currently in draft form.

The AQAP is based on each county's projected emission inventory, which includes stationary, area-wide, and mobile sources. Emission inventories are based on general plans and anticipated development.

Toxic Air Contaminants At the local level, air pollution control or management districts may adopt and enforce ARB control measures. Under SCAQMD Rule V, "Additional Procedures For Issuing Permits To Operate For Sources Subject To Title V Of The Federal Clean Air Act Amendments Of 1990," Rule 2:1, "New Source Review," and Rule 2:1A, "Permits Required," all sources that possess the potential to emit TACs are required to obtain permits from the district. Permits may be granted to these operations if they are constructed and operated in accordance with applicable regulations, including new-source-review standards and air-toxics control measures. SCAQMD limits emissions and public exposure to TACs through a number of programs. SCAQMD prioritizes TAC-emitting stationary sources based on the quantity and toxicity of the TAC emissions and the proximity of the facilities to sensitive receptors.

Shasta County General Plan The Air Quality Element of the *Shasta County General Plan* (Shasta County 2004) contains objectives and policies aimed at protecting and improving Shasta County's air quality, meeting the requirements of the Federal CAA and CCAA, and integrating planning efforts (e.g., transit, land use) to reduce air pollution contaminants, among others.

Tehama County Air Pollution Control District The southern portion of the primary study area is in Tehama County. The Tehama County Air Pollution Control District is the primary local agency with respect to air quality for Tehama County. The Tehama County Air Pollution Control District has rules and regulations similar to those described for SCAQMD. The Tehama County Air Pollution Control District is in the NSVAB and is therefore a participant in NSVAB's 2003 AQAP.

Lower Sacramento River and Delta and CVP/SWP Service Areas

All areas of California are within the jurisdiction of an air pollution control district or an air quality management district. Each district has rules and regulations similar to those described above for SCAQMD. Districts that are classified as nonattainment for one or more criteria pollutants have attainment plans or similar documents as required by ARB. Most districts have guidance documents for the analysis of air quality impacts for CEQA compliance.

Global Study Area—Greenhouse Gases

There are no regional or local policies, regulations, or laws pertaining to GHG emissions.

5.3 Environmental Consequences and Mitigation Measures

5.3.1 Methods and Assumptions

Criteria Air Pollutants

The proposed SLWRI alternatives are quite complex. They consist of implementing construction activities for the dam structure; clearing the reservoir area that would be affected by the increase in pool height; relocating and modifying bridges, roads, utilities, and recreation areas; and completing other related tasks. A Detailed list including each piece of heavy duty construction equipment for every construction activity to be completed under each Comprehensive Plan (CP), including proposed work hours, was available. In addition, total quantities of material hauled and imported was available. Information on daily trips for construction workers and material hauling was also available for each CP. Quantification of air pollutant emissions were based on a combination of methods, including the use of emission factors from the EPA's published AP-42, exhaust emission factors from the Sacramento Metropolitan Air Quality Management District's (SMAQMD) Road Construction Emissions Model, emission rates from OFFROAD 2007 and EMFAC 2011, and the California Emissions Estimator Model (CalEEMod) version 2011.1.1. The application of each methodology is described separately below.

SMAQMD's Road Construction Emissions Model, version 7.1.2 was used to obtain exhaust emission rates for ROG, NO_x, PM_{10}, CO, and CO_2 for heavy duty construction equipment that would be used for construction activities. The model uses emission rates for heavy-duty construction equipment based on OFFROAD 2007 and EMFAC 2011 (described separately below). Emission rates for 2016 (the earliest year that construction would begin) were applied to each piece of equipment based on the anticipated operation hours of equipment by construction activity and CP.

The off-road emissions inventory is an estimate of the population, activity, and emissions estimate of the varied types of off-road equipment within each county in California. The major categories of engines and vehicles include agricultural, construction, lawn and garden, and offroad recreation. OFFROAD was run for Shasta County in 2016 (the earliest year that construction would begin) and was used to generate emission rates for certain, specific equipment such as chippers and chainsaws that were not included in the SMAQMD Road Construction Model described above.

EMFAC 2011 is a model developed by ARB used for estimating emissions from on-road vehicles. EMFAC 2011 was run for Shasta County in 2016 (the earliest year that construction would begin) and was used to generate exhaust emission rates for worker commute trips and truck hauling trips. Emission rates were applied to daily truck trips and worker commute trips required by each CP.

Emission factors obtained from AP-42 were used to calculate dust emissions ($PM_{2.5}$ and PM_{10}) from construction activity (grading, earthmoving, stockpiling of material), travel on paved road for truck haul trips and for worker commute trips. For dust generated during construction activity, two primary construction activities were identified that would represent the dust emissions from all CPs: aggregate handling and storage piles, and grading/earth moving. AP-42 provides emission factors that estimate dust emissions from the loading of aggregate onto storage piles, equipment traffic in storage areas, wind erosion from pile surfaces, loadout of aggregate for shipment or return to the process stream (batch or continuous drop operations), and from bulldozing/grading.

Primary inputs to estimate dust from aggregate handling and storage piles included total quantities of excavated material and inputs for bulldozing/grading included total equipment hours for equipment that perform these activities (e.g., graders, bulldozers).

CalEEMod was developed in collaboration with the air districts of California. Default data (e.g., emission factors, trip lengths, meteorology, source inventory, etc.) were provided by the various California air districts to account for local requirements and conditions. CalEEMod can be used to estimate air pollutant emissions from construction activities, mobile-source emissions, and operational emissions from mobile and area sources. CalEEMod was used to estimate mobile-source emissions of criteria air pollutants (ROG, NO_x, $PM_{2.5}$, PM_{10}, and CO) from operational trips associated with visitation to the recreational sites of the project.

Toxic Air Contaminants and Odors

TACs and odors are discussed in accordance with SCAQMD, ARB, and EPA policies and rules.

Global Warming

Emissions of CO_2e from construction activities and from recreational visitors' vehicles were calculated using emission factors for heavy duty construction equipment from the SMAQMD's Road Construction Emission Model and CalEEMod 2011.1.1. Exhaust emissions from construction equipment were summed by the various construction activities under each Comprehensive Plan. Mobile source GHG emissions associated with recreational visitor trips were estimated using the operational trip rates provided for each Comprehensive Plan in CalEEMod. Data on emissions avoided by generation of electricity from Shasta Dam were obtained from Chapter 5 of the Shasta Lake Water Resources Investigation Plan Formulation Report (Reclamation 2007). GHG emissions from cleared and burned vegetation were estimated using the Carbon Online Estimator (COLE Development Group 2011). Indirect emissions from cement production and CO_2 absorption by water and vegetation are discussed, but not quantified.

5.3.2 Criteria for Determining Significance of Effects

An environmental document prepared to comply with NEPA must consider the context and intensity of the environmental effects that would be caused by, or result from, the proposed action. Under NEPA, the significance of an effect is used solely to determine whether an environmental impact statement must be prepared. An environmental document prepared to comply with CEQA must identify the potentially significant environmental effects of a proposed project. A "[s]ignificant effect on the environment" means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project" (State CEQA Guidelines, Section 15382). CEQA also requires that the environmental document propose feasible measures to avoid or substantially reduce significant environmental effects (State CEQA Guidelines, Section 15126.4(a)).

The following significance criteria were developed based on guidance provided by the State CEQA Guidelines, and consider the context and intensity of the environmental effects as required under NEPA. Impacts of an alternative on air quality and climate would be significant if project implementation would do any of the following:

- Conflict with or obstruct implementation of the applicable air quality plan
- Violate any air quality standard or contribute substantially to an existing or projected air quality violation

- Result in a cumulatively considerable net increase of a criteria air pollutant for which the project region is nonattainment under any applicable Federal or State ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)
- Expose sensitive receptors to substantial pollutant concentrations
- Create objectionable odors affecting a substantial number or people
- Generate GHG emissions, either directly or indirectly, that may have a significant impact on the environment
- Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the emissions of GHGs

As stated in Appendix G of the State CEQA Guidelines, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the above determinations. SCAQMD has adopted air quality thresholds (Table 5-3). These thresholds are based on SCAQMD New Source Review Rule 2:1. The thresholds and policy are published in the *Shasta County General Plan*.

Table 5-3. Shasta County Air Quality Management District's Air Quality Emission Thresholds

NO_X	ROG	PM_{10}	CO
Level A Thresholds			
25 lb/day	25 lb/day	80 lb/day	500 lb/day
Level B Thresholds			
137 lb/day	137 lb/day	137 lb/day	500 lb/day

Source: Shasta County 2004

Note:
These thresholds will be applied during the Shasta County Planning Division's CEQA review process. The CO thresholds do not appear in the general plan, but are included in SCAQMD policy.

Key:
CEQA = California Environmental Quality Act
CO = carbon monoxide
lb/day = pounds per day
NO_X = oxides of nitrogen
PM_{10} = respirable particulate matter
ROG = reactive organic gases
SCAQMD = Shasta County Air Quality Management District

The policy includes standard mitigation measures (SMM) and best available mitigation measures (BAMM). Briefly, the policy for applying SMMs and BAMMs is as follows:

- Apply SMM to all projects; this effort will help contribute to reducing cumulative effects.

- Apply SMM and appropriate BAMM when a project exceeds Level A thresholds.

- Apply SMM, BAMM, and special BAMM when a project exceeds Level B thresholds.

- If application of the above procedures will reduce project emissions below Level B thresholds, the project can proceed with an environmental determination of a mitigated negative declaration, assuming that other project impacts do not require more extensive environmental review.

- If project emissions cannot be reduced to below Level B thresholds, emission offsets will be required. If, after applying the emissions offsets, the project emissions still exceed the Level B threshold, an environmental impact report will be required before the project can be considered for action by the reviewing authority.

Thus, as recommended by SCAQMD, impacts of an alternative on air quality would be significant if either of the following would occur as a result of project implementation:

- Emissions of criteria air pollutants or precursors in Shasta County during construction or long-term operations would exceed the SCAQMD Level B thresholds of 137 pounds per day (lb/day) of ROG, NO_X, or PM_{10} and 500 lb/day of CO after the application of mitigation measures.

- Emissions of criteria air pollutants or precursors in Tehama County during construction or long-term operations would exceed 137 lb/day of ROG, NO_X, or PM_{10} after the application of mitigation measures.

SCAQMD has not adopted a numeric significance criterion for GHGs generated by nonindustrial projects. (However, two California air districts, the Bay Area Air Quality Management District and the South Coast Air Quality Management District, have adopted thresholds for GHG emissions generated by development projects.) No numeric thresholds adopted by any air district or by ARB would be applicable to the action alternatives. However, by adopting AB 32, the State has established GHG reduction targets. Further, the State has determined that GHG emissions, as they relate to global climate change, are a source of adverse environmental impacts in California and should be addressed under CEQA. AB 32 did not amend CEQA, although the legislation identifies the myriad environmental problems in California caused by global warming (Health and Safety Code, Section 38501(a)). SB 97, in contrast, did amend CEQA by requiring OPR to revise the State CEQA Guidelines to address the mitigation of GHG emissions or their consequences (California Public Resources Code, Sections 21083.05 and 21097).

