

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.

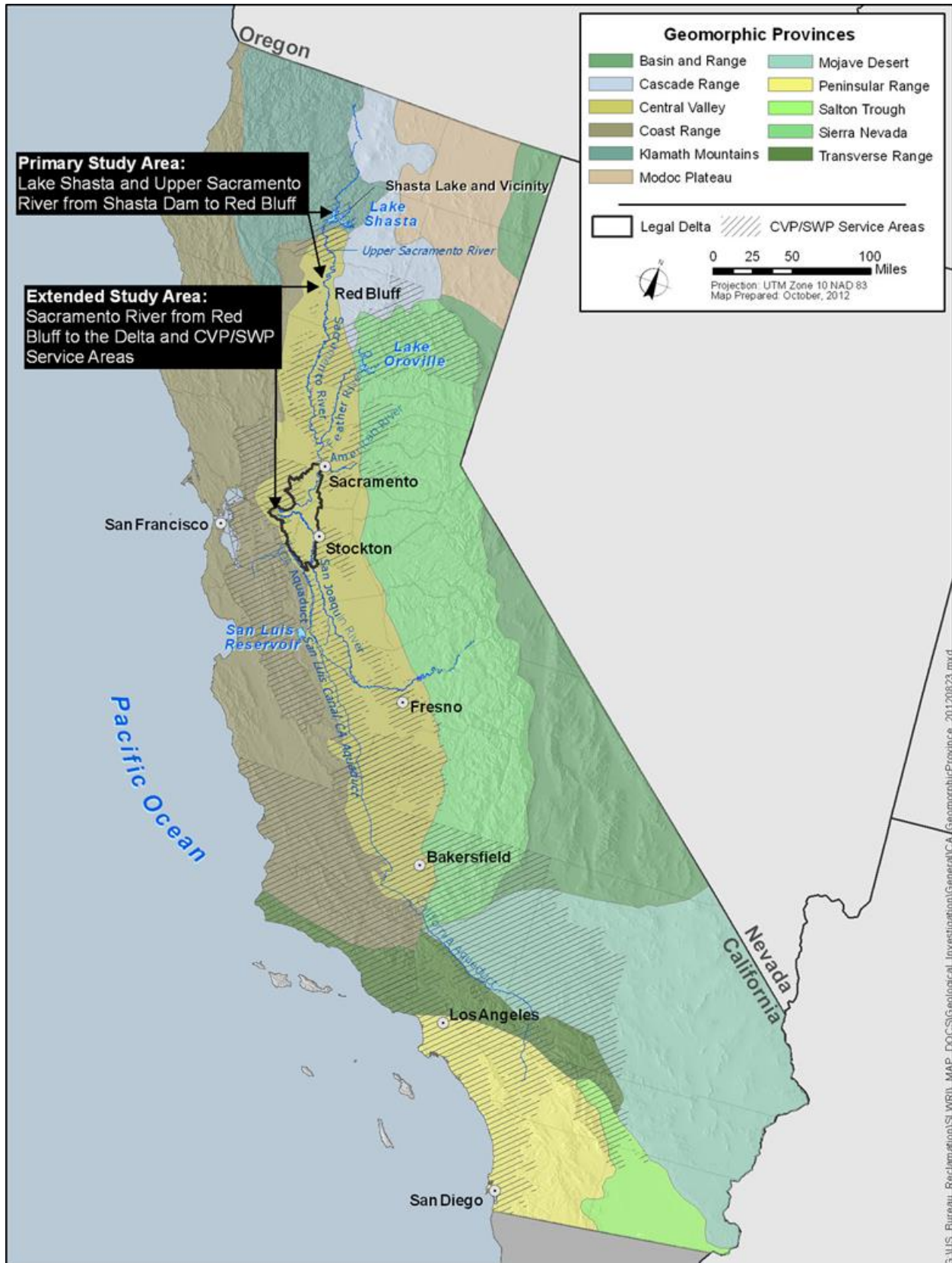
Shasta Lake and Vicinity

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

1 geographically at the interface between the Central Valley, Klamath Mountains,
2 and Modoc Plateau and Cascades geomorphic provinces.

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

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



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Figure 4-1. Geomorphic Provinces of California

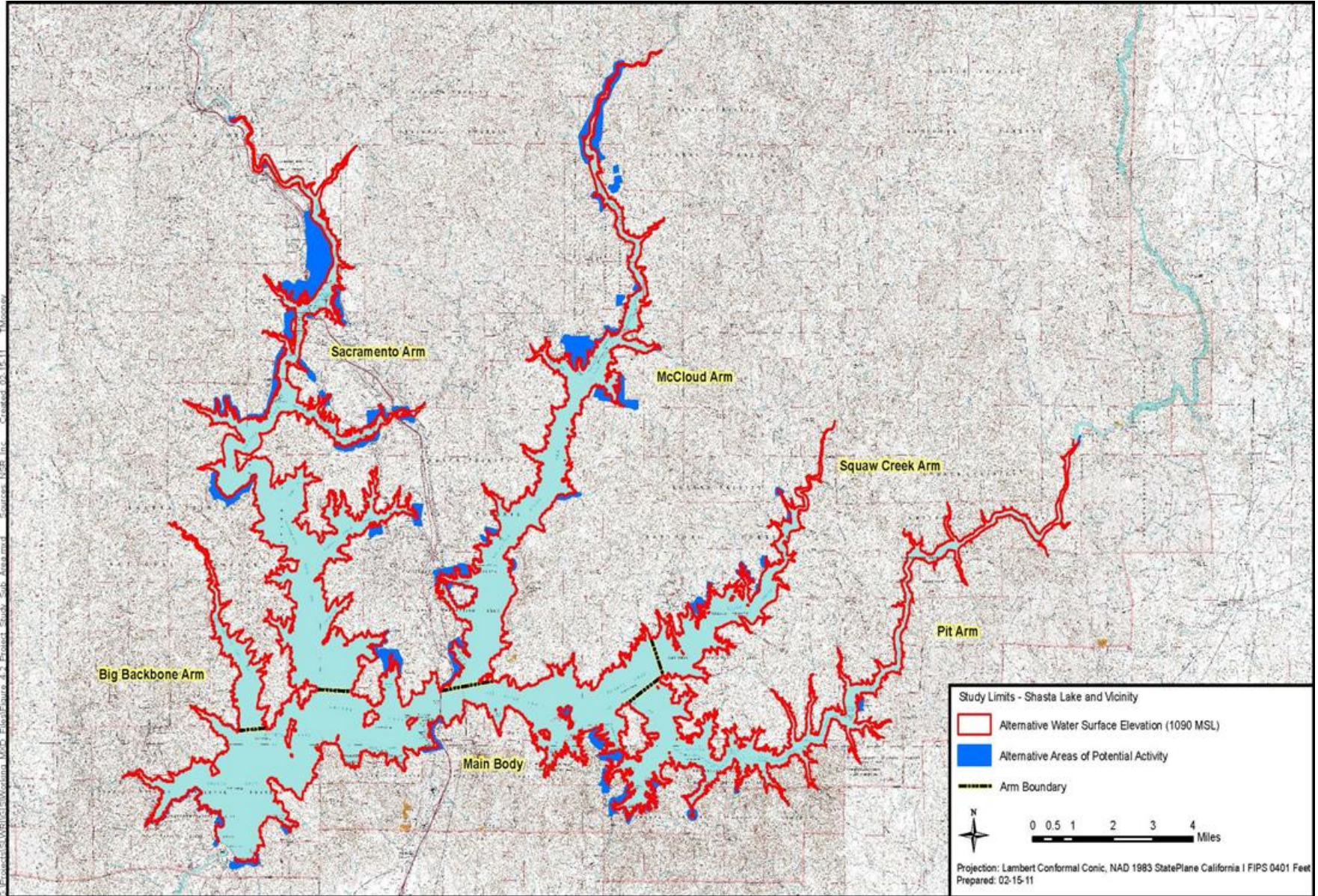


Figure 4-2. Shasta Lake and Vicinity Portion of the Primary Study Area

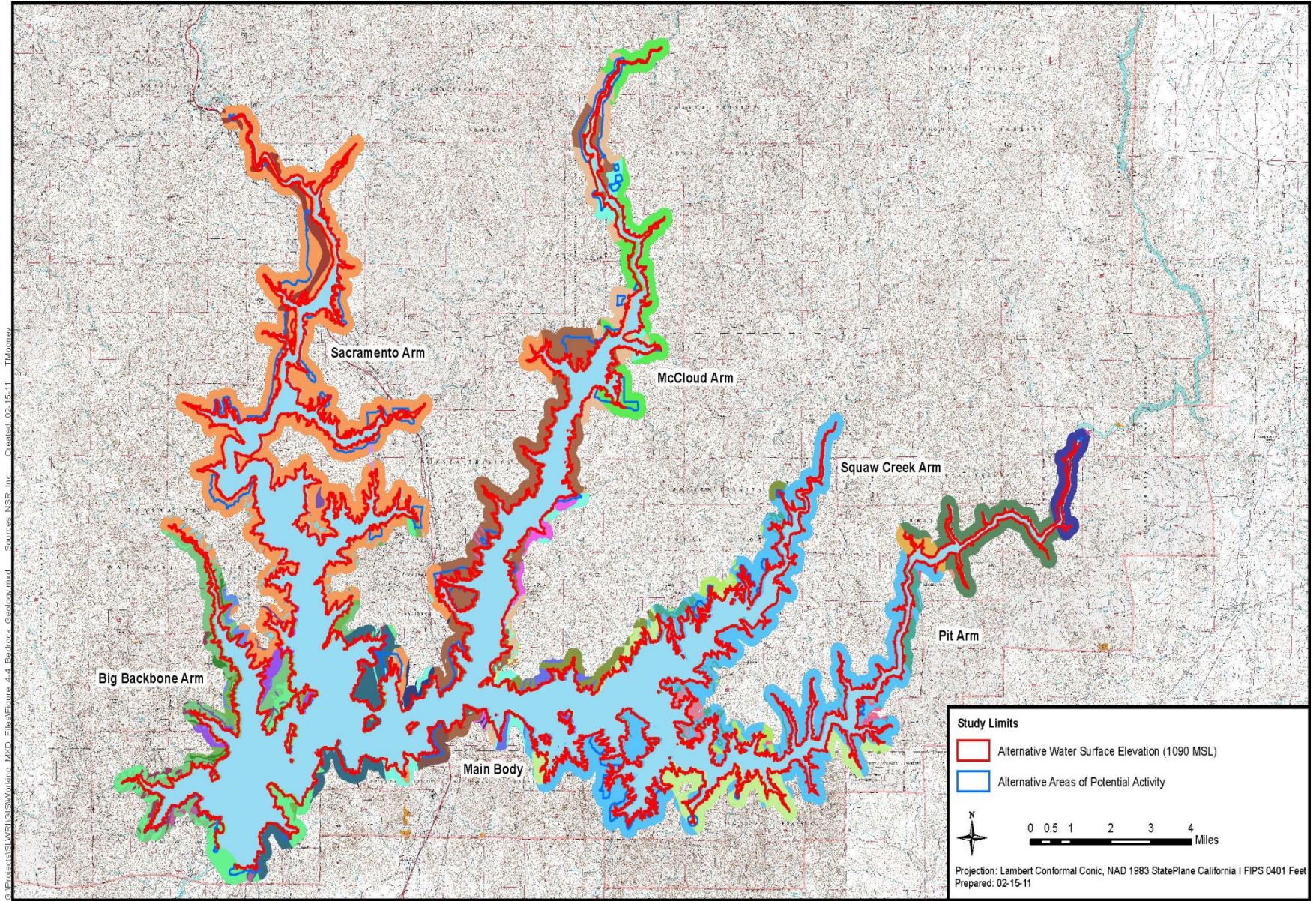


Figure 4-3. Bedrock Geology – Shasta Lake and Vicinity

© Engineers & Geoscientists Consultants, Inc. File: Figure 4-3. Bedrock Geology.mxd Sources: NSR, Inc. Created: 02-15-11 T.Mooney

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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, volcanoclastic & 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
 Pmmis, 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 volcanoclastic & 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: volcanoclastic; 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

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

18 **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.

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1 **Table 4-2. Stratigraphic Column of Formations of the Eastern Klamath Mountain Belt**
 2 **(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.
	Balaglala 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.

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 4 The McCloud Limestone is prominently exposed within the McCloud, Pit, Main
 5 Body, and Big Backbone arms of Shasta Lake. Within the lake footprint, the
 6 McCloud Arm has the largest exposure of this limestone, followed by the Pit,
 7 Main Body, and Big Backbone arms. Along the McCloud Arm, this limestone
 8 crops out on the eastern shore from the mouth at the main body of the lake to
 9 Hirz Bay. Above Hirz Bay, it is intermittently exposed on both sides of the
 10 McCloud Arm. Along the Pit Arm near the mouth of Brock Creek, the
 11 McCloud Limestone is exposed along the north and southern banks. The
 12 McCloud Limestone is exposed near the southern shore of Allie Cove in the
 13 eastern portion of the Main Body of the lake. Along the Big Backbone Arm, the
 14 McCloud Limestone is exposed near the eastern shore between the outlets of
 15 Shoemaker and Limerock creeks. Outside the Shasta Lake footprint, an outcrop
 16 of the McCloud Limestone is exposed along the McCloud River approximately
 17 10 miles upstream from the mouth into the McCloud Arm. The McCloud
 18 Limestone is also exposed on the north side of Bohemotash Mountain, which is
 19 approximately 2 miles from the mouth of Big Backbone Creek at the Big
 20 Backbone Arm.

21 “Skarn” is a geologic term that refers to metamorphic rocks formed in the
 22 contact zone of magmatic intrusions (e.g., granite) with carbonate-rich rocks
 23 (e.g., limestone). Skarn deposits are rich in lime-silicate minerals and locally
 24 contain magnetite. Permian-aged skarn deposits are present within the McCloud
 25 Arm. The deposits are located near the mouths of Marble and Potter creeks and

1 on the peninsula at the eastern margin of the inlet of the McCloud Arm. The
2 skarn deposits occur adjacent to the McCloud Limestone at the mouths of
3 Marble and Potter creeks, but the McCloud Limestone is absent near skarn
4 deposits on the peninsula.

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

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

19 The Cascade volcanics have been divided into the Western Cascade series and
20 the High Cascade series. The Western Cascade series rocks consist of Miocene-
21 aged basalts, andesites, and dacite flows interlayered with rocks of explosive
22 origin, including rhyolite tuff, volcanic breccia, and agglomerate. This series is
23 exposed at the surface in a belt 15 miles wide and 50 miles long from the
24 Oregon border to the town of Mount Shasta. After a short period of uplift and
25 erosion that extended into the Pliocene, volcanism resumed creating the High
26 Cascade volcanic series. The High Cascade series forms a belt 40 miles wide
27 and 150 miles long just east of the Western Cascade series rocks. Early High
28 Cascade rocks formed from very fluid basalt and andesite that extruded from
29 fissures to form low shield volcanoes. Later eruptions during the Pleistocene
30 contained more silica, causing more violent eruptions. Large composite cones
31 like Mount Shasta and Lassen Peak had their origins during the Pleistocene
32 (Norris and Webb 1990).

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

39 Volcanic rocks of the Modoc Plateau and Cascades Geomorphic Province are
40 present adjacent to the eastern and northeastern boundaries of the Shasta Lake
41 and vicinity area. In the vicinity of Shasta Lake they occur near the Pit Arm and
42 along the upper Sacramento Arm. These rocks are generally younger than 4

1 million years old. Volcaniclastic rocks, mudflows, and tuffs of the Tuscan
2 Formation occur in the Pit River area, and localized volcanic deposits occur in
3 isolated locations.

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

8 **Table 4-3. Areal Extent of Bedrock Types – Shasta Lake and Vicinity**
9 **(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%

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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 volcanoclastic and pyroclastic rocks	27.9	1.12%
Trp	Pit	Shale; siltstone; metavolcanic; w 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%

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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%

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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; w limestone	408.5	12.23%
Trpp	Pit	Pyroclastic; tuff and tuff breccia	11.5	0.34%
Tva	Western Cascades	Andesite	2.0	0.06%

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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).

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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.

1 **Upper Sacramento River (Shasta Dam to Red Bluff)**

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

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

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

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

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

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

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

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

1 **Lower Sacramento River and Delta**

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

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

9 **CVP/SWP Service Areas**

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

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

21 **4.1.2 Geologic Hazards**

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

24 **Shasta Lake and Vicinity**

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

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

38 Surface rupture occurs when an earthquake results in ground rupture, causing
39 horizontal and/or vertical displacement. Surface rupture typically is narrow in

1 rock and wider in saturated soils, and also typically tends to occur along
2 previous fault lines.

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

15 According to the California Geological Survey's Alquist-Priolo Act Active
16 Fault Maps, the nearest active fault north of the Shasta Lake and vicinity area is
17 the Hat Creek–Mayfield–McArthur Fault Zone, located about 50 miles to the
18 northeast of Shasta Dam (Jennings 1975). This fault zone is composed of
19 numerous parallel north-northwest–trending normal faults. According to the
20 Alquist-Priolo Act maps, the Hat Creek–Mayfield–McArthur Fault is capable of
21 generating magnitude 7.0 earthquakes with a relatively long return period of
22 750 years (Petersen et al. 1996).

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

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

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

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

1 Seismic activity has been reported in the area of Shasta Dam and Shasta Lake,
2 and has typically been in the 5.0 magnitude or lower range. The nearest seismic
3 activity to Shasta Dam and Shasta Lake was a magnitude 5.2 earthquake that
4 occurred 3 miles northwest of Redding, near Keswick Dam, in 1998 (Petersen
5 1999).

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

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

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

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

35 Eruptions of Mount Shasta could endanger the communities of Weed, Mount
36 Shasta, McCloud, and Dunsmuir. Such eruptions will most likely produce
37 deposits of lithic ash, lava flows, domes, and pyroclastic flows that may affect
38 low- and flat-lying ground almost anywhere within 12 miles of the summit.
39 However, on the basis of its past behavior, Mount Shasta is not likely to erupt
40 large volumes of pumiceous ash (tephra) in the future. Areas subject to the
41 greatest risk from air-fall tephra are located mainly east and within about
42 30 miles of the summit (Miller 1980).

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

13 *Mudflows* Small mudflows not caused by eruptions are common at Mount
14 Shasta. Relatively small but frequent mudflows have been produced historically
15 (1924, 1926, 1931, and 1977) by melting of glaciers on Mount Shasta during
16 warm summer months. Mudflows that occurred during the summer of 1924
17 entered the McCloud River and subsequently flowed into the Sacramento River
18 (Miller 1980).

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

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

30

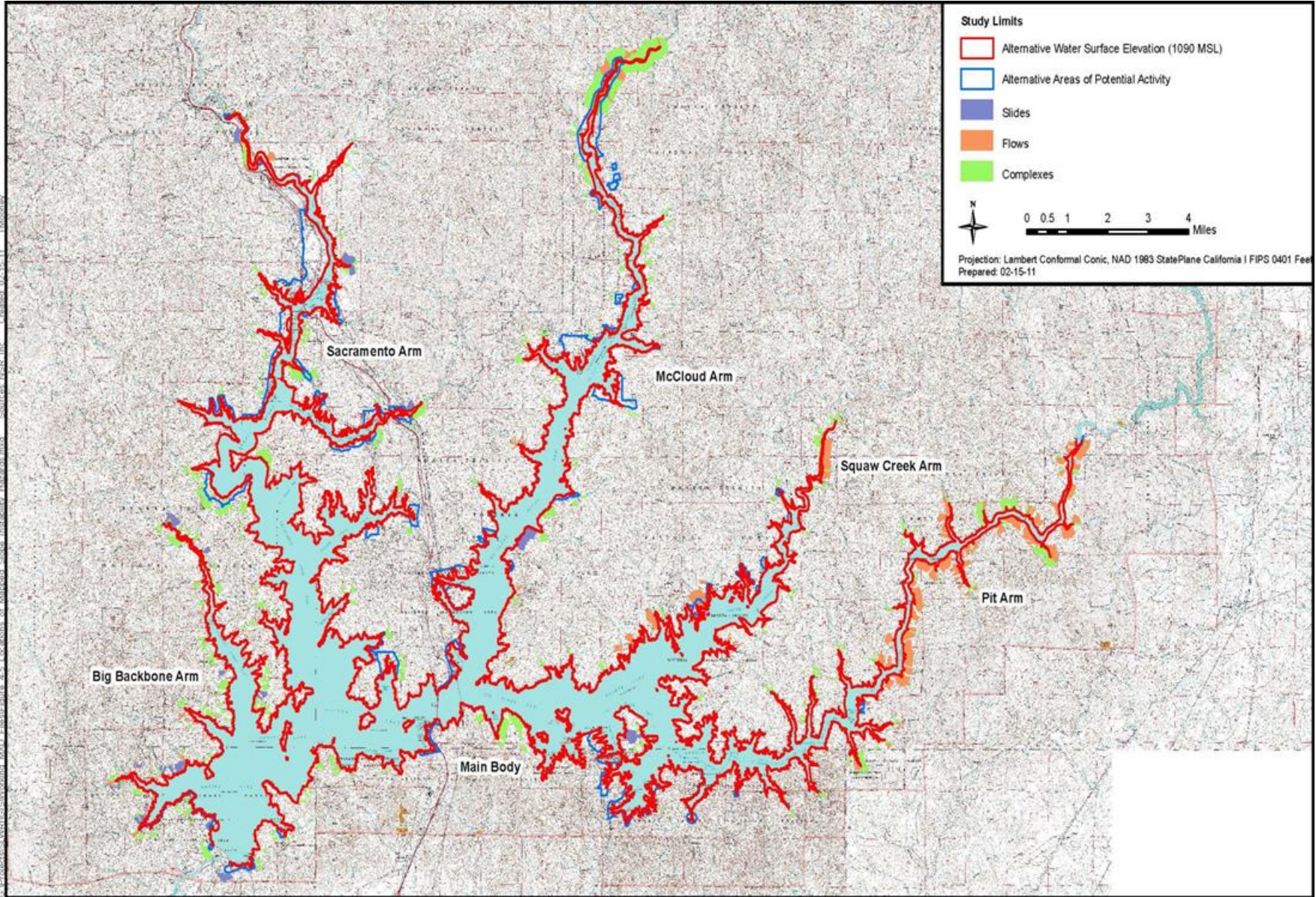


Figure 4-4. Locations of Mapped Slope Instability Hazards – Shasta Lake and Vicinity

1 The terrane underlying the Shasta Lake and vicinity area and the surrounding
 2 region has been influenced by a combination of tectonic uplift, mass wasting,
 3 and fluvial and surface erosion processes. The influence of these processes is
 4 ongoing, with evidence of ancient and more recent mass wasting features over
 5 the entire area, consisting of debris slides, torrents, and flows, with lesser
 6 amounts of rotational/translational landslides. The extent or distribution of mass
 7 wasting features across the region is believed not to have changed appreciably
 8 as a result of land use activities following Anglo-American settlement (USFS
 9 1998).

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

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

25 **Table 4-5. Areal Extent of Mapped Slope Instability Hazards – Shasta Lake**
 26 **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%

27 **Table 4-6. Areal Extent of Mapped Slope Instability Hazards – Shasta Lake**
 28 **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%

29
 30 *Seiches* A seiche is an oscillation of a body of water in an enclosed or
 31 semienclosed basin that varies in period, depending on the physical dimensions
 32 of the basin, from a few minutes to several hours, and in height from a few
 33 millimeters to a few meters. Seiches arise chiefly as a result of sudden local

1 changes in atmospheric pressure, aided by wind and occasionally tidal currents.
2 Seiches can also be triggered by strong earthquake ground motion or large
3 landslides entering a body of water.

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

11 Regardless of its cause, the effects of a seiche would depend on the local
12 conditions at the time. If the reservoir were filled to capacity, there may be
13 some overspill by way of the dam spillways. Substantial overtopping of the dam
14 itself is extremely unlikely, as such an event would require a seiche more than
15 6 meters high, even if the reservoir were filled to capacity. Excess flows into the
16 Sacramento River triggered by a seiche in Shasta Lake would be attenuated by
17 Keswick Reservoir (City of Redding 2000).

18 ***Upper Sacramento River (Shasta Dam to Red Bluff)***

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

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

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

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

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

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

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

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

27 **Volcanic Eruptions and Associated Hazards** Shasta County is at the
28 southern end of the Cascade Range (as described above for the geology of the
29 upper Sacramento River). The most recent volcanic activity in Shasta County
30 occurred between 1914 and 1917, when Lassen Peak erupted, producing lava
31 flows, numerous ash falls, and a large mudflow. The mudflow, a result of
32 melting snow and ash, flowed down Lost Creek and Hat Creek (Shasta County
33 2004).