Based on the size, scope, and purpose of this project, the following significance criteria will be used to determine the significance of GHG emissions from this project:

- Whether the project has the potential to conflict with or is consistent with the following plans to reduce or mitigate GHG emissions:
  - The six key elements of the *Climate Change Scoping Plan* (described previously)
  - ARB's 39 recommended actions in the *Climate Change Scoping Plan*
  - Regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of GHG emissions
- Whether the project is part of a plan that includes overall reductions in GHG emissions
- Whether the relative amounts of GHG emissions over the life of the project are small in comparison to the amount of GHG emissions for major facilities that are required to report such emissions (25,000 MT CO_2e per year)
- Whether the project has the potential to contribute to a lower carbon future, through factors such as the following:
  - The design of the proposed project is inherently energy efficient
  - All applicable best management practices that would reduce GHG emissions are incorporated into the project design
  - The project implements or funds its fair share of a mitigation strategy designed to alleviate climate change
  - There are process improvements or efficiencies gained by implementing the project

5.3.3 Topics Eliminated from Further Consideration

No topics related to air quality and climate change that are included in the significance criteria listed above were eliminated from further consideration. All relevant topics are analyzed below.

5.3.4 Direct and Indirect Effects

No-Action Alternative

Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to Red Bluff)

Impact AQ-1 (No-Action): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction No short-term, construction-related increases in emissions of criteria air pollutants or precursors at Shasta Lake or in the vicinity would result from implementation of the No-Action Alternative. No impact would occur.

Under the No-Action Alternative, no new facilities would be constructed at Shasta Lake or in the vicinity. No changes to Reclamation's existing facilities would occur that would directly or indirectly result in any increases in emissions of criteria air pollutants or precursors in this portion of the primary study area. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

Impact AQ-2 (No-Action): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation No long-term operational increases in emissions of criteria air pollutants or precursors in the primary study area would result from implementation of the No-Action Alternative. However, PM_{10} emissions are expected to continue increasing through 2020 because of increased growth in the area. This impact would be less than significant.

Under the No-Action Alternative, no changes to Reclamation's existing operations in the primary study area would occur that would directly or indirectly result in any increases in emissions of criteria air pollutants or precursors in the primary study area. According to ARB, emission levels for ROG, NO_X, and CO are trending downward from 1990 to 2020 in the project area even with increased population growth (ARB 2009). More stringent mobile-source emission standards, cleaner burning fuels, and new rules have largely contributed to this decline. However, PM_{10} emissions are expected to continue increasing through 2020 because of increased growth in the area and associated emissions (e.g., from travel on paved and unpaved roads). Thus, such emissions will likely be worse in the future. Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

Impact AQ-3 (No-Action): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations The No-Action Alternative would not change existing exposure of sensitive receptors to pollutants. No impact would occur.

Sensitive receptors in the primary study area are not currently exposed to substantial pollutant concentrations. There is no indication of circumstances under the No-Action Alternative that would change exposure levels. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

Impact AQ-4 (No-Action): Exposure of Sensitive Receptors to Odor Emissions The No-Action Alternative would not change existing exposure of sensitive receptors to odors. No impact would occur.

Sensitive receptors in the primary study area are not currently exposed to substantial concentrations of odors. There is no indication of circumstances under the No-Action Alternative that would change the exposure. Therefore, no impact would occur. Mitigation is not required for the No-Action Alternative.

Impact AQ-5 (No-Action): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction No short-term, construction-related increases in emissions of criteria air pollutants or precursors below Shasta Dam would result from implementation of the No-Action Alternative. No impact would occur.

The Gravel Augmentation Program (proposed under CP4 and CP5, as described below) would not be implemented under the No-Action Alternative. No new facilities would be constructed below Shasta Dam. Furthermore, no changes to Reclamation's existing facilities or operations would occur that would directly or indirectly result in any increases in emissions of criteria air pollutants in this portion of the primary study area. No impact would occur. Mitigation is not required for the No-Action Alternative.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under the No-Action Alternative; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area

Impact AQ-6 (No-Action): Generation of Greenhouse Gases State goals to reduce project-related GHG emissions would not be implemented under this alternative; however, the No-Action Alternative would not obstruct or conflict with those goals. This impact would be less than significant.

Under the No-Action Alternative, no new facilities would be constructed. No changes to Reclamation's existing facilities or operations would occur that would directly or indirectly result in any increases or decreases in GHG emissions. Therefore, no efforts would be made to reduce existing GHG emissions in the project vicinity under this alternative. Although the State of California's goals to reduce GHG emissions would not be implemented, the No-Action Alternative would not obstruct or conflict with those goals. Therefore, this impact would be less than significant. Mitigation is not required for the No-Action Alternative.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

Shasta Lake and Vicinity

Impact AQ-1 (CP1): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction Project construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that exceed applicable SCAQMD thresholds. This conclusion is based on detailed calculations of estimated emissions for project elements and the simultaneous occurrence thereof. Shasta County is a nonattainment area for the State ozone and PM_{10} standards. Thus, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. This impact would be significant.

Construction emissions are described as "short-term" or temporary in duration because they would cease when the dam raise and associated construction projects are completed. The emissions of ozone precursors ROG and NO_X are associated primarily with gas and diesel engine equipment exhaust from off-road equipment and on-road vehicles. Off-road equipment anticipated in the project includes construction equipment such as bulldozers, grader, water trucks, and loaders. On-road vehicles include trucks that would bring materials to the project site and haul excavated spoils and materials cleared from lands away from the project site. An additional on-road source would be the vehicles used by workers commuting to and from the project site. Engine equipment exhaust also emits CO, PM_{10}, and $PM_{2.5}$. Refer to Attachment 1 to the *Air Quality and Climate Technical Report* for all air quality modeling inputs and outputs.

The primary sources of PM_{10} and $PM_{2.5}$ emissions are fugitive dust from site preparation, vehicle travel on unpaved and paved roads, and storage piles. Emissions vary as a function of such parameters as soil silt content, soil moisture, wind speed, acreage of disturbance area, and vehicle miles traveled by construction vehicles on- and off-site. Burning of cleared vegetation would be a substantial source of particulate emissions. PM_{10} and $PM_{2.5}$ would also be emitted during the materials handling processes associated with operation of a concrete batch plant.

Major construction elements under CP1 would be the dam raise of 6.5 feet and the clearing of land that would be inundated by the larger full pool. Land-clearing equipment used would be based on the terrain, and would range from full-size bulldozers to smaller backhoes and hand tools. In steep terrain helicopters would be used for material removal. In addition, wing dams and reservoir dikes would be constructed; railroad and roadway bridges would be replaced; roads, structures, and utilities would be relocated; and excavation and loading would occur at borrow areas to provide materials for dam construction.

Emissions were calculated as described above in Section 5.3.1, "Methods and Assumptions." The results are shown in Table 5-4 for individual project elements. (All air quality modeling inputs and outputs for the comprehensive plans are presented in Attachment 1 to the *Air Quality and Climate Technical Report*.) As seen in Table 5-4, ROG, NO_X, and PM emissions for several of the individual project elements could exceed applicable Shasta County thresholds, which would result in a significant impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP1 could reach 260 for ROG, 1,682 for NO_x, 107 for PM_{10} exhaust, 2,944 for PM_{10} dust, 93 $PM_{2.5}$ exhaust, 309 for $PM_{2.5}$ dust, and 1,125 for CO based on the worst-case simultaneous construction of project elements as shown in detail in Attachment 1 to the *Air Quality and Climate Change Technical Report*.

Particulate emissions from operation of a concrete batch plant are not included in the above calculations. Batch plants must obtain operating permits from Shasta County Air Pollution Control District. The granting of a permit would assure that the impact of PM_{10} and $PM_{2.5}$ emissions from batch plant sources would not exceed applicable thresholds.

Based on the data in Table 5-4 and the preceding discussion, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. As a result, this impact would be significant.

The Shasta County standards require standard mitigation measures for all projects and additional mitigation measures when project emissions are anticipated to exceed applicable thresholds. Mitigation for this impact that incorporates these mitigation measures is proposed in Section 5.3.5.

Table 5-4. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP1[a]

Project Element for 6.5-Foot Raise (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
UPRR Doney Creek Bridge	20	140	8	34	7	5	82
Left Wing Dam – 6.5-foot raise	18	138	7	165	6	18	106
Main Concrete Dam	20	138	8	26	2	4	90
Outlet Works	13	138	5	26	5	4	53
Pit River Bridge Pier 3 and 4 Prot	15	138	6	26	5	4	66
Powerplant and Penstocks	12	138	4	26	4	4	48
Railroad Realignment	12	138	4	159	4	17	53

Table 5-4. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP1[a] (contd.)

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Right Wing Dam	11	138	3	54	3	7	45
Sacramento River UPRR 2nd Crossing	28	141	12	35	11	5	121
Spillway	27	139	11	26	10	4	113
TCD Mods	20	138	8	26	8	4	82
Visitor Center Replacement	10	138	3	43	3	6	41
Vehicular Bridges	24	155	10	34	9	5	110
Reservoir Clearing	35	260	12	27	11	4	112
Dikes	28	138	12	902	11	91	100
Buildings/Facilities - Recreation	40	141	20	1,483	18	150	166
Roads	28	138	12	588	11	60	102
Utilities	18	138	7	26	6	4	70

Note:
[a] Totals may not add due to rounding

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh.= exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

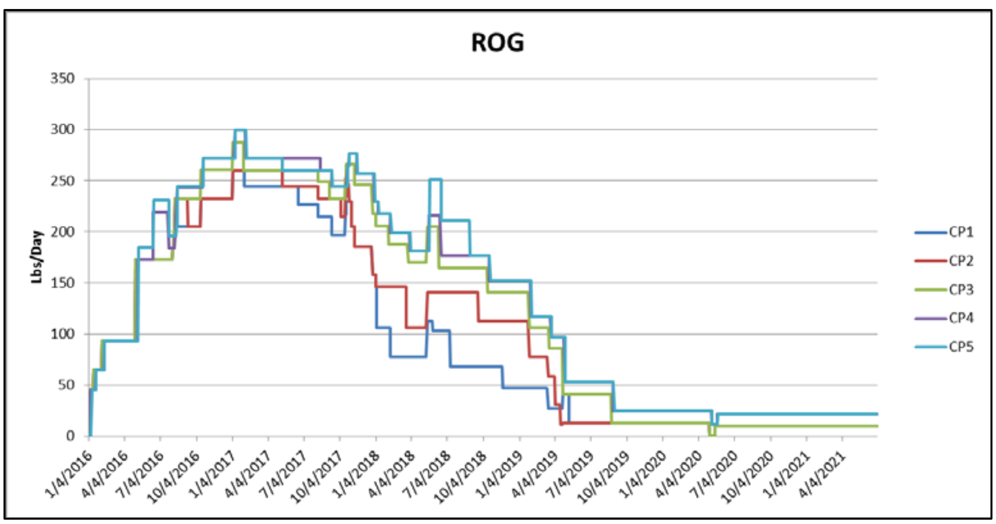


Figure 5-2. Maximum Daily Short-Term Construction-Generated Emissions of Reactive Organic Gases by Action Alternative (Pounds per Day)