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

36 ***Lower Sacramento River and Delta***

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

1 The nearest active fault to the lower Sacramento River below Red Bluff is the
2 Dunnigan Hills Fault, which has experienced fault displacement within the last
3 10,000 years (Jennings 1994). The Dunnigan Hills Fault runs along the
4 Sacramento River and is located between 6 and 10 miles west of the river near
5 the town of Dunnigan. The Cleveland Fault is located approximately 30 miles
6 east of the Sacramento River near the city of Oroville. In addition, the Great
7 Valley thrust fault system and San Andreas fault system extend along the
8 Sacramento River to the west, as described above for the upper Sacramento
9 River portion of the primary study area.

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

18 ***CVP/SWP Service Areas***

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

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

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

34 Active faults likely to affect the upper watersheds at the end of the San Joaquin
35 Valley include the White Wolf Fault, which ruptured in 1952 with a magnitude
36 7.2 earthquake; the Garlock Fault, capable of a magnitude 7.3 earthquake; and
37 several smaller faults 10–30 miles north of the White Wolf Fault.

38 A list of all of the reported faults, fault zones, and systems, according to the
39 California Geological Survey, that are located south of the Delta in the
40 CVP/SWP service areas is presented in the California Public Resources Code,

1 in Division 2, “Geology, Mines and Mining,” Chapter 7.5, “Earthquake Fault
2 Zoning” (CDMG 2006a).

3 **4.1.3 Geomorphology**

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

6 ***Shasta Lake and Vicinity***

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

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

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

28 In general, the stream networks adjacent and directly tributary to Shasta Lake
29 are irregular and dendritic. The drainages are steep, and the drainage density
30 ranges from 3.0 to 6.4 miles of stream per square mile of drainage area (Table
31 4-7). The drainage density is the lowest in the Main Body of the lake because
32 this area has several small catchments. The density is the highest in the more
33 well-defined arms, a function of their larger catchment areas of the tributary
34 watersheds.

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

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

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

9

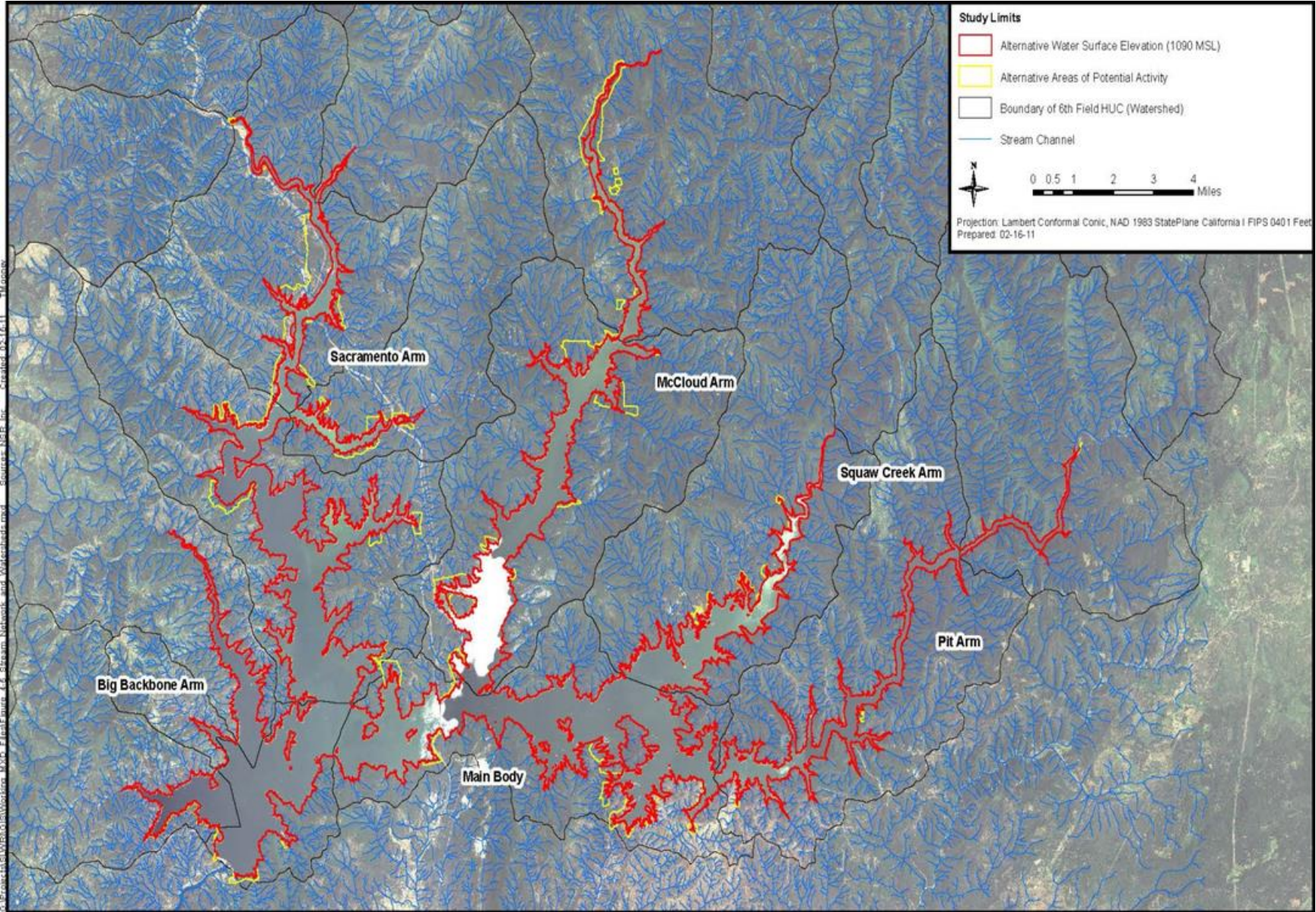


Figure 4-5. Regional Stream Network and Boundaries of Watersheds Adjacent to Shasta Lake and Vicinity

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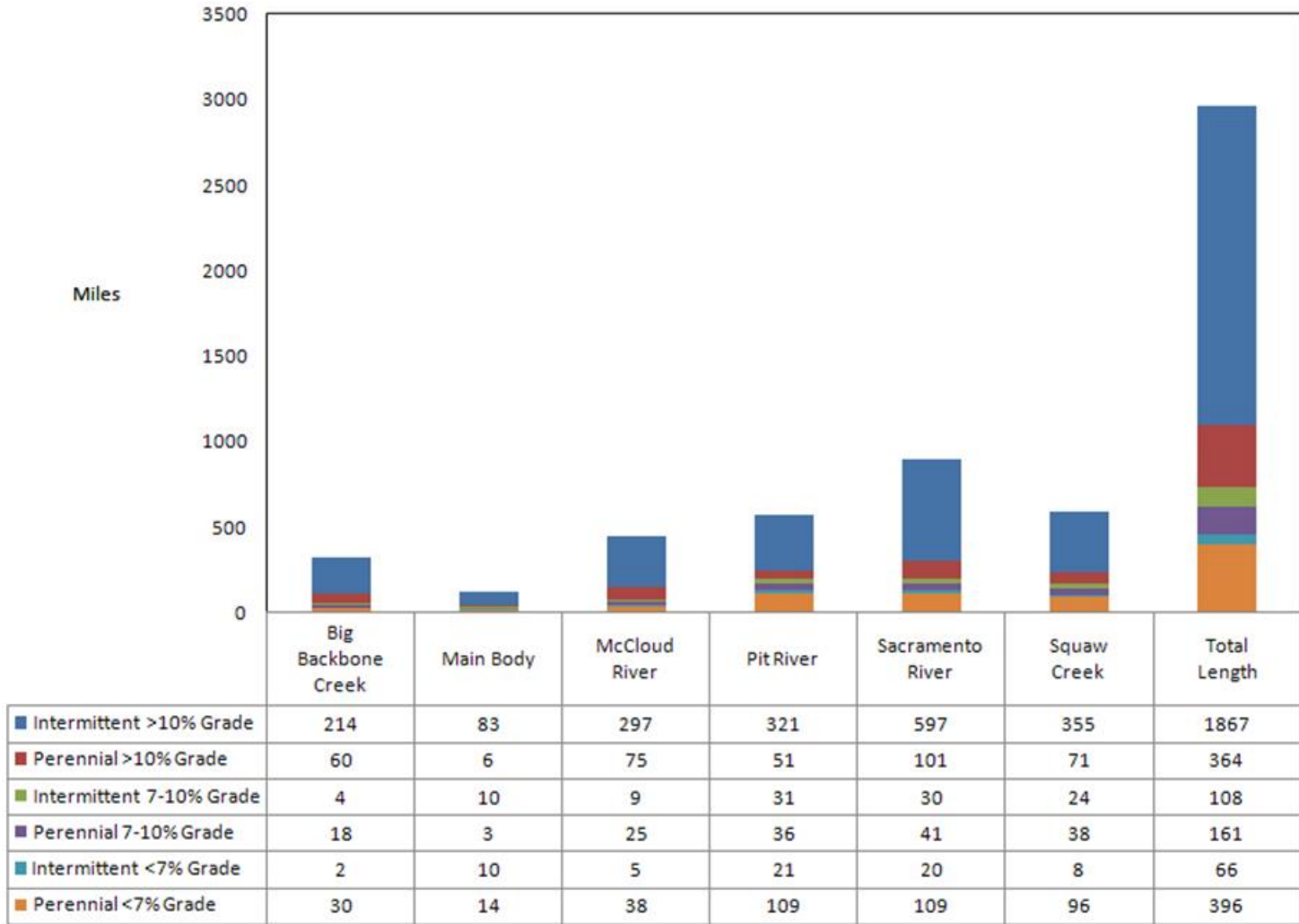


Figure 4-6. Regional-Scale Characteristics of Streams Tributary to Shasta Lake

1 **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

2
3 Using existing data and information (NSR 2003), the following observations
4 were made about the relative stability of the riverine reaches. Of the five main
5 tributaries influencing Shasta Lake, all except Big Backbone Creek and the
6 Sacramento River are underlain by shallow bedrock that limits channel incision.
7 For this reason, Squaw Creek and the Pit and McCloud rivers are relatively
8 stable streams that are unlikely to change significantly in response to average
9 floods. Although they occur infrequently, debris flows have the potential to
10 substantially affect particularly shallow bedrock reaches of these tributaries, as
11 is evident in Dekkas Creek. The Sacramento River and Big Backbone Creek are
12 relatively dynamic because the channel bed has the potential to undergo
13 physical changes in response to a moderate flood. Although Big Backbone
14 Creek and Squaw Creek have similar watershed areas, Squaw Creek has more
15 bedrock reaches than Big Backbone Creek and therefore is inherently more
16 stable.

17 ***Upper Sacramento River (Shasta Dam to Red Bluff)***

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

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

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

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

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

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

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

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

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

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

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

13 The lower Clear Creek watershed has been impacted by direct and indirect
14 human activities for over a century. Widespread alterations to the watershed
15 began in the 1800s, when the channel was placer mined and then dredged for
16 gold, which caused extensive modifications to natural channel form and process
17 by removing point bars, floodplains and riparian vegetation (WSRCD 1996). In
18 some areas, the stream is incised completely down to clay hardpan or bedrock.
19 Clear Creek is straight and highly entrenched in some areas; in others, it has
20 multiple, braided channels due to direct and indirect human impacts (GMA
21 2007). Later, timber harvesting and associated road building caused excessive
22 erosion throughout the watershed (WSRCD 1996).

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

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

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

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

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

17 ***Lower Sacramento River and Delta***

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

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

37 ***CVP/SWP Service Areas***

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

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

21 **4.1.4 Mineral Resources**

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

27 ***Shasta Lake and Vicinity***

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

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

39 The Golinsky mine complex is located in the west Shasta district, approximately
40 7 miles west of Shasta Dam in the headwaters of Dry Creek and Little
41 Backbone Creek. This inactive, abandoned mine complex is the only large
42 historic producing mine within the Shasta Unit of the Whiskeytown-Shasta-
43 Trinity NRA. Other mines within the NRA occur in the east Shasta district,

1 concentrated between the McCloud and Squaw arms of Shasta Lake. The east
2 Shasta district includes the Bully Hill, Copper City, and Rising Star mines, all
3 of which are located in the Bully Hill area. These mines ceased operation before
4 Shasta Dam was built.

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

10 **Industrial Minerals** Industrial minerals occurring in the vicinity of Shasta
11 Lake include alluvial sand and gravel, crushed stone, volcanic cinders,
12 limestone, and diatomite. In 2002, Shasta County produced 462,000 tons of
13 sand and gravel, 852,000 tons of crushed stone (including limestone), and
14 51,000 tons of volcanic cinders. Limestone (used to produce Portland cement)
15 and diatomite are not included in these figures.