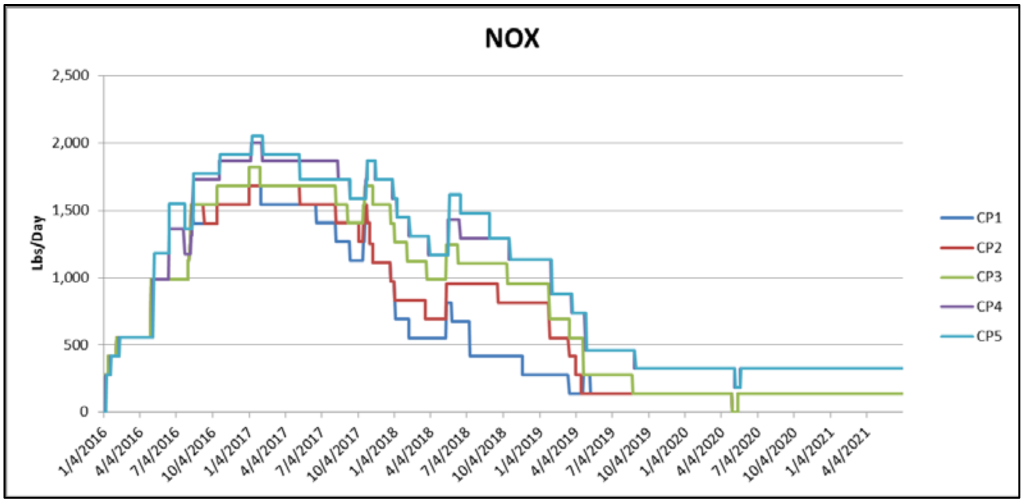


Figure 5-3. Maximum Daily Short-Term Construction-Generated Emissions of Oxides of Nitrogen by Action Alternative (Pounds per Day)

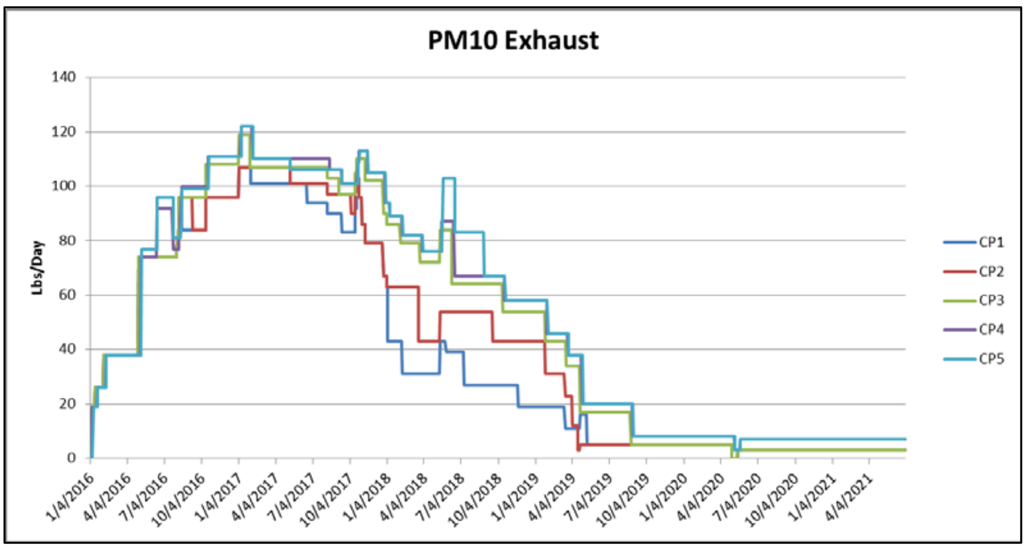


Figure 5-4. Maximum Daily Short-Term Construction-Generated Emissions of Respirable Particulate Matter Exhaust by Action Alternative (Pounds per Day)

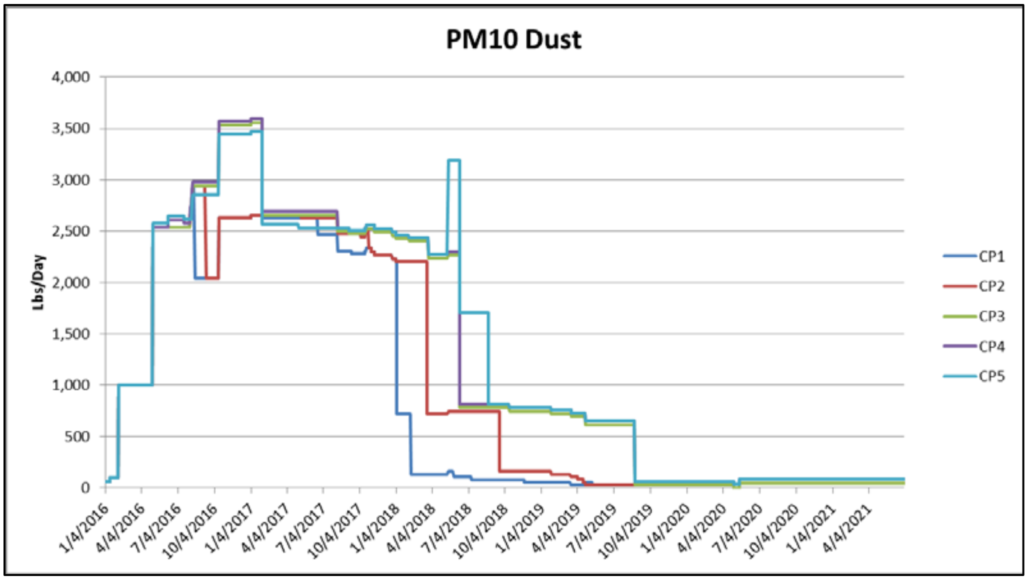


Figure 5-5. Maximum Daily Short-Term Construction-Generated Emissions of Respirable Particulate Matter Dust by Action Alternative (Pounds per Day)

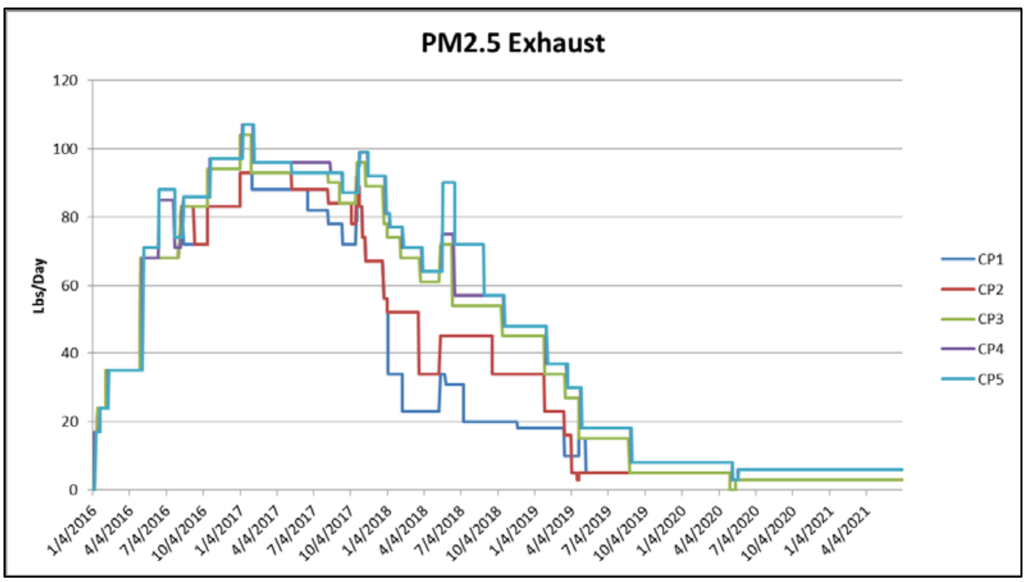


Figure 5-6. Maximum Daily Short-Term Construction-Generated Emissions of Fine Particulate Matter Exhaust by Action Alternative (Pounds per Day)

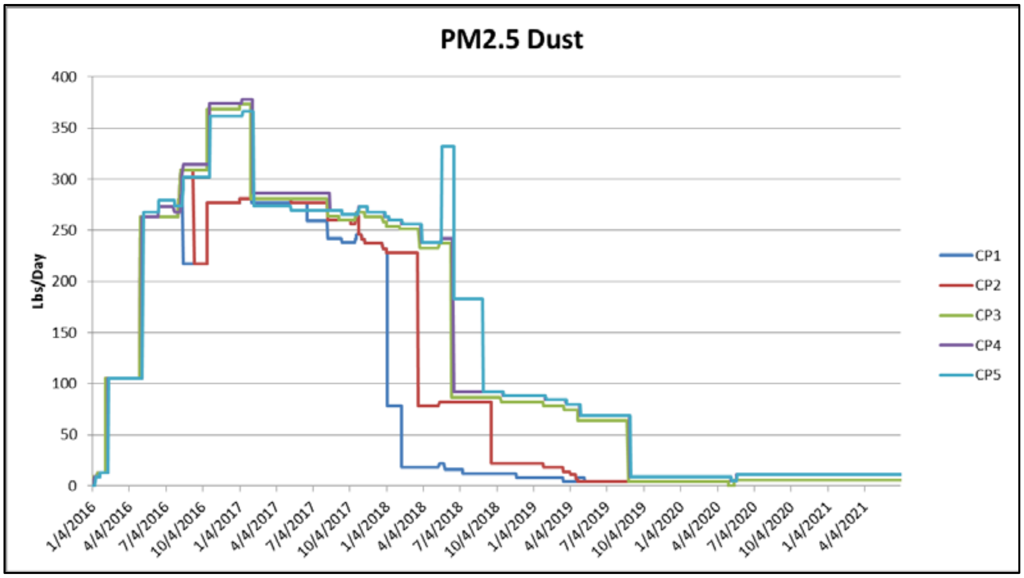


Figure 5-7. Maximum Daily Short-Term Construction-Generated Emissions of Fine Particulate Matter Dust by Action Alternative (Pounds per Day)

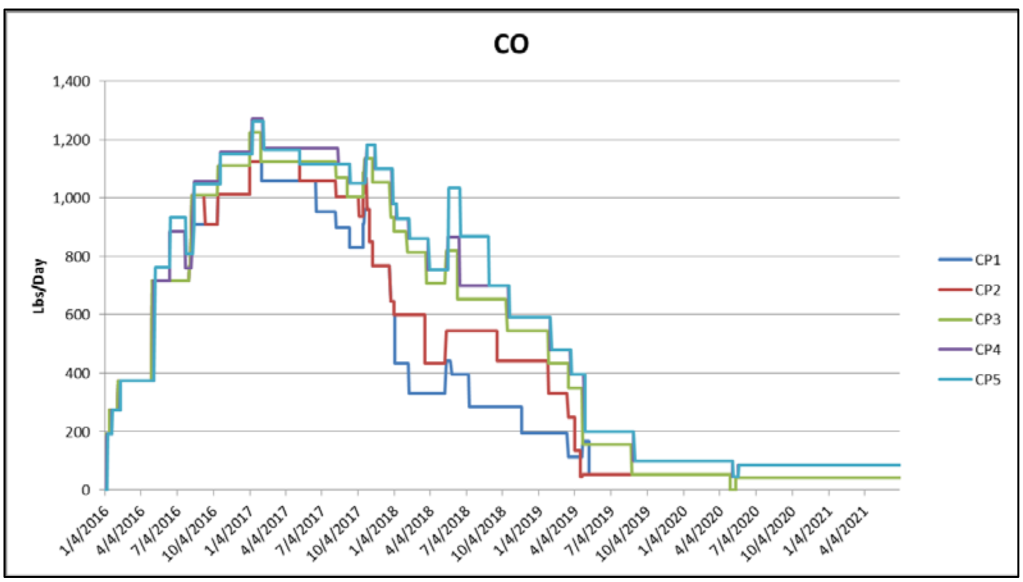


Figure 5-8. Maximum Daily Short-Term Construction-Generated Emissions of Carbon Monoxide by Action Alternative (Pounds per Day)

Impact AQ-2 (CP1): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation Long-term project operation is not anticipated to result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAMQD thresholds. Thus, long-term operational emissions would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant.

Long-term operational emissions would come from stationary, area, and mobile sources. Stationary sources could include emergency generators powered by diesel engines or pumps, boilers, and major kitchen equipment. No new stationary sources of note are anticipated as part of the project. Pollutant-emitting replacement equipment would be anticipated to be similar to equipment presently in operation.

Area sources include gas-fired building heating and hot water equipment, landscape maintenance equipment, and architectural coatings (paints, lacquers) used in maintenance. Area-source increases would be anticipated to be negligible.

After completion of the dam raise, the principal sources of long-term emissions would be mobile sources; an increase in vehicle trips would result from increased recreational activity at Shasta Lake and the associated recreation areas. It is assumed that maintenance activity for the dam and recreation areas would not change markedly. No new stationary sources of emissions would be anticipated as part of the project.

Enlarging Shasta Dam would include facilities to ensure that at least the existing recreation capacity is maintained. CP1would affect recreation participation by increasing the reservoir's surface area and decreasing reservoir draw-down during the peak recreation season. Table 5-5 compares user days (visitor days) for each of the comprehensive plans to existing and future conditions. The Modeling Appendix provides additional information on recreational visitation estimates.

Table 5-5. Average Annual Predicted Increase in User Days[a]

Item	CP1	CP2	CP3	CP4	CP5
Existing Conditions					
Increase in user days (thousands)	78	164	216	363	199
Future Conditions					
Increase in user days (thousands)	89	134	205	370	175

Note:
[a] All alternatives are to include features to, at minimum, maintain existing Shasta Lake recreation capacity.

Key:
CP = Comprehensive Plan

The increase in recreational opportunities and visitor days would generate vehicle trips for the travel of visitors to and from the Shasta Lake area. Increased trip generation and vehicle emissions were calculated using CalEEMod and the following assumptions:

- The average visitor stay is 2.5 days.
- The average number of visitors per vehicle is 2.5.
- The recreation season for most visitors is 180 days.
- The average one-way trip distance for visitors is 25 miles.
- The first year of operations is expected to be 2015 or later.

With these assumptions and 78,000 increased visitor days under existing conditions from Table 5-5, there would be an increase of an average of 138 one-way trips per day for CP1 under existing conditions. With these assumptions and 89,000 increased visitor days under future conditions from Table 5-5, there would be an increase of an average of 158 one-way trips per day for CP1 under future conditions.

The results of the emissions calculations are shown in Table 5-6. Anticipated emissions would be less than the SCAQMD significance thresholds.

Table 5-6. Operations Emissions for Shasta Dam Raise, 2015 – CP1

Activity	Emissions—pounds per day						
	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Existing Conditions							
Vehicle trips for increase in recreational visitors	1.1	3.6	0.1	1.9	0.1	-	7.8
Future Conditions							
Vehicle trips for increase in recreational visitors	1.2	4.1	0.1	2.2	0.1	-	8.9

Note:
Totals may not add due to rounding.

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh. = exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases

Based on the above analysis, operation under CP1 would not result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD Level A thresholds. Consequently, long-term emissions during project operation under CP1 would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-3 (CP1): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations Neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, or TACs. This impact would be less than significant.

Pollutants of concern for exposure of sensitive receptors include CO, PM_{10} and $PM_{2.5}$, and TACs. Local exposure of CO may occur near severe congestion on major roadways. The project is not anticipated to generate areas of severe roadway congestion, nor would the project locate receptors near major roadways; no local CO impact would occur.

Sensitive receptors could be exposed to substantial amounts of PM_{10} and $PM_{2.5}$ if receptors were located near large areas of grading or earthmoving and dust generation was not controlled. Similarly, substantial exposure to particulates and other smoke-borne pollutants could result if receptors were near areas where cleared brush would be burned. There are no sensitive receptors near the dam raise areas; however, there may be sensitive receptors near the some of the lands that would be cleared before inundation by the expanded reservoir. Dust control measures would be required for all land clearing activities; these measures would prevent most PM_{10} and $PM_{2.5}$ from reaching sensitive receptors. Similarly, smoke control measures would be required by SCAQMD Rule 2:7. The impact of exposure of sensitive receptors to PM_{10} and $PM_{2.5}$ would be less than significant.

The principal TAC of concern for project construction is diesel PM. Diesel PM would be generated in the exhaust of diesel engine construction equipment. The largest concentration of diesel engines would be located at the dam raise site. There are no sensitive receptors within one-half mile of the dam site, and sensitive receptors would not be exposed to diesel PM from that source. Diesel equipment would be used for land clearing operations, and there may be sensitive receptors near the land clearing. The dose to which receptors are exposed is the primary factor used to determine health risk (i.e., potential exposure to TAC emission levels that exceed applicable standards). Dose is a function of the concentration of a substance or substances in the environment and the duration of exposure to the substance. Dose is positively correlated with time, meaning that a longer exposure period would result in a higher exposure level for the maximally exposed individual. Thus, the risks estimated for a maximally exposed individual are higher if a fixed exposure occurs over a longer period of time. According to the Office of Environmental Health Hazard Assessment, health risk assessments, which determine the exposure of sensitive receptors to TAC emissions, should be based on a 70-year exposure period; however, such assessments should be limited to the period/duration of activities associated with the project. Thus, because the use of off-road construction equipment would be limited to a few days near any sensitive receptor, short-term construction activities would not result in exposure of sensitive receptors to substantial TAC emissions.

Project implementation is not expected to result in the operation of any new significant sources of TAC emissions after construction is complete. Thus, short-term construction and long-term operational sources would not expose sensitive receptors to substantial TAC concentrations. As a result, this impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-4 (CP1): Exposure of Sensitive Receptors to Odor Emissions Short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant.

The occurrence and severity of odor impacts depend on numerous factors: the nature, frequency, and intensity of the source; wind speed and direction; and the presence of sensitive receptors. Although offensive odors rarely cause any physical harm, they still can be very unpleasant, leading to considerable distress and often generating citizen complaints to local governments and regulatory agencies.

Diesel exhaust has some odor, but it dissipates rapidly from the source with an increase in distance. There are no sensitive receptors immediately adjacent to the project site and people would not be exposed to substantial odors in that area. At other work sites, construction equipment use would be intermittent and temporary, resulting in an odor impact that would be less than significant.

Project implementation would not develop any major sources of odor. The project does not include one of the common types of facilities that are known to produce odors such as a landfill or a coffee roaster. Thus, short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact AQ-5 (CP1): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction Gravel augmentation and habitat restoration in the upper Sacramento River proposed under CP4 and CP5 would not be implemented under CP1. No other project construction or long-term operation activities that would affect emissions of criteria air pollutants and precursors are planned in the Shasta Dam-to-Red Bluff area under CP1. Therefore, no impact would occur.

Gravel augmentation and habitat restoration (proposed under CP4 and CP5, as described below) would not be implemented under CP1. No new facilities would be constructed below Shasta Dam under this alternative, and no changes in Reclamation’s existing facilities or operations would occur that would directly or indirectly result in any increases in criteria air pollutant emissions in this portion of the primary study area. No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under CP1; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area

Impact AQ-6 (CP1): Generation of Greenhouse Gases Project construction and operational activities would result in emission of a less than significant quantity of GHGs. Overall, implementation of CP1 would result in beneficial effects on GHG emissions because generation of electricity at Shasta Dam would increase. This impact would be less than significant.

There are no established quantitative criteria under CEQA for determining a significant impact related to GHG emissions. The criteria suggested by various agencies principally address long-term emissions, and not the relatively short-term emissions of construction activities. One of the more commonly suggested mass emissions thresholds is 25,000 MT CO_2e per year. This value has been selected because it is the threshold established for mandatory emissions reporting for most sources in California under AB 32. Due to a longer than usual period of construction, construction-generated emissions are amortized over the lifetime of the project and added to operational emissions to determine the overall level of GHG generation. Based on the modeling conducted, construction of CP1 would result in 3,319 MT CO_2e/year amortized over the project lifetime.

GHG emissions of sequestered carbon in removed vegetation were calculated at 3,156 MT CO_2e per year for CP1. This calculation assumes that all vegetation removal, overstory removal, and relocation acreages (370 acres total) would be covered in 70-year-old stands of forest vegetation (Ponderosa pine, Douglas-fir, montane hardwood-conifer, and montane hardwood forest) and that all above-ground vegetation would be disposed of in a manner that releases the sequestered carbon into the atmosphere. All 370 acres would not be covered with 70-year forest as used in the model (ages would vary) or release all carbon to the atmosphere. Also, most utilities would be relocated in roadways, but separate relocation (and additional disturbance) was assumed in the estimated relocation acreages. This approach was applied to ensure that underestimating would not occur.

With implementation of CP1, increased activity by recreational visitors to the Shasta Lake area would result in additional vehicle trips and estimated CO_2e emissions of 296 MT/year under existing conditions and 337 MT/year under future conditions based on the same assumptions described above (Table 5-5). Increasing the size of Shasta Dam and Shasta Lake would result in the ability to increase hydropower generation at Shasta generating facilities. Generation of electricity by hydropower reduces the need for fossil-fuel generation of electricity and the GHG emissions that would occur with that generation.

For existing conditions, raising Shasta Dam by 6.5 feet and implementing the operational strategy for CP1 would result in a net increase in CVP/SWP power generation of 2.7 gigawatt-hours (GWh) per year (Table 5-7). This net generation estimate accounts for the energy required for pumping the increased water supplies. Fossil-fuel generation of 2.7 GWh of energy would produce an estimated 2,400 MT of CO_2e, also shown in Table 5-7. Therefore, the increased generation of electricity at Shasta Dam would reduce the need to build facilities for fossil-fueled generation of 2.7 GWh per year in the global study area.

For future conditions, raising Shasta Dam by 6.5 feet and implementing the operational strategy for CP1 would result in a net decrease in CVP/SWP power generation of 2.2 GWh per year (Table 5-7). Fossil-fuel generation of 2.2 GWh of energy would produce an estimated 1,900 MT of CO_2e, also shown in Table 5-7. Therefore, the overall net generation decrease would increase the need to build facilities for fossil-fueled generation of 2.2 GWh per year in the global study area.