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

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

33 **Geothermal Resources** Significant geothermal resources occur in the
34 Medicine Lake Highlands, approximately 65 air miles northeast of Shasta Lake.
35 The potential capacity of the Medicine Lake Highlands has been estimated at
36 480 megawatts (PacifiCorp 2010). Development of the Medicine Lake
37 Highlands' geothermal resources has been the subject of extensive litigation of
38 environmental issues and Native American concerns.

39 ***Upper Sacramento River (Shasta Dam to Red Bluff)***

40 Economically viable minerals found within the upper Sacramento River portion
41 of the primary study area consist of alluvial sand and gravel, crushed stone,

1 volcanic cinders, limestone, and diatomite. Additional mineral resources are
2 found in the surrounding regions in Shasta and Tehama counties. These mineral
3 resources include asbestos, barium, calcium, chromium, copper, gold, iron, lead,
4 manganese, molybdenum, silver, and zinc (USGS 2005).

5 ***Lower Sacramento River and Delta***

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

11 ***CVP/SWP Service Areas***

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

20 **4.1.5 Soils**

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

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

35 The susceptibility of soil to erosion is characterized in terms of the soil's
36 erosion hazard rating. The ratings indicate the hazards of topsoil loss in an
37 unvegetated condition, as might occur following disturbance by construction.
38 Ratings are based on the soil erosion factor (K), slope, and content of rock
39 fragments. (The soil erosion factor (K) is a measure of the susceptibility of soil
40 particles to detachment and transport by rainfall and runoff, based primarily on
41 soil texture but also considering structure, organic matter, and permeability.).
42 Three ratings are recognized: slight, moderate, and severe. A rating of "slight"

1 indicates that no postdisturbance acceleration of naturally occurring erosion is
2 likely; “moderate” indicates that some acceleration of erosion is likely, and that
3 simple erosion-control measures are needed; and “severe” indicates that
4 significant erosion is expected, and that extensive erosion-control measures are
5 needed.

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

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

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

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

36 ***Shasta Lake and Vicinity***

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

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

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

19

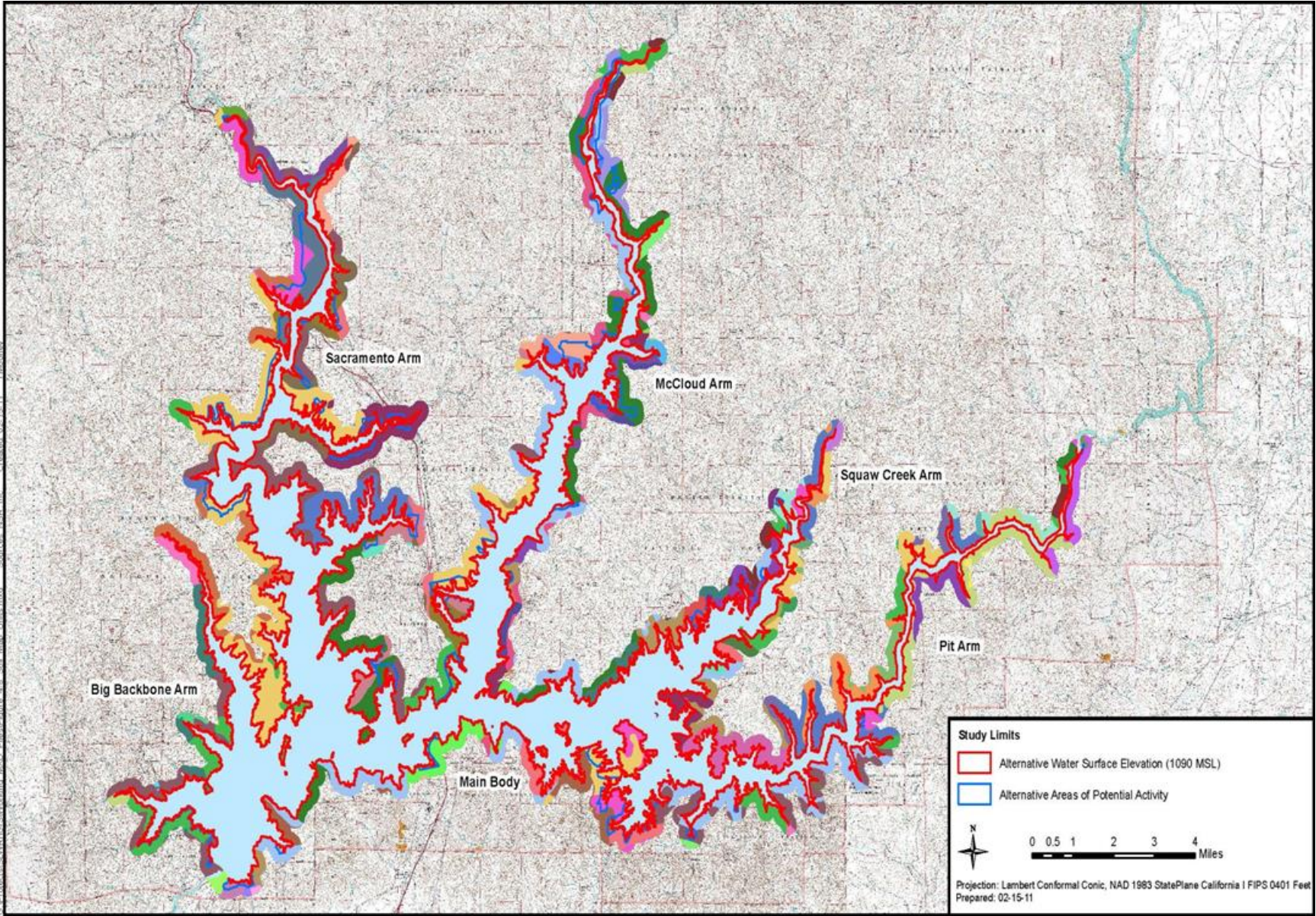


Figure 4-7. Soil Map Units – Shasta Lake and Vicinity

1

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-Leadmunt 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.

2
 3
 4

1 **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

2
 3 **Table 4-9. Areal Extent of Soil Map Units – Shasta Lake and Vicinity (Impoundment Area)**
 4

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%

1
2

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%

3

1 **Table 4-10. Areal Extent of Soil Map Units – Shasta Lake and Vicinity (Relocation**
2 **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 outcrop 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%

3

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

1 decomposition of soil organic matter is low because of the absence of soils
2 derived from peaty or mucky parent materials. Similarly, the likelihood of
3 subsidence caused by aquifer-system compaction is low because of the absence
4 of significant, widespread groundwater withdrawal in the Shasta Lake and
5 vicinity area. Land subsidence has the potential to occur in areas underlain by
6 highly weatherable, carbonate-rich rocks (e.g., certain limestones), and in areas
7 affected by underground construction.

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

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

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

25 ***Upper Sacramento River (Shasta Dam to Red Bluff)***

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

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

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

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

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

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

30 ***Lower Sacramento River and Delta***

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

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

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

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

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

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

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

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

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

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

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

20 ***CVP/SWP Service Areas***

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

29 **4.2 Regulatory Framework**

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

32 **4.2.1 Federal**

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

35 ***Clean Water Act***

36 The Clean Water Act (CWA) includes provisions for reducing soil erosion for
37 the protection of water quality. The CWA makes it unlawful for any person to
38 discharge pollutants from a point source (including construction sites) into
39 navigable waters, unless a permit has been obtained under its provisions. This

1 pertains to construction sites where soil erosion and storm runoff and other
2 pollutant discharges could affect downstream water quality.

3 ***National Pollutant Discharge Elimination System***

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

14 ***Clean Air Act***

15 The Clean Air Act also has provisions for reducing soil erosion relevant to air
16 and water quality. On construction sites, exposed soil surfaces are vulnerable to
17 wind erosion, and small soil particulates are carried into the atmosphere.
18 Suspended particulate matter (consisting of PM₁₀ and PM_{2.5}, as defined in
19 Chapter 5, “Air Quality and Climate”) is one of the six criteria air pollutants of
20 the Clean Air Act.

21 ***Earthquake Hazards Reduction Act***

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

34 ***Antiquities Act of 1906***

35 Federal protection for significant paleontological resources would apply to the
36 project if any construction or other related project impacts occurred on
37 Federally owned or managed lands. Federal legislative protection for
38 paleontological resources stems from the Antiquities Act of 1906 (Public Law
39 59-209; 16 U.S. Code 431 et seq.; 34 Stat. 225), which calls for protection of
40 historic landmarks, historic and prehistoric structures, and other objects of
41 historic or scientific interest on federal land.

1 ***Federal Cave Resource Protection Act of 1988***

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

8 ***Shasta-Trinity National Forest Land and Resource Management Plan***

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

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

27 ***U.S. Bureau of Land Management Resource Management Plan***

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

1 **Federal Minerals Management**

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

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

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

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

25 **4.2.2 State**

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

29 **Porter-Cologne Act**

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

36 **California Fish and Game Code Section 1600**

37 California Fish and Game Code Section 1600 requires notification for projects
38 that are planned to occur in, or in close proximity to, a river, stream, or lake, or
39 their tributaries. Applicants are to enter into a “streambed alteration agreement”
40 with the California Department of Fish and Wildlife when a construction
41 activity would (1) divert, obstruct, or change the natural flow or the bed,

1 channel, or bank of any river, stream, or lake; (2) use material from a
2 streambed; or (3) result in the disposal of debris, waste, or other material
3 containing crumbled, flaked, or ground pavement that could pass into a river,
4 stream, or lake. The Federal government is not required to submit a Fish and
5 Game Code 1600 permit; however, the same impacts will be addressed under
6 CWA Section 401 and 404 permits.

7 ***Alquist-Priolo Earthquake Fault Zoning Act***

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

18 ***1990 Seismic Hazards Mapping Act***

19 The 1990 Seismic Hazards Mapping Act (California Public Resources Code
20 Sections 2690 through 2699.6) addresses strong ground shaking, liquefaction,
21 landslides, or other ground failures as a result of earthquakes. This act requires
22 statewide identification and mapping of seismic hazard zones, which would be
23 used by cities and counties to adequately prepare the safety element of their
24 general plans and protect public health and safety (California Geological Survey
25 2003). Local agencies are also required to regulate development in any seismic
26 hazard zones, primarily through permitting. Permits for development projects
27 are not issued until geologic investigations have been completed and mitigation
28 measures have been developed to address identified issues.

29 ***Surface Mining and Reclamation Act of 1975***

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

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

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

20 ***Asbestos Airborne Toxic Control Measure for Surfacing Applications***

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

35 ***California Public Resources Code Chapter 1.7***

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

1 **California Building Standards Code**

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

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

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

21 **4.2.3 Regional and Local**

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

24 **County General Plans**

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

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

- 29 • Surface faulting
- 30 • Ground shaking
- 31 • Ground failure

32 Nonseismic hazards addressed include the following:

- 33 • Volcanoes
- 34 • Erosion
- 35 • Expansive soils

1 **Local Guiding Ordinances**

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

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

17 **4.3 Environmental Consequences and Mitigation Measures**

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

23 **4.3.1 Methods and Assumptions**

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

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

1 **Geomorphology**

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

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

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

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

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

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

25 **Soil Erosion (Shoreline)**

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

43 The model divided the shoreline into two zones, which helped account for the
44 episodic nature of erosional events. The nearshore zone is classified as the area

1 above the 1,070-foot contour, and represents the “bathtub” ring around the
2 reservoir. The drawdown zone is classified as the area between the 1,070-foot
3 contour and the 1,020-foot contour. The latter contour was used to represent the
4 drawdown level that typically occurs to meet USACE requirements for flood
5 storage capacity. The nearshore zone is eroded by wave action when the
6 reservoir is full. During drawdown periods, this zone erodes as a result of
7 upland surface runoff, subsurface flow, and fluvial incision along stream
8 channels and gullies.

9 To represent the temporal component of shoreline erosion, the model
10 compartmentalizes shoreline development into three time steps. The first step
11 lasts for about 15 years and is when most of the erosion occurs (Morris and Fan
12 1997). During this time, the inundated soils are fully saturated; as a result, they
13 lose cohesion and are subject to rapid erosion, transport, and deposition.
14 Shoreline exposed in the drawdown zone is typically eroded to bedrock or to
15 resilient soil layers, leaving an exposed surface that supports little vegetation.
16 Within this zone, stream channels and gullies rapidly incise the underlying soil
17 and rock.