Table 5-7. Average Annual Hydropower CVP/SWP Generation

Item	CP1	CP2	CP3	CP4	CP5
Existing Condition (2005)					
Net increased generation (GWh/year)	2.7	15.0	71.2	81.1	23.6
CO_2e displaced (1,000 metric tons)	2.4	13.4	63.6	72.4	21.0
Future Condition (2030)					
Net increased generation (GWh/year)	(2.2)	0.9	70.2	76.1	4.2
CO_2e displaced (1,000 metric tons)	(1.9)	0.8	62.7	67.9	3.8

Key:
CO2 = carbon dioxide
CO2e = carbon dioxide equivalent
CP = Comprehensive Plan
GWh/year = gigawatt-hours per year

The results of the above analysis show that CP1 would result in short-term emissions of GHG for the years of construction, followed by long-term benefits of GHG reduction through generation of electricity at Shasta Dam for existing conditions. The results of the above analysis show that CP1 would result in short-term emissions of GHG for the years of construction, followed by a long-term effect of GHG increase for future conditions. The GHG emissions from construction activities would be temporary in duration and mitigated to the extent feasible; therefore, such emissions would not conflict with State or regional planning efforts or emit GHG in excess of mandatory reporting standards. GHG emissions from long-term operations would likely have a net benefit as a result of increased hydroelectric generation and would thus also not conflict with planning efforts or mandatory reporting thresholds. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

In addition to the effects described above, the loss of vegetation presently in the area that would be inundated would likely result in a loss of CO_2 absorption by that vegetation, as well as increased emissions of decomposing material present in the lake as a result of increases volume. There may be some offset to this effect with increased surface area of Shasta Lake for absorption. These effects are speculative and infeasible to quantify at this time.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

Shasta Lake and Vicinity

Impact AQ-1 (CP2): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction Project construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that exceed applicable SCAQMD thresholds. This conclusion is based on detailed calculations of estimated emissions for project elements and the simultaneous occurrence thereof. Shasta County is a nonattainment area for the State ozone and PM_{10} standards. Thus, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. This impact would be significant.

CP2 includes a dam raise of 12.5 feet. This impact would be similar to Impact AQ-1 (CP1) as the same type of construction equipment and activities would be involved. Emissions were calculated as described above in Section 5.3.1, “Methods and Assumptions.” The results are shown in Table 5-8 for individual project elements. (All air quality modeling inputs and outputs for the comprehensive plans are presented in Attachment 1 to the *Air Quality and Climate Technical Report*.) As shown in Table 5-8 (similar to CP1), ROG, NO_x, and PM emissions for several of the individual project elements could exceed applicable Shasta County thresholds, which would result in a significant impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP2 (similar to CP1), could reach much higher levels based on the worst-case simultaneous construction of project elements as shown in detail in Attachment 1 to the *Air Quality and Climate Change Technical Report*. For the same reasons as described for CP1, this impact would be significant. Mitigation for this impact is proposed in Section 5.3.5.

Table 5-8. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP2[a]

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
UPRR Doney Creek Bridge – 12.5-foot raise	20	140	8	34	7	5	82
Left Wing Dam – 12.5-foot raise	18	138	7	165	6	18	106
Main Concrete Dam – 12.5-foot raise	20	138	8	26	2	4	90
Outlet Works – 12.5-foot raise	13	138	5	26	5	4	53
Pit River Bridge Pier 3 and 4 Prot – 12.5-foot raise	15	138	6	26	5	4	66
Powerplant and Penstocks – 12.5-foot raise	12	138	4	26	4	4	48
Railroad Realignment – 12.5-foot raise	12	138	4	159	4	17	53
Right Wing Dam – 12.5-foot raise	11	138	3	54	3	7	45
Sacramento River UPRR 2nd Crossing – 12.5-foot raise	28	141	12	35	11	5	121
Spillway – 12.5-foot raise	27	139	11	26	10	4	113
TCD Mods – 12.5-foot raise	20	138	8	26	8	4	82
Visitor Center Replacement – 12.5-foot raise	10	138	3	43	3	6	41
Vehicular Bridges – 12.5-foot raise	24	155	10	34	9	5	110
Reservoir Clearing – 12.5-foot raise	35	260	12	27	11	4	112
Dikes – 12.5-foot raise	28	138	12	902	11	91	100
Buildings/Facilities – Recreation – 12.5-foot raise	40	141	20	1,483	18	150	166
Roads – 12.5-foot raise	28	138	12	588	11	60	102
Utilities – 12.5-foot raise	18	138	7	26	6	4	70

Note:
[a] Totals may not add due to rounding

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh.= exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

Impact AQ-2 (CP2): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation Long-term project operation is not anticipated to result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD thresholds. Thus, long-term operational emissions would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant.

Long-term operational emissions would come from stationary, area, and mobile sources. This impact would be the same as Impact AQ-2 (CP1) for stationary and area sources and similar to Impact AQ-2 (CP1) for mobile sources. With CP2, there would be an annual increase of 164,000 and 134,000 visitor days under existing and future conditions, respectively, as was shown in Table 5-5, resulting in 291 and 238 average daily trips under existing and future conditions, respectively. The associated daily emissions are shown in Table 5-9.

Based on the above analysis, operation under CP2 would not result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD Level A thresholds. Consequently, long-term emissions during project operation under CP2 would not violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Table 5-9. Operations Emissions for Shasta Dam Raise, 2015 – CP2

Activity	Emissions – pounds per day						
	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Existing Conditions							
Vehicle trips for increase in recreational visitors	2.2	7.6	0.2	4.0	0.2	0.1	16.5
Future Conditions							
Vehicle trips for increase in recreational visitors	1.8	6.2	0.2	3.3	0.2	0.1	13.5

Note: Totals may not add due to rounding.

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh. = exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases

Impact AQ-3 (CP2): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations Neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, or TACs. This impact would be less than significant.

This impact would be the same as Impact AQ-3 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-4 (CP2): Exposure of Sensitive Receptors to Odor Emissions Short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant.

This impact would be the same as Impact AQ-4 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact AQ-5 (CP2): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction Gravel augmentation and habitat restoration in the upper Sacramento River proposed under CP4 and CP5 would not be implemented under CP2. No other project construction or long-term operation activities that would affect emissions of criteria air pollutants and precursors are planned in the Shasta Dam–to–Red Bluff area under CP2. Therefore, no impact would occur.

This impact would be the same as Impact AQ-5 (CP1). No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under CP2; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area

Impact AQ-6 (CP2): Generation of Greenhouse Gases Project construction and operational activities would result in emission of a less than significant quantity of GHGs. Overall, implementation of CP2 would result in beneficial effects on GHG emissions because generation of electricity at Shasta Dam would increase. This impact would be less than significant.

This impact would be similar to Impact AQ-6 (CP1) for construction and operations. Based on the modeling conducted, construction of CP2 would result in 3,807 MT CO2e/year amortized over the project lifetime. GHG emissions of sequestered carbon in removed vegetation were calculated at 5,031 MT CO_2e per year for CP2 (590 acres total). Increased activity by recreational visitors to the Shasta Lake area would result in additional vehicle trips and estimated CO_2 emissions of 622 and 507 MT CO_2e per year for existing conditions and future conditions, respectively.

For existing conditions, raising Shasta Dam by 12.5 feet and implementing the operational strategy for CP2 would result in a net increase in CVP/SWP power generation of 15.0 GWh per year (Table 5-7). Fossil-fuel generation of 15.0 GWh of energy would produce an estimated 13,400 MT CO_2, also shown in Table 5-7. Thus, CP2 would reduce the need to build facilities for fossil-fueled generation of 15.0 GWh per year in the global study area.

For future conditions, raising Shasta Dam by 12.5 feet and implementing the operational strategy for CP2 would result in a net increase in CVP/SWP power generation of 0.9 GWh per year (Table 5-7). Fossil-fuel generation of 0.9 GWh of energy would produce an estimated 800 MT of CO_2e, also shown in Table 5-

7. Therefore, the overall net generation increase would reduce the need to build facilities for fossil-fueled generation of 0.9 GWh per year in the global study area.

Thus, the results of the above analysis show that CP2 would result in short-term emissions of GHG for the years of construction, followed by long-term benefits of GHG reduction through generation of electricity at Shasta Dam for existing conditions. The results of the above analysis show that CP2 would result in short-term emissions of GHG for the years of construction, followed by a long-term effect of GHG increase for future conditions. Considering construction emissions, the magnitude of the GHG "savings" for each year of operation would be approximately 3,940 MT CO2e for existing conditions and a GHG "deficit" of 8,500 MTCO2e for future conditions amortized over the project lifetime. The GHG emissions from construction activities would be temporary in duration and mitigated to the extent feasible; therefore, such emissions would not conflict with State or regional planning efforts or emit GHG in excess of mandatory reporting standards. GHG emissions from long-term operations would likely - not conflict with planning efforts or mandatory reporting thresholds. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Agricultural Water Supply

Shasta Lake and Vicinity

Impact AQ-1 (CP3): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction Project construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that exceed applicable SCAQMD thresholds. This conclusion is based on detailed calculations of estimated emissions for project elements and the simultaneous occurrence thereof. Shasta County is a nonattainment area for the State ozone and PM_{10} standards. Thus, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. This impact would be significant.

CP3 includes a dam raise of 18.5 feet. This impact would be similar to Impact AQ-1 (CP1) as the same type of construction equipment and activities would be involved. Emissions were calculated as described above in Section 5.3.1, "Methods and Assumptions." The results are shown in Table 5-6 for individual project elements. (All air quality modeling inputs and outputs for the comprehensive plans are presented in Attachment 1 to the *Air Quality and Climate Technical Report*.) As shown in Table 5-10 (similar to CP1), ROG, NO_x, and PM emissions for several of the individual project elements could exceed applicable Shasta County thresholds, which would result in a significant impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP3 (similar to CP1), could reach much higher levels based on the worst-case simultaneous construction of project elements as shown in detail in Attachment 1 to the *Air Quality and Climate Change Technical Report*. For the same reasons as described for CP1, this impact would be significant. Mitigation for this impact is proposed in Section 5.3.5.

Table 5-10. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP3[a]

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
UPRR Doney Creek Bridge – 18.5-foot raise	20	140	8	34	7	5	82
Left Wing Dam – 18.5-foot raise	18	138	7	165	6	18	106
Main Concrete Dam – 18.5-foot raise	20	138	8	26	2	4	90
Outlet Works – 18.5-foot raise	13	138	5	26	5	4	53
Pit River Bridge Pier 3 and 4 Protection – 18.5-foot raise	15	138	6	26	5	4	66
Powerplant and Penstocks – 18.5-foot raise	12	138	4	26	4	4	48
Railroad Realignment – 18.5-foot raise	12	138	4	159	4	17	53
Right Wing Dam – 18.5-foot raise	11	138	3	54	3	7	45
Sacramento River UPRR 2nd Crossing – 18.5-foot raise	28	141	12	35	11	5	121
Spillway – 18.5-foot raise	27	139	11	26	10	4	113
TCD Mods – 18.5-foot raise	20	138	8	26	8	4	82
Visitor Center Replacement – 18.5-foot raise	10	138	3	43	3	6	41
Vehicular Bridges – 18.5-foot raise	24	155	10	34	9	5	110
Reservoir Clearing – 18.5-foot raise	35	260	12	27	11	4	112
Dikes – 18.5-foot raise	28	138	12	902	11	91	100
Buildings/Facilities – Recreation – 18.5-foot raise	40	141	20	1,483	18	150	166
Roads – 18.5-foot raise	28	138	12	588	11	60	102
Utilities – 18.5-foot raise	18	138	7	26	6	4	70

Notes:
[a] Totals may not add due to rounding

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh.= exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

Impact AQ-2 (CP3): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation Long-term project operation is not anticipated to result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD thresholds. Thus, long-term operational emissions would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant.