18 The second time step can last between about 0 and 150 years. During this time,
19 stable shoreline topography is developing through a sequence of slope-forming
20 events. For modeling purposes, the types of slope-forming events were
21 classified by lithotopo unit because several common processes trigger and
22 control erosion. The shoreline erosion survey data suggest that stable hillslopes
23 are typically associated with shallow soils on coherent bedrock, forming steep
24 topography (greater than 65 percent slope gradient). Unstable hillslopes are
25 associated with deep soils on moderately steep areas (between 30 percent and
26 65 percent). Around Shasta Lake, stable shoreline formed rapidly during the
27 first 15 years of lake management. Conversely, about 60 years later, unstable
28 hillslopes are still responding to erosional forces and, in some locations,
29 continue to erode at a very high rate (greater than 900 cubic yards/acre/year).

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

36 **4.3.2 Criteria for Determining Significance of Effects**

37 An environmental document prepared to comply with NEPA must consider the
38 context and intensity of the environmental consequences that would be caused
39 by, or result from, the proposed action. Under NEPA, the significance of an
40 environmental consequence is used solely to determine whether an EIS must be
41 prepared. An environmental document prepared to comply with CEQA must
42 identify the potentially significant environmental effects of a proposed project.
43 A “[s]ignificant effect on the environment” means a substantial, or potentially

1 substantial, adverse change in any of the physical conditions within the area
2 affected by the project (State CEQA Guidelines, Section 15382). CEQA also
3 requires that the environmental document propose feasible measures to avoid or
4 substantially reduce significant environmental effects (State CEQA Guidelines,
5 Section 15126.4(a).

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

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

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

1 **4.3.3 Topics Eliminated from Further Discussion**

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

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

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

21 **4.3.4 Direct and Indirect Effects**

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

24 ***No-Action Alternative***

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

36 Under CP1, the pool level increase would inundate 78 acres of mapped slope
37 instability hazards (i.e., active and relict landslides, debris flows, inner gorge
38 landscape positions, and complexes of these features). Relocation of
39 infrastructure is proposed to occur in the vicinity of up to about 232 acres of
40 mapped slope instability hazards. Inundation of bedrock and soils resulting from
41 the increased pool elevation, and earthwork and vegetation removal associated
42 with new construction, could reduce the stability of hillslopes prone to mass

1 wasting. The existing relict and active mass wasting features may become less
2 stable. The risks associated with increased slope instability due to the rise in
3 pool elevation and relocation of infrastructure have been considered in
4 formulating the description of CP1. Areas of known instability have been
5 addressed via avoidance or through design measures intended to minimize the
6 risk of increased instability. This impact would be less than significant.

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

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

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

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

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

11 The increase in full pool would affect streams by altering fluvial
12 geomorphology and the hydrology of aquatic habitats as described above. This
13 impact would be significant. Mitigation for this impact is proposed in Section
14 4.3.5.

15

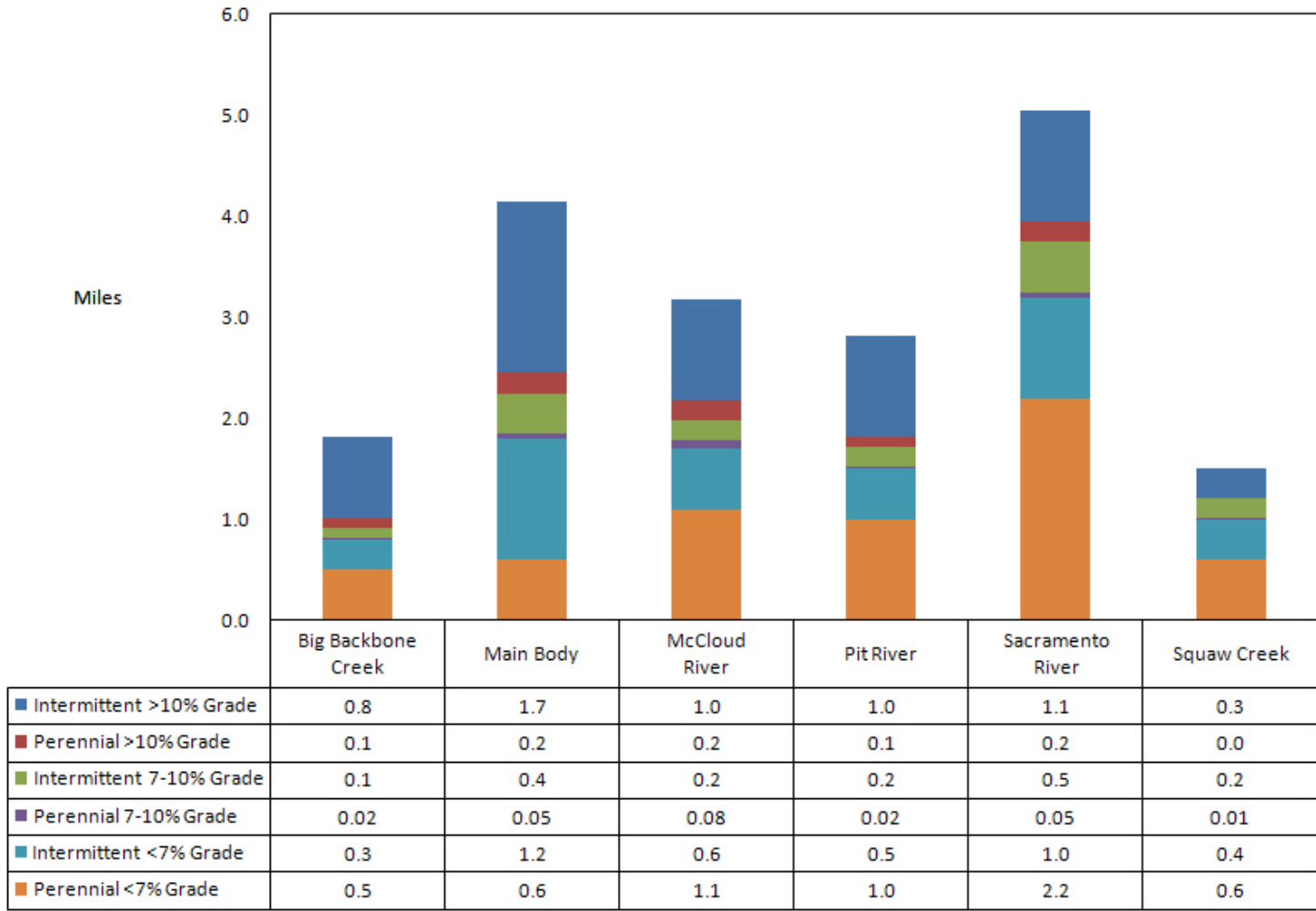


Figure 4-8. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP1

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

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

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

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

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

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

1 26,000 cubic yards per year. The Pit Arm is predicted to produce about 50,000
2 cubic yards per year and the Squaw Creek Arm about 35,000 cubic yards per
3 year.

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

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

20 Soil erosion due to shoreline processes is estimated to be 421,000 cubic yards
21 per year, assuming the available vegetation removal prescriptions between
22 1,070-foot and 1,080-foot contours would occur in the first 15 years after the
23 raising of Shasta Dam. This impact would be significant. Mitigation for this
24 impact is not proposed in Section 4.3.5 because no feasible mitigation is
25 available to reduce the impact to a less-than-significant level.

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

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

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

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

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

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

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

1 factors such as flow, sediment supply, and floodplain erodibility, thus affecting
2 the dynamics of riverine and floodplain characteristics.

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

12 The first significant natural source of sediment to the Sacramento River is
13 nearly 30 miles (48 kilometers) downstream from Keswick Dam at Cottonwood
14 Creek (River Mile 273.5). Tributaries between Keswick Dam and Cottonwood
15 Creek contribute little sediment to the mainstem because they drain small basins
16 of erosion-resistant material or, as is the case for Clear Creek, are themselves
17 regulated by dams and are affected by aggregate mining. Much of the upper
18 Sacramento River (i.e., from River Mile 302 to approximately River Mile
19 273.5) is bounded by erosion-resistant bedrock and terrace deposits, such that
20 bank erosion is not fast enough, relative to in-channel transport, to provide a
21 significant source of coarse sediment. In other words, the rate of supply from
22 erosion of banks due to meander migration in the upper river is minimal.

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

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

41 *Impact Geo-10 (CP1): Substantial Soil Erosion or Loss of Topsoil Due to*
42 *Construction* With implementation of CP1, no gravel augmentation activities

1 or construction activities would occur at potential upper Sacramento River
2 restoration sites. Therefore, no additional soil erosion would be anticipated on
3 the banks along the river channel. No impact would occur. Mitigation for this
4 impact is not needed, and thus not proposed.

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

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

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

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

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

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

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

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

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

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

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

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

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

38 Under CP2, the pool level increase would inundate 110 acres of mapped slope
39 instability hazards. Relocation of infrastructure under CP2 would occur in the
40 vicinity of mapped slope instability hazards to a similar but greater extent than

1 under CP1 (up to about 232 acres). For the same reasons as apply to CP1,
2 impacts resulting from slope instability hazards would be less than significant
3 for CP2.

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

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

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

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

30 The increase in full pool would affect streams by altering fluvial
31 geomorphology and the hydrology of aquatic habitats as described above. This
32 impact would be significant. Mitigation for this impact is proposed in Section
33 4.3.5.

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

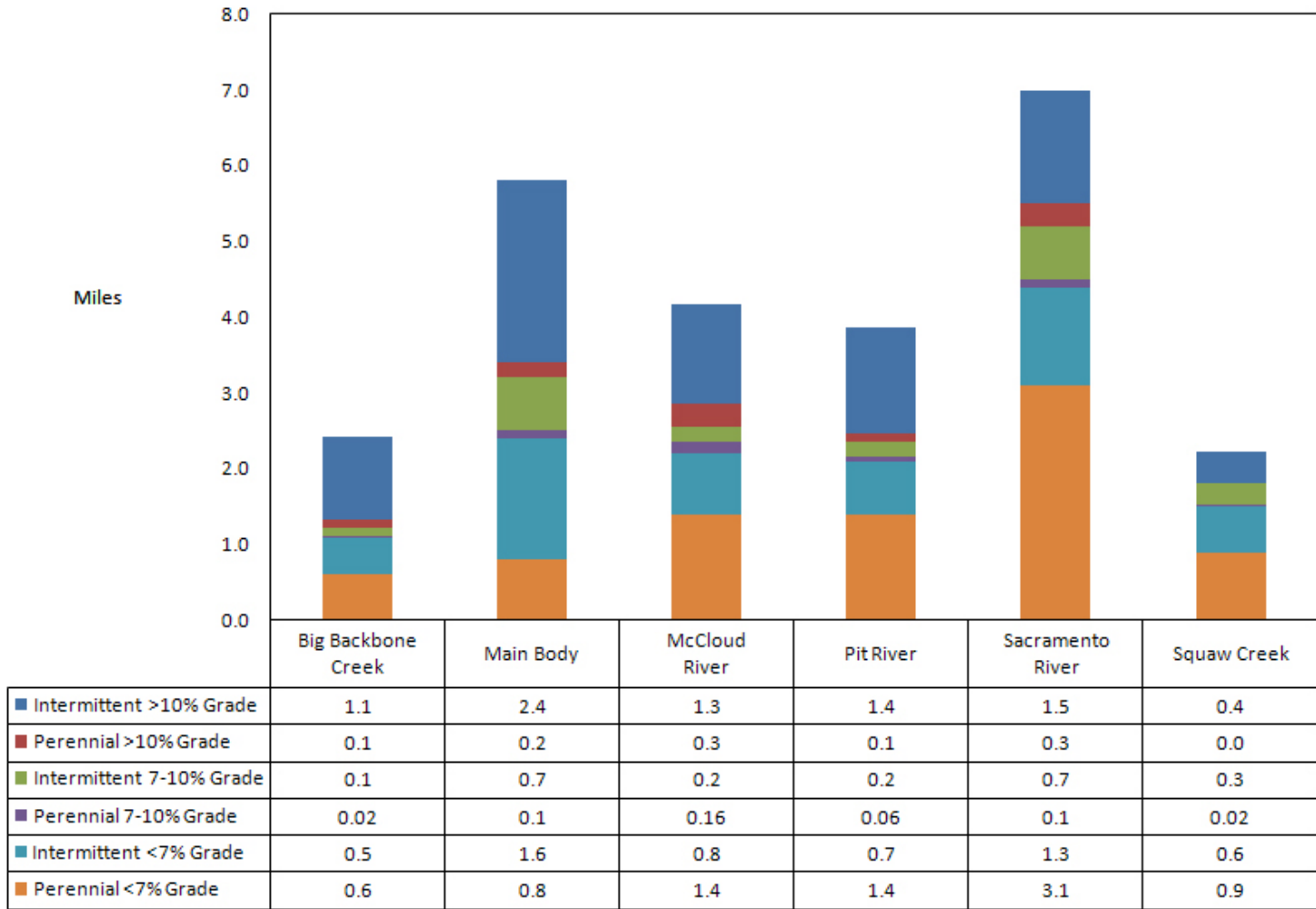


Figure 4-9. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP2

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

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

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

15 For the first 15 years after the dam raise, the average rate of shoreline erosion
16 would increase substantially, from 90 cubic yards per acre per year to about 300
17 cubic yards per acre per year. For the first time step (i.e., 15 years), the total
18 average annual volume of potential shoreline erosion from CP2 would be about
19 549,000 cubic yards per year. Within 60 years of the dam raise, the average
20 annual volume is predicted to decrease to 150,000 cubic yards per year.