Long-term operational emissions would come from stationary, area, and mobile sources. This impact would be the same as Impact AQ-2 (CP1) for stationary and area sources and similar to Impact AQ-2 (CP1 and CP2) for mobile sources. With CP3, there would be an annual increase of 216,000 and 205,000 visitor days under existing and future conditions, respectively, as was shown in Table 5-5, resulting in 384 and 364 average daily trips under existing and future conditions, respectively. The associated daily emissions are shown in Table 5-11. Overall trip levels would be greater than under CP1 and CP2, but emissions would remain below significance thresholds.

Table 5-11. Operations Emissions for Shasta Dam Raise, 2015 – CP3

Activity	Emissions – pounds per day						
	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Existing Conditions							
Vehicle trips for increase in recreational visitors	2.8	10.0	0.3	5.4	0.3	0.1	21.7
Future Conditions							
Vehicle trips for increase in recreational visitors	2.7	9.5	0.3	5.1	0.3	0.1	20.6

Note: Totals may not add due to rounding.

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh. = exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases

Based on the above analysis, operation under CP3 would not result in ROG, NO_X, PM_{10}, or CO emissions that exceed SCAQMD Level A thresholds. Consequently, long-term emissions during operation under CP3 would not violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-3 (CP3): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations Neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, or TACs. This impact would be less than significant.

This impact would be the same as Impact AQ-3 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-4 (CP3): Exposure of Sensitive Receptors to Odor Emissions Short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant.

This impact would be the same as Impact AQ-4 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)
Impact AQ-5 (CP3): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction Gravel augmentation and habitat restoration in the upper Sacramento River proposed under CP4 and CP5 would not be implemented under CP3. No other project construction or long-term operation activities that would affect emissions of criteria air pollutants and precursors are planned in the Shasta Dam–to–Red Bluff area under CP3. Therefore, no impact would occur.

This impact would be the same as Impact AQ-5 (CP1). No impact would occur. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under CP3; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area
Impact AQ-6 (CP3): Generation of Greenhouse Gases Project construction and operational activities would result in emission of a less than significant quantity of GHGs. Overall, implementation of CP3 would result in beneficial effects on GHG emissions because generation of electricity at Shasta Dam would increase. This impact would be less than significant.

This impact would be similar to Impact AQ-6 (CP1) for construction and operations. Based on the modeling conducted, construction of CP3 would result in 4,350 MT CO_2e/year amortized over the project lifetime. GHG emissions of sequestered carbon in removed vegetation were calculated at 7,164 MT CO_2e per year for CP3 (840 acres total). Increased activity by recreational visitors to the Shasta Lake area would result in additional vehicle trips and estimated emissions of 819 and 776 MT CO_2e per year for existing conditions and future conditions, respectively.

For existing conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP3 would result in a net increase in CVP/SWP power generation of 71.2 GWh per year, as was shown in Table 5-7. Fossil-fuel generation of 71.2 GWh of energy would produce an estimated 63,600 MT of CO_2, also shown in Table 5-7. Thus, CP3 would reduce the need to build facilities for fossil-fueled generation of 71.2 GWh per year in the global study area.

For future conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP3 would result in a net increase in power generation of 70.2 GWh per year, as was shown in Table 5-7. Fossil-fuel generation of 70.2 GWh of energy would produce an estimated 62,700 MT of CO_2, also shown in Table 5-7. Thus, CP3 would reduce the need to build facilities for fossil-fueled generation of 70.2 GWh per year in the global study area.

Thus, the results of the above analysis show that CP3 would result in short-term emissions of GHG for the years of construction, followed by long-term benefits of GHG reduction through generation of electricity at Shasta Dam. The magnitude of the GHG "savings" for each year of operation would be approximately 51,267 and 50,410 MT CO2e for existing conditions and future conditions, respectively, considering construction emissions amortized over the project lifetime. The GHG emissions from construction activities would be temporary in duration and mitigated to the extent feasible; therefore, such emissions would not conflict with State or regional planning efforts or emit GHG in excess of mandatory reporting standards. GHG emissions from long-term operations would likely have a net benefit as a result of increased hydroelectric generation and would thus also not conflict with planning efforts or mandatory reporting thresholds. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

Shasta Lake and Vicinity

Impact AQ-1 (CP4): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction Project construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that exceed applicable SCAQMD thresholds. This conclusion is based on detailed calculations of estimated emissions for project elements and the simultaneous occurrence thereof. Shasta County is a nonattainment area for the State ozone and PM_{10} standards. Thus, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. This impact would be significant.

CP4 includes a dam raise of 18.5 feet. This impact would be similar to Impact AQ-1 (CP1) as the same type of construction equipment and activities would be involved. Emissions were calculated as described above in Section 5.3.1, "Methods and Assumptions." The results are shown in Table 5-12 for individual project elements. (All air quality modeling inputs and outputs for the comprehensive plans are presented in Attachment 1 to the *Air Quality and Climate Technical Report*.) As shown in Table 5-12 (similar to CP1), ROG, NO_x, and PM emissions for several of the individual project elements could exceed applicable Shasta County thresholds, which would result in a significant impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP4 (similar to CP1), could reach much higher levels based on the worst-case simultaneous construction of project elements as shown in detail in Attachment 1 to the *Air Quality and Climate Change Technical Report*. For the same reasons as described for CP1, this impact would be significant. Mitigation for this impact is proposed in Section 5.3.5.

Table 5-12. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP4[a]

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
UPRR Doney Creek Bridge – 18.5-foot raise	20	140	8	34	7	5	82
Left Wing Dam – 18.5-foot raise	18	138	7	165	6	18	106
Main Concrete Dam – 18.5-foot raise	20	138	8	26	2	4	90
Outlet Works – 18.5-foot raise	13	138	5	26	5	4	53
Pit River Bridge Pier 3 and 4 Prot – 18.5-foot raise	15	138	6	26	5	4	66
Powerplant and Penstocks – 18.5-foot raise	12	138	4	26	4	4	48
Railroad Realignment – 18.5-foot raise	12	138	4	159	4	17	53
Right Wing Dam – 18.5-foot raise	11	138	3	54	3	7	45
Sacramento River UPRR 2nd Crossing – 18.5-foot raise	28	141	12	35	11	5	121
Spillway – 18.5-foot raise	27	139	11	26	10	4	113
TCD Mods – 18.5-foot raise	20	138	8	26	8	4	82
Visitor Center Replacement – 18.5-foot raise	10	138	3	43	3	6	41
Vehicular Bridges – 18.5-foot raise	24	155	10	34	9	5	110
Reservoir Clearing – 18.5-foot raise	35	260	12	27	11	4	112
Dikes – 18.5-foot raise	28	138	12	902	11	91	100
Buildings/Facilities – Recreation – 18.5-foot raise	40	141	20	1,483	18	150	166
Roads – 18.5-foot raise	28	138	12	588	11	60	102
Utilities – 18.5-foot raise	18	138	7	26	6	4	70
Gravel Augmentation – 18.5-foot raise	11	184	3	35	3	5	46

Table 5-12. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP4[a] (contd.)

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Restore Riparian and Floodplain Habitat – 18.5-foot raise	35	185	15	34	14	5	125

Notes:
[a] Totals may not add due to rounding

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh.= exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

Impact AQ-2 (CP4): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation Long-term project operation is not anticipated to result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD thresholds. Thus, long-term operational emissions would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant.

Long-term operational emissions would come from stationary, area, and mobile sources. This impact would be similar to AQ-2 (CP1) for stationary, area, and mobile sources. With CP4, there would be an annual increase of 363,000 and 370,000 visitor days under existing and future conditions, respectively, as shown in Table 5-5, resulting in 646 and 658 average daily trips under existing and future conditions, respectively. The associated daily emissions are shown in Table 5-13. Overall trip levels would be greater than under CP1 and CP2, but emissions would remain below significance thresholds.

Table 5-13. Operations Emissions for Shasta Dam Raise, 2015 – CP4

Activity	Emissions—pounds per day						
	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Existing Conditions							
Vehicle trips for increase in recreational visitors	4.8	16.8	0.5	9.0	0.5	0.1	36.5
Future Conditions							
Vehicle trips for increase in recreational visitors	4.9	17.1	0.5	9.2	0.5	0.1	37.2

Note:
Totals may not add due to rounding.

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh. = exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases

Based on the above analysis, operation under CP4 would not result in ROG, NO_X, PM_{10}, or CO emissions that exceed SCAQMD Level A thresholds. Consequently, long-term emissions during operation under CP3 would not violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-3 (CP4): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations Neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, or TACs. This impact would be less than significant.

This impact would be the same as Impact AQ-3 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-4 (CP4): Exposure of Sensitive Receptors to Odor Emissions Short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant.

This impact would be the same as Impact AQ-4 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact AQ-5 (CP4): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction Gravel augmentation proposed for areas along the upper Sacramento River would add to emissions of ROG, NO_X, and PM_{10} from project construction. Habitat restoration activities proposed for the upper Sacramento River would also add ROG, NO_X, and PM_{10} emissions. However, these emissions separately and combined would add negligible amounts to annual emission levels. This impact would be less than significant.

Gravel Augmentation proposed under CP4 would add an additional 1 lb/day of ROG, 16 lb/day of NO_X, and 1 lb/day of PM_{10} to project construction emission levels. Emissions from gravel augmentation would be from gravel material hauling consisting of approximately 18 trips per day, 40 miles round trip to sites identified to the south along the Sacramento River. Gravel augmentation would only occur for 2 months out of the year; therefore, these emissions would add negligible amounts to annual emission levels.

Habitat restoration in the upper Sacramento River proposed under CP4 would add an additional 6.7 lb/day of ROG, 50.1 lb/day of NO_X, and 12.4 lb/day of PM_{10} to project construction emission levels. During habitat restoration, emissions would be generated from potentially removing vegetation from the Sacramento River's side channel, removing noxious invasive plant species from the area, minor grading, and hauling away waste materials (approximately 25 trips per day). Restoration activities would occur for only 2 months for a total of 44 8-hour work days; therefore, these emissions would add negligible amounts to annual emission levels.

The combined emissions from gravel augmentation and habitat restoration activities would be 7.7 lb/day of ROG, 76 lb/day of NO_X, and 13.4 lb/day of PM_{10}. These emissions are below SCAQMD's Level A thresholds of 25 lb/day of ROG, 25 lb/day of NO_X, and 80 lb/day of PM_{10}. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under CP4; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area

Impact AQ-6 (CP4): Generation of Greenhouse Gases Project construction and operational activities would result in emission of a less than significant quantity of GHGs. Overall, implementation of CP4 would result in beneficial effects on GHG emissions because generation of electricity at Shasta Dam would increase. This impact would be less than significant.