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

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

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

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

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

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

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

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

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

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

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

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

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

37 *Impact Geo-12 (CP2): Alteration of Downstream Tributary Fluvial*
38 *Geomorphology Due to Shasta Dam Operations* Under CP2, the fluvial
39 geomorphology of downstream tributaries would not be affected by changes in
40 Sacramento River stage attributed to Shasta Dam operations. By altering storage
41 and operations at Shasta Lake as compared to the No-Action Alternative and
42 existing conditions, CP2 would change the maximum pool elevation and

1 seasonal pool elevations at Shasta Lake and the flow regime in the Sacramento
2 River. Small increases in Sacramento River stage may occur with
3 implementation of CP2. However, the frequency and duration of high-flow
4 events resulting from CP2 implementation are expected to be reduced as
5 compared to existing conditions with current operations.

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

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

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

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

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

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

1 would not be expected to result in an increase in channel erosion or meander
2 migration. This impact would be less than significant.

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

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

9 This section describes impacts associated with CP3, which focuses on the
10 greatest practical enlargement of Shasta Dam and Reservoir consistent with the
11 goals of the 2000 CALFED Bay-Delta Program Record of Decision (CALFED
12 2000b). CP3 was formulated for the primary purposes of increased agricultural
13 water supply reliability and increased anadromous fish survival by raising
14 Shasta Dam 18.5 feet. The dam raise would raise the reservoir’s full pool by
15 20.5 feet, and enlarge total storage space in the reservoir by 5.19 million acre-
16 feet. Section 2.3.8 in Chapter 2, “Alternatives” describes the construction
17 activities and potential borrow sources associated with CP3.

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

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

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

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

35 There are few seismic hazard areas within the Shasta Lake and vicinity area that
36 would expose structures or people to geologic hazards. However, site-specific
37 geologic and foundation investigations will be conducted to develop design
38 criteria to withstand reasonably probable seismic events. In addition, areas of
39 known instability around the perimeter of the lake shore have been addressed
40 via avoidance or through design measures to minimize exposure of structures or

1 people to slope instability. There is a low probability of hazards associated with
2 volcanic eruptions within the Shasta Lake and vicinity area, but any potential
3 for floods caused by eruptions is similar to that from floods having other origins
4 and would be mitigated via the proposed dam modifications and operational
5 procedures. This impact would be less than significant for CP3. Mitigation for
6 this impact is not needed, and thus not proposed.

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

14 Based on a GIS-generated stream network, the total stream length inundated as
15 a result of CP3 would be 36.5 miles (see Figure 4-10), which equates to about
16 1.3 percent of the total length of the streams in watersheds that are directly
17 adjacent and contributory to Shasta Lake. Of the 36.5 miles inundated, about
18 12.1 miles are streams with a gradient less than 7 percent.

19 The increase in full pool would affect streams by altering fluvial
20 geomorphology and the hydrology of aquatic habitats as described above. This
21 impact would be significant. Mitigation for this impact is proposed in Section
22 4.3.5.

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

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

37

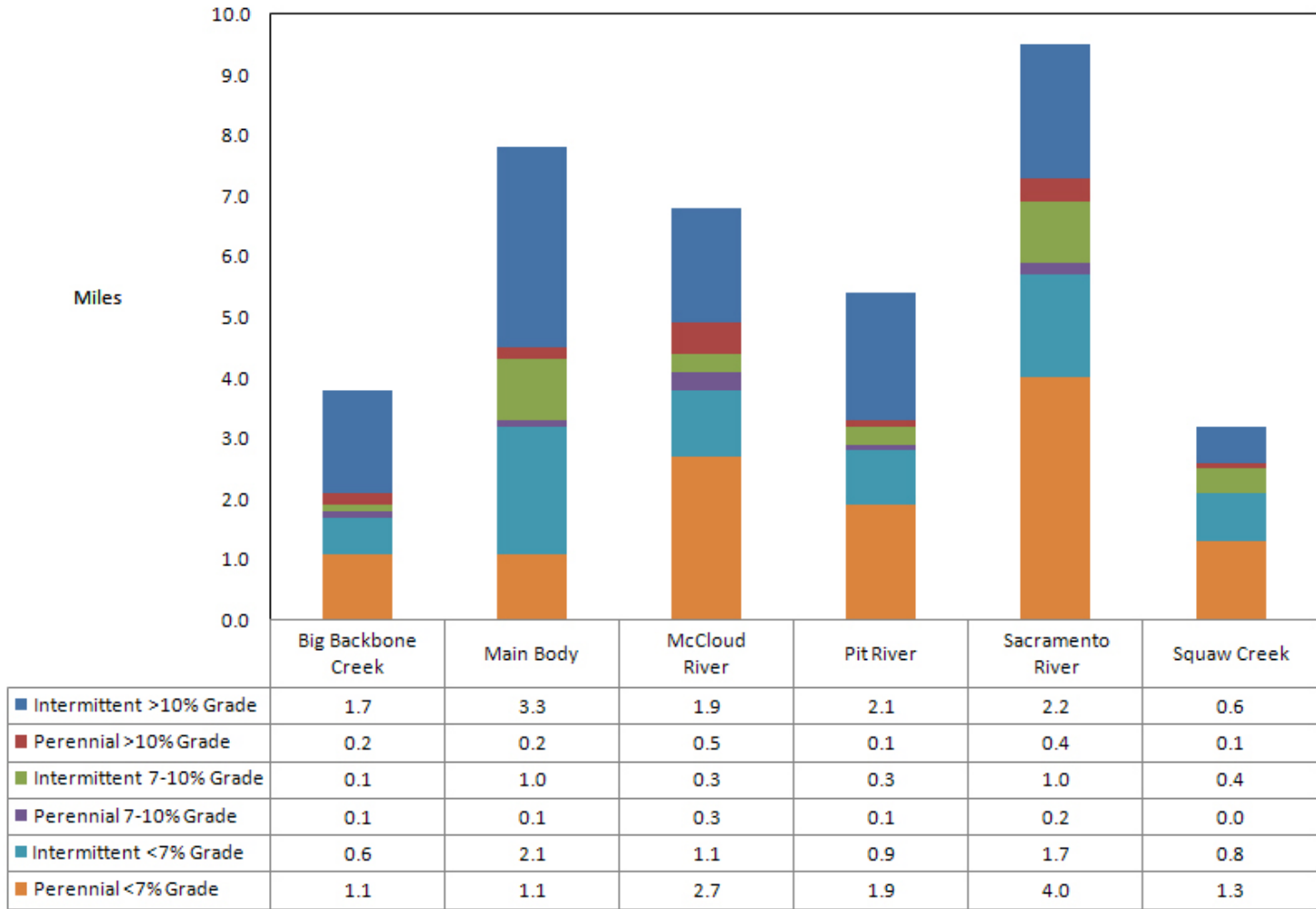


Figure 4-10. Stream Lengths in Watersheds Adjacent to Shasta Lake that Would Be Periodically Inundated Under CP3, CP4, and CP5

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

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

8 For the first 15 years after the dam raise, the average rate of shoreline erosion
9 would increase substantially, from 90 cubic yards per acre per year to about 300
10 cubic yards per acre per year. For the first time step (i.e., 15 years), the total
11 average annual volume of potential shoreline erosion from CP3 would be about
12 767,000 cubic yards per year. Within 60 years of the dam raise, the average
13 annual volume is predicted to decrease to 216,000 cubic yards per year.

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

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

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

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

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

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

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

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

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

39 *Impact Geo-9 (CP3): Potential Increase in Channel Erosion and Meander*
40 *Migration* It is not anticipated that implementation of CP3 would lead to
41 increased channel erosion and meander migration as compared to the No-Action
42 Alternative and existing conditions. However, by altering storage and

1 operations at Shasta Lake as compared to the No-Action Alternative and
2 existing conditions, this alternative would change the maximum pool elevation
3 and seasonal pool elevations at Shasta Lake and the flow regime in the
4 Sacramento River and potentially several other reservoirs and downstream
5 waterways. Alterations to river flows could potentially change downstream
6 stream erosion and change downstream geomorphologic characteristics.
7 However, the frequency and duration of high-flow events resulting from this
8 action are expected to be reduced as compared to existing conditions with
9 current operations. Therefore, downstream erosion would not be anticipated to
10 increase. An erosion and sediment control plan would be implemented, as
11 described in Section 2.3.2, “Environmental Commitments Common to All
12 Action Alternatives,” in Chapter 2, “Alternatives,” to control any short-term and
13 long-term erosion and sedimentation effects of construction activities. This
14 impact would be less than significant.

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

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

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

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

41 Where they occur, geomorphic changes (headcutting, channel incisement, etc.)
42 in major tributaries in Cow, Clear and Cottonwood creeks has been directly

1 attributed to the presence of dams (on Clear Creek) and past and current
2 instream gravel mining on the tributaries themselves. Geomorphic changes at
3 these major tributaries have not been linked with Shasta Dam operations. This
4 impact would be less than significant. Mitigation for this impact is not needed,
5 and thus not proposed.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

8 Based on a GIS-generated stream network, the total stream length inundated as
9 a result of CP4 would be the same as for CP3, about 36.5 miles (see Figure
10 4-10). This value equates to about 1.3 percent of the total length of the streams
11 in watersheds that are directly adjacent and contributory to Shasta Lake. Of the
12 36.5 miles inundated, about 12.1 miles are streams with a gradient less than 7
13 percent.

14 The increase in full pool would affect streams by altering fluvial
15 geomorphology and the hydrology of aquatic habitats as described above. This
16 impact would be significant. Mitigation for this impact is proposed in Section
17 4.3.5.

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

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

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

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

1 Soil erosion due to shoreline processes is estimated to be 767,000 cubic yards
2 per year, assuming the available vegetation removal prescriptions between
3 1,070-foot and 1,090-foot contours would occur in the first 15 years after the
4 raising of Shasta Dam. This impact would be significant. Mitigation for this
5 impact is not proposed in Section 4.3.5 because no feasible mitigation is
6 available to reduce the impact to a less-than-significant level.

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

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

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

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

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

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

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

36 *Impact Geo-11 (CP4): Alteration of Fluvial Geomorphology* Under CP4,
37 riparian, floodplain, and side-channel habitat restoration would be constructed
38 at one or a combination of potential locations along the upper Sacramento
39 River. Descriptions of restoration measures for six potential sites, referred to
40 collectively as upper Sacramento River restoration sites, are detailed in the
41 Downstream Restoration Technical Memorandum. Stream restoration activities
42 could potentially cause changes in fluvial geomorphology that could result in
43 channelized or unstable braided streams, depending on the gradient of the
44 channel and specific restoration activities. However, restoration of habitat

1 through planting of native vegetation would stabilize channel banks. This
2 impact would be less than significant. Mitigation for this impact is not needed,
3 and thus not proposed.

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

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

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

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

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

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

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

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

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

15 **CP5 – 18.5-Foot Dam Raise, Combination Plan**

16 This section describes impacts associated with CP5, which includes raising
17 Shasta Dam 18.5 feet. This alternative also includes (1) implementing
18 environmental restoration features along the lower reaches of major tributaries
19 to Shasta Lake, (2) constructing shoreline fish habitat around Shasta Lake, and
20 (3) constructing additional and/or improved recreation features at various
21 locations around Shasta Lake to increase the value of the recreational
22 experience. The dam raise would increase the reservoir’s full pool elevation by
23 20.5 feet to about 1,090 feet above msl, and enlarge total storage space by
24 634,000 acre-feet. Section 2.3.8 in Chapter 2, “Alternatives” describes the
25 construction activities and potential borrow sources associated with CP5.

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

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

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

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

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

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

22 Based on a GIS-generated stream network, the total stream length inundated as
23 a result of CP5 would be the same as for CP3, about 36.5 miles (see Figure
24 4-10). This value equates to about 1.3 percent of the total length of the streams
25 in watersheds that are directly adjacent and contributory to Shasta Lake. Of the
26 36.5 miles inundated, about 12.1 miles are streams with a gradient less than 7
27 percent.