This impact would be similar to Impact AQ-6 (CP1) for construction and operations. Based on the modeling conducted, construction of CP4 would result in 5,112 MT CO_2e/year amortized over the project lifetime. GHG emissions of sequestered carbon in removed vegetation were calculated at 7,164 MT CO_2e per year for CP3 (840 acres total). Increased activity by recreational visitors to the Shasta Lake area would result in additional vehicle trips and estimated emissions of 1,376 and 1,403 MT CO_2e per year for existing conditions and future conditions, respectively.

For existing conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP4 would result in a net increase in CVP/SWP power generation of 81.1 GWh per year (Table 5-7). Fossil-fuel generation of 81.1 GWh of energy would produce an estimated 72,400 MT CO_2 (Table 5-7). Thus, CP4 would reduce the need to build facilities for fossil-fueled generation of 81.1 GWh per year in the global study area.

For future conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP4 would result in a net increase in CVP/SWP power generation of 76.1 GWh per year (Table 5-7). Fossil-fuel generation of 76.1 GWh of energy would produce an estimated 67,900 MT CO_2 (Table 5-7). Thus, CP4 would reduce the need to build facilities for fossil-fueled generation of 76.1 GWh per year in the global study area.

Thus, the results of the above analysis show that CP4 would result in short-term emissions of GHG for the years of construction, followed by long-term benefits of GHG reduction through generation of electricity at Shasta Dam. The magnitude of the GHG "savings" for each year of operation would be approximately 58,748 and 54,221 MT CO2e for existing conditions and future conditions, respectively, considering construction emissions amortized over the project lifetime. The GHG emissions from construction activities would be temporary in duration and mitigated to the extent feasible; therefore, such emissions would not conflict with State or regional planning efforts or emit GHG in excess of mandatory reporting standards. GHG emissions from long-term operations would likely have a net benefit as a result of increased hydroelectric generation and would thus also not conflict with planning efforts or mandatory reporting thresholds. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

CP5 – 18.5-Foot Dam Raise, Combination Plan

Shasta Lake and Vicinity

Impact AQ-1 (CP5): Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction Project construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that exceed applicable SCAQMD thresholds. This conclusion is based on detailed calculations of estimated emissions for project elements and the simultaneous occurrence thereof. Shasta County is a nonattainment area for the State ozone and PM_{10} standards. Thus, short-term emissions generated during construction could contribute substantially to an existing or projected air quality violation. This impact would be significant.

CP5 includes a dam raise of 18.5 feet. This impact would be similar to Impact AQ-1 (CP1) as the same type of construction equipment and activities would be involved. Emissions were calculated as described above in Section 5.3.1, “Methods and Assumptions.” The results are shown in Table 5-14 for individual project elements. (All air quality modeling inputs and outputs for the comprehensive plans are presented in Attachment 1 to the *Air Quality and Climate Technical Report*.) As shown in Table 5-14 (similar to CP1), ROG, NO_x, and PM emissions for several of the individual project elements could exceed applicable Shasta County thresholds, which would result in a significant impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP5 (similar to CP1), could reach much higher levels based on the worst-case simultaneous construction of project elements as shown in detail in Attachment 1 to the *Air Quality and Climate Change Technical Report*. For the same reasons as described for CP1, this impact would be significant. Mitigation for this impact is proposed in Section 5.3.5.

Table 5-14. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP5[a]

Project Element (Activities)	ROG	NOx	PM10 Exh.	PM10 Dust	PM2.5 Exh.	PM2.5 Dust	CO
UPRR Doney Creek Bridge – 18.5-foot raise	20	140	8	34	7	5	82
Left Wing Dam – 18.5-foot raise	18	138	7	165	6	18	106
Main Concrete Dam – 18.5-foot raise	20	138	8	26	2	4	90
Outlet Works – 18.5-foot raise	13	138	5	26	5	4	53
Pit River Bridge Pier 3 and 4 Prot – 18.5-foot raise	15	138	6	26	5	4	66
Powerplant and Penstocks – 18.5-foot raise	12	138	4	26	4	4	48
Railroad Realignment – 18.5-foot raise	12	138	4	159	4	17	53
Right Wing Dam – 18.5-foot raise	11	138	3	54	3	7	45
Sacramento River UPRR 2nd Crossing – 18.5-foot raise	28	141	12	35	11	5	121
Spillway – 18.5-foot raise	27	139	11	26	10	4	113
TCD Mods – 18.5-foot raise	20	138	8	26	8	4	82
Visitor Center Replacement – 18.5-foot raise	10	138	3	43	3	6	41
Vehicular Bridges – 18.5-foot raise	24	155	10	34	9	5	110
Reservoir Clearing – 18.5-foot raise	35	260	12	27	11	4	112
Dikes – 18.5-foot raise	28	138	12	902	11	91	100
Buildings/Facilities – Recreation – 18.5-foot raise	40	141	20	1,483	18	150	166
Roads – 18.5-foot raise	28	138	12	588	11	60	102
Utilities – 18.5-foot raise	18	138	7	26	6	4	70
Gravel Augmentation – 18.5-foot raise	11	184	3	35	3	5	46

Table 5-14. Summary of Daily Short-Term Construction-Generated Emissions by Project Element (Pounds per Day) – CP5[a] (contd.)

Project Element (Activities)	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Restore Riparian and Floodplain Habitat – 18.5-foot raise	35	185	15	34	14	5	125
Recreation Facilities Enhancement – 18.5-foot raise	12	187	3	35	3	5	47
Shoreline Enhancement & Tributary Aquatic Habitat Enhancement – 18.5-foot raise	34	187	16	887	15	90	168

Note:
[a] Totals may not add due to rounding

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh.= exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

Impact AQ-2 (CP5): Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation Long-term project operation is not anticipated to result in ROG, NO_X, PM_{10}, or CO emissions that exceed applicable SCAQMD thresholds. Thus, long-term operational emissions would not be anticipated to violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant.

Long-term operational emissions would come from stationary, area, and mobile sources. This impact would be similar to AQ-2 (CP1) for stationary, area, and mobile sources. With CP5 there would be an annual increase of 199,000 and 175,000 visitor days under existing and future conditions, respectively, as shown in Table 5-5, resulting in 354 and 311 average daily trips under existing and future conditions, respectively. The associated daily emissions are shown in Table 5-15.

Table 5-15. Operations Emissions for Shasta Dam Raise, 2015 – CP5

Activity	Emissions—pounds per day						
	ROG	NO_x	PM_{10} Exh.	PM_{10} Dust	$PM_{2.5}$ Exh.	$PM_{2.5}$ Dust	CO
Existing Conditions							
Vehicle trips for increase in recreational visitors	2.6	9.2	0.3	5.0	0.3	0.1	20.0
Future Conditions							
Vehicle trips for increase in recreational visitors	2.3	8.1	0.3	4.4	0.3	0.1	17.6

Note: Totals may not add due to rounding.

Key:
CO = carbon monoxide
CP = Comprehensive Plan
Exh. = exhaust
NO_X = oxides of nitrogen
$PM_{2.5}$ = fine particulate matter
PM_{10} = respirable particulate matter
ROG = reactive organic gases

Based on the above analysis, operation under CP4 would not result in ROG, NO_X, PM_{10}, or CO emissions that exceed SCAQMD Level A thresholds. Consequently, long-term emissions during operation under CP3 would not violate an air quality standard or contribute substantially to an existing or projected air quality violation. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-3 (CP5): Exposure of Sensitive Receptors to Substantial Pollutant Concentrations Neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, or TACs. This impact would be less than significant.

This impact would be the same as Impact AQ-3 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Impact AQ-4 (CP5): Exposure of Sensitive Receptors to Odor Emissions Short-term construction and long-term operational sources would not expose sensitive receptors to substantial odor emissions. This impact would be less than significant.

This impact would be the same as Impact AQ-4 (CP1) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Upper Sacramento River (Shasta Dam to Red Bluff)

Impact AQ-5 (CP5): Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction The Gravel Augmentation Program proposed for areas along the upper Sacramento River would add to emissions of ROG, NO_X, and PM_{10} from project construction.

However, these emissions would add negligible amounts to annual emission levels. This impact would be less than significant.

This impact would be the same as Impact AQ-5 (CP4) and would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

Lower Sacramento River and Delta and CVP/SWP Service Areas No effects on climate and air quality are expected to occur in the lower Sacramento River and Delta and CVP/SWP service areas under CP5; therefore, potential effects in those geographic regions are not discussed further in this DEIS.

Global Study Area

Impact AQ-6 (CP5): Generation of Greenhouse Gases Project construction and operational activities would result in emission of a less than significant quantity of GHGs. Overall, implementation of CP4 would result in beneficial effects on GHG emissions because generation of electricity at Shasta Dam would increase. This impact would be less than significant.

This impact would be similar to Impact AQ-6 (CP1) for construction and operations. Based on the modeling conducted, construction of CP5 would result in 5,199 MT CO_2e/year amortized over the project lifetime. GHG emissions of sequestered carbon in removed vegetation were calculated at 7,164 MT CO_2e per year for CP3 (840 acres total). Increased activity by recreational visitors to the Shasta Lake area would result in additional vehicle trips and estimated emissions of 754 MT CO_2e per year.

For existing conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP5 would result in a net increase in CVP/SWP power generation of 23.6 GWh per year, as was shown in Table 5-7. Fossil fuel generation of 23.6 GWh of energy would produce an estimated 21,000 MT CO_2, also shown in Table 5-7. Thus, CP5 would reduce the need to build facilities for fossil-fueled generation of 23.6 GWh per year in the global study area.

For future conditions, raising Shasta Dam by 18.5 feet and implementing the operational strategy for CP5 would result in a net increase in CVP/SWP power generation of 4.2 GWh per year, as was shown in Table 5-7. Fossil fuel generation of 4.2 GWh of energy would produce an estimated 3,800 MT CO_2, also shown in Table 5-7. Thus, CP5 would reduce the need to build facilities for fossil-fueled generation of 4.2 GWh per year in the global study area.

Thus, the results of the above analysis show that CP5 would result in short-term emissions of GHG for the years of construction, followed by long-term benefits of GHG reduction through generation of electricity at Shasta Dam for existing conditions. The magnitude of the GHG “savings” for each year of operation would be approximately 7,883 MT CO2e for existing conditions and a GHG “deficit” of 9,226 MTCO2e for future conditions considering construction emissions amortized over the project lifetime. The GHG emissions from construction activities would be temporary in duration and mitigated to the extent feasible; therefore, such emissions would not conflict with State or regional planning efforts or emit GHG in excess of mandatory reporting standards. GHG emissions from long-term operations would likely not conflict with planning efforts or mandatory reporting thresholds. This impact would be less than significant. Mitigation for this impact is not needed, and thus not proposed.

5.3.5 Mitigation Measures

Table 5-16 presents a summary of mitigation measures for air quality and climate.