28 The increase in full pool would affect streams by altering fluvial
29 geomorphology and the hydrology of aquatic habitats as described above. This
30 impact would be significant. Mitigation for this impact is proposed in Section
31 4.3.5.

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

39 *Impact Geo-4 (CP5): Lost or Diminished Soil Biomass Productivity* Like CP3,
40 under CP5 soil productivity would be lost due to periodic inundation caused by
41 increasing the full pool elevation and by construction including relocation of

1 infrastructure. The acreages of these losses would be the same as those reported
2 for CP3.

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

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

12 Soil erosion due to shoreline processes is estimated to be 767,000 cubic yards
13 per year, assuming the available vegetation removal prescriptions between
14 1,070-foot and 1,090-foot contours would occur in the first 15 years after the
15 raising of Shasta Dam. This impact would be significant. Mitigation for this
16 impact is not proposed in Section 4.3.5 because no feasible mitigation is
17 available to reduce the impact to a less-than-significant level.

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

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

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

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

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

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

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

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

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

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

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

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

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

39 *Impact Geo-13 (CP5): Substantial Increase in Channel Erosion and Meander*
40 *Migration* It is not anticipated that implementation of CP5 would lead to
41 increased channel erosion and meander migration as compared to the No-Action
42 Alternative and existing conditions. With implementation of CP1, there would

1 be a potential reduction in high-flow events. Therefore, increases in Sacramento
2 River flow would be limited and effects on reservoirs and rivers in the extended
3 study area would be attenuated and dissipated by the large number of these
4 water bodies, as well as by flood bypasses in the extended study area. This
5 impact would be less than significant.

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

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

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

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

27 **4.3.5 Mitigation Measures**

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

30

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 Unsuitable 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

1 **No-Action Alternative**

2 No mitigation measures are required for this alternative.

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

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

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

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

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

39 In wet years, CP1 would decrease potential channel erosion and meander
40 migration compared to the existing condition, because of the dam's ability to
41 store more water than is currently possible. Greater storage capacity would

1 provide dam operators more flexibility in timing and amount of water that
2 would be released during wet years, decreasing the need for large releases when
3 the dam is at or near capacity. This impact would be less than significant after
4 implementation of channel-sensitive water release schedules.

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

6 No mitigation is required for Impact Geo-1 (CP2), Impacts Geo-6 (CP2)
7 through Geo-8 (CP2), and Impacts Geo-10 (CP2) through Geo-14 (CP2). No
8 feasible mitigation measures are available at the time of preparation of this
9 DEIS to reduce Impacts Geo-3 (CP2) through Geo-5 (CP2) to a less-than-
10 significant level. Therefore, Impacts Geo-3 (CP2), Geo-4 (CP2), and Geo-5
11 (CP2) would be significant and unavoidable.

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

16 **Mitigation Measure Geo-2 (CP2): Replace Lost Ecological Functions of**
17 **Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the**
18 **Vicinity of the Impact**

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

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

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

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

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

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

13 **Mitigation Measure Geo-2 (CP3): Replace Lost Ecological Functions of**
14 **Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the**

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

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

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

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

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

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

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

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

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

31 **CP5 – 18.5-Foot Dam Raise, Combination Plan**

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

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

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

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

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

19 **4.3.6 Cumulative Effects**

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

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

37 The effects of climate change on operations at Shasta Lake could potentially
38 result in changes to downstream geomorphology. As described in the Climate
39 Change Projection Appendix, climate change could result in higher reservoir
40 releases in the future because of an increase in winter and early-spring inflow
41 into the lake from high-intensity storm events. The change in reservoir releases
42 could be necessary to manage for flood events resulting from these potentially

1 larger storms. The potential increase in releases from the reservoir could lead to
2 long-term changes in downstream channel equilibrium.

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

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

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

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

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

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

39 As discussed in Section 4.3.4 above, CP2 could result in several localized
40 project-level impacts related to (1) exposure of structures and people to
41 geologic hazards (less than significant); (2) alteration of fluvial geomorphology
42 and hydrology of aquatic habitats (significant but mitigable); (3) soil erosion

1 from shoreline processes (significant and unavoidable); (4) soil erosion from
2 upland processes (less than significant); (5) location of project features on
3 unstable geologic or soil units (less than significant); and (6) the suitability of
4 soils for wastewater disposal systems (less than significant). As with many
5 types of geologic impacts, these project-level impacts are localized and would
6 not contribute to any cumulative impacts.

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

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

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

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

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

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

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

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

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

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

1 **CP5 – 18.5-Foot Dam Raise, Combination Plan**

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

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

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

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1 Chapter 5

2 Air Quality and Climate

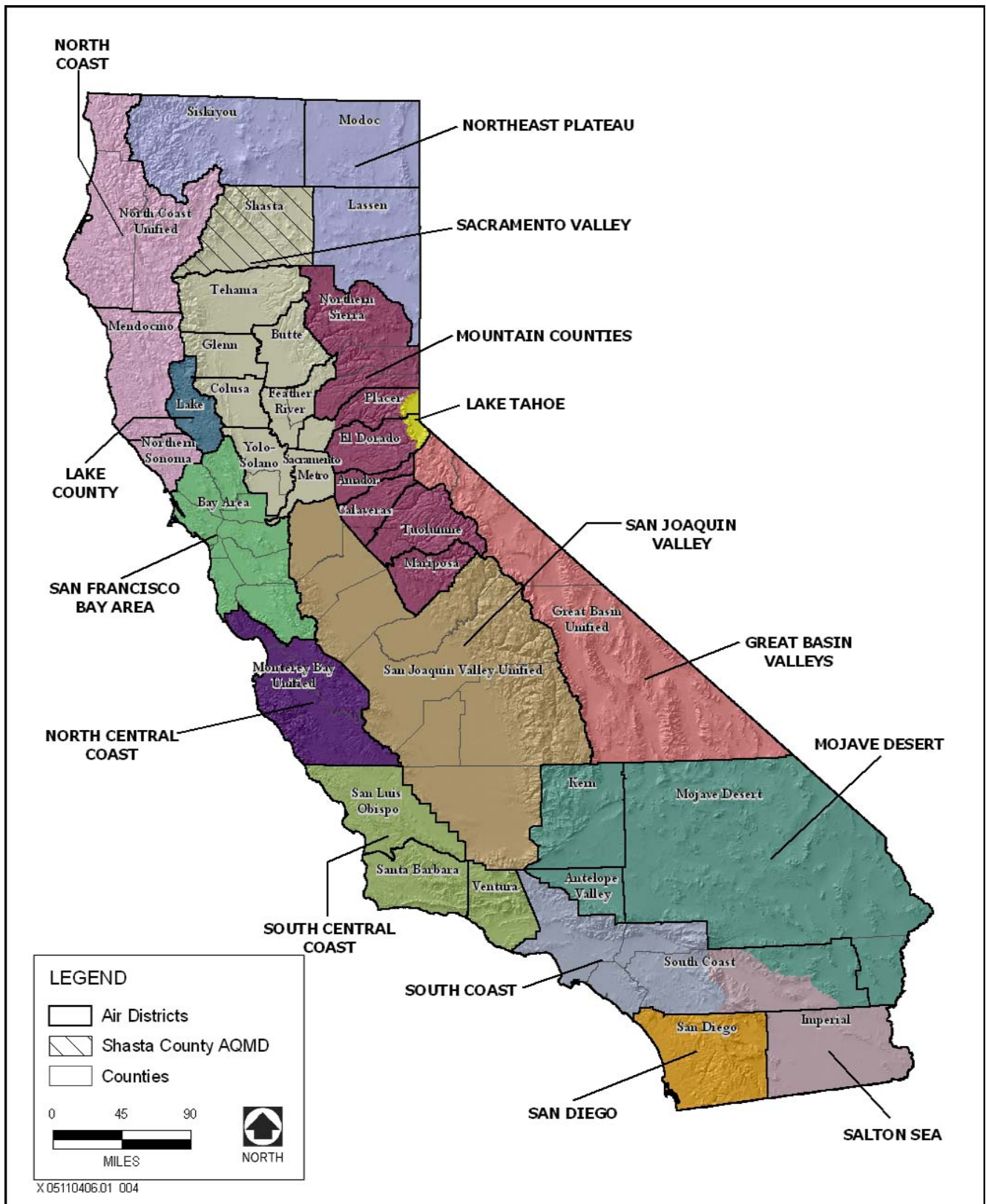
3 5.1 Affected Environment

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

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

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

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



1
 2 Source: ARB 2004

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

1 **5.1.1 Regional Climate in the Primary Study Area**

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

10 **5.1.2 Criteria Air Pollutants**

11 Concentrations of the following air pollutants are used as indicators of ambient
12 air quality conditions: ozone, carbon monoxide (CO), nitrogen dioxide (NO₂),
13 sulfur dioxide (SO₂), respirable and fine particulate matter (PM₁₀ and PM_{2.5}),
14 and lead. Because these are the most prevalent air pollutants known to be
15 deleterious to human health, they are commonly referred to as “criteria air
16 pollutants.”

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

19 **Ozone**

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

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

36 **Carbon Monoxide**

37 CO is a colorless, odorless, and poisonous gas produced by incomplete burning
38 of carbon in fuels, primarily from mobile (transportation) sources.
39 Approximately 77 percent of the nation’s CO emissions are from mobile
40 sources. The other 23 percent consist of CO emissions from wood-burning
41 stoves, incinerators, and industrial sources. The highest concentrations are
42 generally associated with cold, stagnant weather conditions that occur during

1 winter. In contrast to ozone, which is a regional pollutant, CO causes problems
2 on a local scale.

3 ***Nitrogen Dioxide***

4 NO₂ is a brownish, highly reactive gas that is present in all urban environments.
5 The major human-made sources of NO₂ are combustion devices, such as
6 boilers, gas turbines, and mobile and stationary combustion engines. NO₂ forms
7 quickly from emissions from cars, trucks and buses, power plants, and off-road
8 equipment. In addition to contributing to the formation of ground-level ozone
9 and fine particle pollution, NO₂ is linked with a number of adverse effects on
10 the respiratory system (EPA 2010a). The combined emissions of NO and NO₂
11 are referred to as NO_x, which are reported as equivalent NO₂. Because NO₂ is
12 formed and depleted by reactions associated with ozone, the NO₂ concentration
13 in a particular geographical area may not be representative of the local NO_x
14 emission sources.

15 ***Sulfur Dioxide***

16 SO₂ is produced by such stationary sources as coal and oil combustion, steel
17 mills, refineries, and pulp and paper mills. SO₂ is a respiratory irritant. On
18 contact with the moist mucous membranes, SO₂ produces sulfurous acid.

19 ***Particulate Matter***

20 Respirable particulate matter with an aerodynamic diameter of 10 micrometers
21 or less is referred to as PM₁₀. PM₁₀ consists of particulate matter emitted
22 directly into the air, such as fugitive dust, soot, and smoke from mobile and
23 stationary sources, construction operations, fires, and natural windblown dust,
24 and particulate matter formed in the atmosphere by condensation and/or
25 transformation of SO₂ and ROG. PM_{2.5} includes a subgroup of finer particles
26 that have an aerodynamic diameter of 2.5 micrometers or less (EPA 2011a).

27 ***Lead***

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

34 **5.1.3 Monitoring Station Data and Criteria Pollutant Attainment Area Designations**

35 ***Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to*** 36 ***Red Bluff)***

37 Concentrations of criteria air pollutants are measured at several monitoring
38 stations in Shasta County. The Redding Health Department and Shasta Lake
39 stations are the closest stations to the project construction area with recent data
40 for ozone and particulate matter. In general, the ambient air quality
41 measurements from these stations are representative of the study area's air

1 quality. Table 5-1 summarizes the air quality data from the most recent 3 years.
 2 The data are compared with the ambient air quality standards as noted below.
 3 Refer to Table 5-2 for a full listing of all ambient all quality standards.

4 **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 (µg/m ³)	20.2	10.7	18.8
Number of days national standard exceeded (measured ^a)	0	0	0
Respirable Particulate Matter (PM₁₀)			
Redding Health Department Monitoring Station			
Maximum concentration (µg/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 (µg/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

PM₁₀ = 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		National Standards ^a		
		Standards ^{b,c}	Attainment Status (Shasta County) ^d	Primary ^{c,e}	Secondary ^{c,f}	Attainment Status (Shasta County) ^g
Ozone	1-hour	0.09 ppm (180 µg/m ³)	N (Moderate)	<i>Note h</i>	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 [†]		
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	–	Same as primary standard	A
	Calendar Quarter	–		1.5 µg/m ³		
	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), SO₂ (1- and 24-hour), NO₂, 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 (µg/m³)). 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 SO₂ 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 SO₂ standard of 0.14 ppm and the annual primary SO₂ standard of 0.030 ppm, effective August 23, 2010.
 The secondary SO₂ 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:

µg/m³ = micrograms per cubic meter

mg/m³ = milligrams per cubic meter

ppm = parts per million

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

12 **Lower Sacramento River and Delta**

13 The lower Sacramento River and Delta areas are within the SVAB and the San
14 Joaquin Valley Air Basin. As described in greater detail in the *Air Quality and*
15 *Climate Technical Report*, these basins are Federal and State nonattainment
16 areas for ozone, PM₁₀, and PM_{2.5}.