Table 5-16. Summary of Mitigation Measures for Air Quality and Climate Change

		No-Action Alternative	CP1	CP2	CP3	CP4	CP5
Impact AQ-1: Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction	LOS before Mitigation	NI	S	S	S	S	S
	Mitigation Measure	None required.	Mitigation Measure AQ-1: Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels.				
	LOS after Mitigation	NI	SU	SU	SU	SU	SU
Impact AQ-2: Long-Term Emissions of Criteria Air Pollutants and Precursors During Project Operation	LOS before Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
Impact AQ-3: Exposure of Sensitive Receptors to Substantial Pollutant Concentrations	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact AQ-4: Exposure of Sensitive Receptors to Odor Emissions	LOS before Mitigation	NI	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	LTS	LTS	LTS	LTS	LTS
Impact AQ-5: Short-Term Emissions of Criteria Air Pollutants and Precursors Below Shasta Dam During Project Construction	LOS before Mitigation	NI	NI	NI	NI	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	NI	NI	NI	NI	LTS	LTS
Impact AQ-6: Generation of Greenhouse Gases	LOS before Mitigation	LTS	LTS	LTS	LTS	LTS	LTS
	Mitigation Measure	None required.	None needed; thus, none proposed.				
	LOS after Mitigation	LTS	LTS	LTS	LTS	LTS	LTS

Notes:
LOS = level of significance
LTS = less than significant
NA = not applicable
NI = no impact
PS = potentially significant
SU = significant and unavoidable

No-Action Alternative

No mitigation measures are needed for this alternative.

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is needed for Impacts AQ-2 (CP1), AQ-3 (CP1), AQ-4 (CP1), AQ-5, and AQ-6 (CP1). Mitigation is provided below for the remaining impact of CP1 on air quality.

Mitigation Measure AQ-1 (CP1): Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels Reclamation (referred to below as "the project applicant" or "the applicant") and its primary construction contractor(s) will implement the mitigation measures listed below to reduce emissions of criteria air pollutants and precursors generated during construction.

Standard Mitigation Measures The following SCAQMD standard mitigation measures are applicable to all projects.

PM10 Controls

- Alternatives to open burning of vegetative material on the project site shall be used by the project applicant unless otherwise deemed infeasible by SCAQMD. Among suitable alternatives is chipping, mulching, or conversion to biomass fuel.

- The applicant shall be responsible for ensuring that all adequate dust control measures are implemented in a timely and effective manner during all phases of project development and construction.

- All material excavated, stockpiled, or graded shall be sufficiently watered to prevent fugitive PM_{10} dust emissions from leaving the property boundaries and causing a public nuisance or a violation of an ambient air standard. Watering shall occur at least twice daily with complete site coverage, preferably in the mid-morning and after work is completed each day.

- All areas (including unpaved roads) with vehicle traffic shall be watered periodically or dust palliatives applied for stabilization of fugitive PM_{10} dust emissions.

- All on site vehicles shall be limited to a speed of 15 miles per hour on unpaved roads.

- All land clearing, grading, earthmoving, or excavation activities on a project shall be suspended when winds are expected to exceed 20 miles per hour.

- All inactive portions of the development site shall be seeded and watered until a suitable grass cover is established.

- The applicant shall be responsible for applying Shasta County Department of Public Works–approved nontoxic soil stabilizers (according to manufacturers' specifications) to all inactive construction areas (previously graded areas that remain inactive for 96 hours) in accordance with the Shasta County Grading Ordinance.

- All trucks hauling dirt, sand, soil, or other loose material shall be covered or maintain at least 2 feet of freeboard (i.e., minimum vertical distance between top of the load and the trailer) in accordance with the requirements of California Vehicle Code Section 23114. This provision shall be enforced by local law enforcement agencies.

- All material transported off site shall be either sufficiently watered or securely covered to prevent a public nuisance.

- During initial grading, earthmoving, or site preparation, the project shall be required to construct a paved (or dust palliative–treated) apron, at least 100 feet in length, onto the project site from the adjacent paved road(s).

- Paved streets adjacent to the development site shall be swept or washed at the end of each day to remove excessive accumulations of silt and/or mud that may have accumulated as a result of activities on the development site.

- Adjacent paved streets shall be swept (water sweeper with reclaimed water recommended) at the end of each day if substantial volumes of soil materials have been carried onto adjacent public paved roads from the project site.

- Wheel washers shall be installed where project vehicles and/or equipment enter and/or exit onto paved streets from unpaved roads. Vehicles and/or equipment shall be washed before each trip.

- Before final occupancy, the applicant shall reestablish ground cover on the construction site through seeding and watering in accordance with the Shasta County Grading Ordinance.

Streets

- The project shall provide for temporary traffic control as appropriate during all phases of construction to improve traffic flow as deemed appropriate by the Shasta County Department of Public Works and/or the California Department of Transportation.

- Construction activities shall be scheduled that direct traffic flow to off-peak hours as much as practicable.

Energy Conservation For any new or relocated structures, the following features will be incorporated as much as practicable:

- The project shall provide for the use of energy-efficient lighting, including controls, and process systems such as water heaters, furnaces, and boiler units.

- The project shall use a central water heating system featuring the use of low-NO_X hot water heaters.

Best Available Mitigation Measures None of the SCAQMD BAMMs are appropriate for the project. Therefore, the following measures will be incorporated into the project:

- The project applicant will prepare and submit to SCAQMD for approval a plan demonstrating that the heavy-duty (equal to or greater than 50 horsepower) off-road vehicles to be used in the construction project, including owned, leased, and subcontractor vehicles, shall achieve a project-wide fleet-average 20 percent NO_X reduction and 45 percent particulate reduction compared to the most recent ARB fleet average at time of construction. Acceptable options for reducing emissions may include use of late-model engines, low-emission diesel products, alternative fuels, engine retrofit technology, after-treatment products, and/or other options as they become available.

- The project applicant will locate all construction equipment maintenance and staging areas at the farthest distance possible from nearby sensitive land uses.

- Idling of diesel-powered vehicles and equipment will not be permitted during periods of nonactive vehicle use. Diesel-powered engines will not be allowed to idle for more than 5 consecutive minutes in a 60-minute period when the equipment is not in use, occupied by an operator, or otherwise in motion, except under the following conditions:

  - When equipment is forced to remain motionless because of traffic conditions or mechanical difficulties over which the operator has no control

  - When it is necessary to operate auxiliary systems installed on the equipment, only when such system operation is necessary to accomplish the intended use of the equipment

- To bring the equipment to the manufacturer’s recommended operating temperature
- When the ambient temperature is below 40ºF or above 85ºF
- When equipment is being repaired

Implementation of the above mitigation measure would reduce ROG, NO_X, and PM_{10} emissions from on-site heavy-duty equipment exhaust by approximately 5 percent, 20 percent, and 45 percent, respectively, and fugitive PM_{10} dust emissions by 75 percent. However, NO_X emissions generated during construction would still exceed the SCAQMD Level B threshold of 137 lb/day. Thus, this impact would be significant and unavoidable.

CP2 – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

No mitigation is needed for Impacts AQ-2 (CP2), AQ-3 (CP2), AQ-4 (CP2), AQ-5, and AQ-6 (CP2). Mitigation is provided below for the remaining impact of CP2 on air quality.

Mitigation Measure AQ-1 (CP2): Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels This mitigation measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons described above under Mitigation Measure AQ-1 (CP1), this impact would be significant and unavoidable.

CP3 – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply

No mitigation is needed for Impacts AQ-2 (CP3), AQ-3 (CP3), AQ-4 (CP3), AQ-5, and AQ-6 (CP3). Mitigation is provided below for the remaining impact of CP3 on air quality.

Mitigation Measure AQ-1 (CP3): Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels This mitigation measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons described above under Mitigation Measure AQ-1 (CP1), this impact would be significant and unavoidable.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

No mitigation is needed for Impacts AQ-2 (CP4), AQ-3 (CP4), AQ-4 (CP4), AQ-5, and AQ-6 (CP4). Mitigation is provided below for the remaining impact of CP4 on air quality.

Mitigation Measure AQ-1 (CP4): Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels This mitigation measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons described above under Mitigation Measure AQ-1 (CP1), this impact would be significant and unavoidable.

CP5 – 18.5-Foot Dam Raise, Combination Plan

No mitigation is needed for Impacts AQ-2 (CP5), AQ-3 (CP5), AQ-4 (CP5), AQ-5, and AQ-6 (CP5). Mitigation is provided below for the remaining impact of CP5 on air quality.

Mitigation Measure AQ-1 (CP5): Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels This mitigation measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons described above under Mitigation Measure AQ-1 (CP1), this impact would be significant and unavoidable.

5.3.6 Cumulative Effects

The effects of climate change on operations at Shasta Lake could potentially result in changes downstream. As described in the Climate Change Appendix, climate change could result in higher reservoir releases in the future due to an increase in winter and early spring inflow into the lake from high intensity storm events. The change in reservoir releases could be necessary to manage for flood events resulting from these potentially larger storms. The potential increase in releases from the reservoir could lead to long-term changes in downstream channel equilibrium.

Growth is likely to occur throughout the primary and extended study areas and some future projects are reasonably foreseeable, but substantial increases in emissions of criteria air pollutants or precursors in the primary and extended study areas are unlikely to make a cumulatively considerable contribution to an overall cumulatively significant impact on air quality. For cumulative effects of climate change on other resource areas, please see the "Cumulative Effects" sections in other chapters of this DEIS.

Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to Red Bluff)

Under the project alternatives (CP1 – CP5), construction activities would result in short-term emissions of ROG, NO_X, and PM_{10} that without mitigation would exceed applicable SCAQMD thresholds. After implementing the best available and all feasible mitigation measures, ROG and PM_{10} emissions would not exceed applicable thresholds; and in combination with past, present, and reasonably foreseeable future projects, would not result in an overall cumulatively significant impact. Therefore, with mitigation, these emissions would not be cumulatively considerable. Emissions of NO_X, however, would still exceed the applicable SCAQMD threshold after implementation of the best available mitigation measures. These emissions would be cumulatively considerable, and this would be a cumulatively significant and unavoidable impact.

Operation of any of the action alternatives would not result in cumulatively considerable emissions of ROG, NO_X, and PM_{10}. Also, neither short-term construction nor long-term operational sources would expose sensitive receptors to substantial concentrations of CO, PM_{10}, $PM_{2.5}$, TACs, or odors. None of these emissions would be cumulatively considerable contributions to a significant cumulative impact of ROG, NO_X, and PM_{10}.

Lower Sacramento River and Delta and CVP/SWP Service Areas

The project alternatives would not generate any short-term or long-term air pollutant emissions in the extended study area. Therefore, there would be no cumulative air quality impact.

Global Study Area—Climate Change

As discussed in Section 5.1, "Affected Environment," of this chapter, climate change is a global phenomenon. All GHG emissions are considered cumulative. The impact analyses for Impacts AQ-6 (CP1), AQ-6 (CP2), AQ-6 (CP3), AQ-6 (CP4), and AQ-6 (CP5), in Section 5.3.4, "Direct and Indirect Effects," of this chapter are cumulative analyses. All five project alternatives (CP1–CP5) would result in short-term cumulative impacts that would be less than the suggested significance threshold for this cumulative effect, and therefore are considered to not make a cumulatively considerable incremental contribution to a significant cumulative impact, and would have beneficial long-term effects. For cumulative effects of climate change on other resource areas, please see the "Cumulative Effects" sections in other chapters of this DEIS.