17 **CVP/SWP Service Areas**

18 The CVP and SWP service areas extend beyond the Central Valley into the San
19 Francisco Bay Area, North Central Coast, South Central Coast, and Mountain
20 Counties air basins. Federal and State ozone attainment designations for all
21 California counties and air basins are provided in the *Air Quality and Climate*
22 *Technical Report*. All counties in California south of Shasta County, with the
23 exception of Lake, Sonoma, Tuolumne, and Mariposa counties, are State
24 nonattainment areas for PM₁₀ (ARB 2010a).

25 **5.1.4 Toxic Air Contaminants in the Primary Study Area**

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

39 **5.1.5 Global Study Area**

40 Atmospheric GHGs play a critical role in determining the earth’s surface
41 temperature. Solar radiation enters the earth’s atmosphere from space.
42 Prominent GHGs contributing to the greenhouse effect are carbon dioxide (CO₂),
43 methane, nitrous oxide, hydrofluorocarbons, chlorofluorocarbons, and sulfur

1 hexafluoride. Sources of GHG emissions associated with existing operations
2 include vehicles used for operation and maintenance of the dam and recreation
3 areas, vehicles used by recreational visitors, and fossil fuel-powered boats on
4 Shasta Lake. Human-caused emissions of these GHGs that exceed natural
5 ambient concentrations are responsible for intensifying the greenhouse effect and
6 have led to a trend of unnatural warming of the earth's climate, known as global
7 climate change or global warming (Ahrens 2003).

8 To provide a method of quantifying GHG emissions, the standard unit of CO₂e,
9 or CO₂ equivalent, was developed. The definition of CO₂e is "The quantity of a
10 given GHG multiplied by its total global warming potential (GWP). This is the
11 standard unit for comparing the degree of warming that can be caused by GHGs"
12 (CCAR 2009). The GWP of a GHG is dependent on the lifetime, or persistence,
13 of the gas molecule in the atmosphere compared to CO₂. The GWP of methane is
14 23; the GWP of nitrous oxide is 296. Therefore, methane and nitrous oxide are
15 more potent GHGs than CO₂. Expressing emissions in CO₂e takes the
16 contributions of all GHG emissions to the greenhouse effect and converts them to
17 a single unit equivalent to the effect that would occur if only CO₂ were being
18 emitted. The most common quantity unit for CO₂e is million metric tons (MMT).
19 In some reports, CO₂e is written as CO₂e, and million metric tons is written as
20 MMT CO₂e.

21 Climate change is a global phenomenon. GHGs are global pollutants, unlike
22 criteria air pollutants and TACs, which are pollutants of regional and local
23 concern. Whereas pollutants with localized air quality effects have relatively short
24 atmospheric lifetimes (about 1 day), GHGs have long atmospheric lifetimes (1
25 year to several thousand years). GHGs persist in the atmosphere for long enough
26 time periods to be dispersed around the globe. Although the exact lifetime of any
27 particular GHG molecule is dependent on multiple variables and cannot be
28 pinpointed, it is understood that more CO₂ is emitted into the atmosphere than is
29 sequestered by ocean uptake, vegetation, and other forms of sequestration. Of the
30 total annual human-caused CO₂ emissions, approximately 54 percent is
31 sequestered through ocean uptake, uptake by Northern Hemisphere forest
32 regrowth, and other terrestrial sinks within a year, whereas the remaining 46
33 percent of human-caused CO₂ emissions remains stored in the atmosphere
34 (Seinfeld and Pandis 1998).

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

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

1 **5.2 Regulatory Framework**

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

8 **5.2.1 Federal**

9 ***Criteria Air Pollutants***

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

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

29 ***Hazardous Air Pollutants***

30 Air quality regulations also focus on TACs, or in Federal parlance, HAPs. In
31 general, for those TACs that may cause cancer, there is no concentration that
32 does not present some risk. In other words, there is no threshold level below
33 which adverse health effects may not be expected to occur. This contrasts with
34 the criteria air pollutants, for which acceptable levels of exposure can be
35 determined and for which the ambient standards have been established (Table
36 5-2). Instead, EPA and ARB regulate HAPs and TACs, respectively, through
37 statutes and regulations that generally require the use of the maximum available
38 control technology or best available control technology for toxics to limit
39 emissions. These statutes and regulations establish the regulatory framework for
40 TACs.

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

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

25 **General Conformity**

26 The 1990 amendments to CAA Section 176 require EPA to promulgate rules to
27 ensure that Federal actions conform to the appropriate SIP. These rules are
28 known as the General Conformity Rule (40 Code of Federal Regulations Parts
29 51.850–51.860 and 93.150–93.160). Any Federal agency responsible for an
30 action in a nonattainment/maintenance area must determine whether that action
31 conforms to the applicable SIP or is exempt from General Conformity Rule
32 requirements.

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

37 **Greenhouse Gases**

38 **Mandatory Greenhouse Gas Reporting Rule** On September 22, 2009, EPA
39 released its final Greenhouse Gas Reporting Rule (Reporting Rule). The
40 Reporting Rule is a response to the fiscal year 2008 Consolidated
41 Appropriations Act (House Bill 2764; Public Law 110-161), which required
42 EPA to develop “... mandatory reporting of greenhouse gases above appropriate
43 thresholds in all sectors of the economy....” The Reporting Rule applies to most

1 entities that emit 25,000 metric tons (MT) CO₂e or more per year. Since 2010,
2 facility owners have been required to submit an annual GHG emissions report
3 with detailed calculations of facility GHG emissions. The Reporting Rule also
4 mandates recordkeeping and administrative requirements for EPA to verify
5 annual GHG emissions reports.

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

- 9
- 10 • **Endangerment Finding** – The current and projected concentrations of
11 the six key well-mixed GHGs – CO₂, methane, nitrous oxide,
12 hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride – in the
13 atmosphere threaten the public health and welfare of current and future
generations.
 - 14 • **Cause or Contribute Finding** – The combined emissions of these
15 well-mixed GHGs from new motor vehicles and new motor vehicle
16 engines contribute to GHG pollution, which threatens public health and
17 welfare.

18 **Council on Environmental Quality Draft NEPA Guidelines** Because of
19 uneven treatment of climate change under NEPA, the International Center for
20 Technology Assessment, Natural Resources Defense Council, and Sierra Club
21 filed a petition with the Council on Environmental Quality (CEQ) in March
22 2008. The petition requested that climate change analyses be included in all
23 Federal environmental review documents. In October 2009, President Barack
24 Obama signed Executive Order 13514, “Federal Leadership in Environmental,
25 Energy, and Economic Performance.” The goal of this executive order is “to
26 establish an integrated strategy towards sustainability in the Federal
27 Government and to make reduction of GHGs a priority for Federal agencies”
28 (FedCenter 2011).

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

- 38
- 39 • The effects of a proposed action and alternative actions on GHG
emissions
 - 40 • The impacts of climate change on a proposed action or alternatives

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

9 CEQ states that if a proposed action would cause direct annual emissions of
10 more than 25,000 MT CO₂e, a quantitative and qualitative assessment may be
11 meaningful to decision makers and the public. If annual direct emissions would
12 be less than 25,000 MT CO₂e, Federal agencies are encouraged to consider
13 whether the action’s long-term emissions should receive similar analysis.

14 **Greenhouse Gas Permitting Requirements on Large Industrial Facilities**

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

20 The rule establishes a schedule that will initially focus permitting programs on
21 the largest sources and then expands to cover the largest sources of GHG that
22 may not have been previously covered by the CAA for other pollutants (EPA
23 2010b). During Step 1, from January 2, 2011 to June 30, 2011, only sources
24 currently subject to the PSD permitting program (i.e., those that are newly-
25 constructed or modified in a way that significantly increases emissions of a
26 pollutant other than GHGs) would be subject to permitting requirements for
27 their GHG emissions under PSD; and, for these projects, only GHG increases of
28 75,000 tons (68,039 MT) per year or more of total GHG, on a CO₂e basis,
29 would need to determine the Best Available Control Technology for their GHG
30 emissions. Similarly for the operating permit program, only sources currently
31 subject to the program (i.e., newly constructed or existing major sources for a
32 pollutant other than GHGs) would be subject to Title V requirements for GHG.
33 During this time, no sources would be subject to Clean Air Act permitting
34 requirements due solely to GHG emissions.

35 Step 2 will build on Step 1. During Step 2, from July 1, 2011 to June 30, 2013,
36 PSD permitting requirements will cover for the first time new construction
37 projects that emit GHG emissions of at least 100,000 tons (90,718 MT) per year
38 even if they do not exceed the permitting thresholds for any other pollutant.
39 Modifications at existing facilities that increase GHG emissions by at least
40 75,000 tons (68,039 MT) per year will be subject to permitting requirements,
41 even if they do not significantly increase emissions of any other pollutant. In
42 Step 2, operating permit requirements will, for the first time, apply to sources
43 based on their GHG emissions even if they would not apply based on emissions

1 of any other pollutant. Facilities that emit at least 100,000 tons (90,718 MT) per
2 year of CO₂e will be subject to Title V permitting requirements.

3 As part of this rule, EPA also commits to undertake another rulemaking, to
4 begin in 2011 and conclude no later than July 1, 2012. That action will consist
5 of an additional Step 3 for phasing in GHG permitting. Step three, if
6 established, will not require permitting for sources with GHG emissions below
7 50,000 tons (45,359 MT) per year.

8 **5.2.2 State**

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

11 ***Criteria Air Pollutants***

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

23 ***Toxic Air Contaminants***

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

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

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

- 39 • 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.

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

- 4 1. Will the project increase or reduce GHGs as compared to the baseline?
- 5 2. Will the project’s GHG emissions exceed the lead agency’s threshold
6 of significance?
- 7 3. Does the project comply with regulations or requirements to implement
8 a statewide, regional, or local GHG reduction or mitigation plan?

9 These questions are addressed in Section 5.3.

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

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

- 17 • Project features, project design, or other measures that are incorporated
18 into the project to substantially reduce energy consumption or GHG
19 emissions
- 20 • Compliance with the requirements in a previously approved plan or
21 mitigation program to reduce or sequester GHG emissions, when the
22 plan or program provides specific requirements that will avoid or
23 substantially lessen the potential impacts of the project
- 24 • Measures that sequester carbon or carbon-equivalent emissions

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

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

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

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

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

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

21 The performance standards focus on construction activities, energy and water
22 consumption, generation of solid waste, and transportation. For industrial
23 projects, the draft proposal recommends a tiered analysis procedure similar to
24 the procedure for analyzing nonindustrial projects. However, for industrial
25 projects a quantitative limit for less than significant impacts is established at
26 approximately 7,000 MT CO₂e per year. These standards have not yet been
27 adopted or finalized as a basis for evaluating the significance of a project's
28 contribution to climate change.

29 Overall, as directed by SB 97, the Natural Resources Agency adopted
30 Amendments to the CEQA Guidelines for GHGs emissions on December 30,
31 2009. On February 16, 2010, the Office of Administrative Law approved the
32 Amendments, and filed them with the Secretary of State for inclusion in the
33 California Code of Regulations. The Amendments became effective on March
34 18, 2010.

35 **Executive Order S-3-05** Executive Order S-3-05 made California the first
36 state to formally establish GHG emissions reduction goals. Executive Order S-
37 3-05 includes the following GHG emissions reduction targets for California:

- 38 • By 2010, reduce GHG emissions to 2000 levels.

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

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

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

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

15 This group was subsequently named the Climate Action Team.

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

20 *Assembly Bill 32* In 2006, California passed the California Global Warming
21 Solutions Act of 2006 (AB 32; California Health and Safety Code, Sections
22 38500 et seq.). AB 32 further details and puts into law the midterm GHG
23 reduction target established in Executive Order S-3-05 – reduce GHG emissions
24 to 1990 levels by 2020. AB 32 also identifies ARB as the State agency
25 responsible for the design and implementation of emissions limits, regulations,
26 and other measures to meet the target.

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

- 29 • By June 30, 2007, ARB had to publish a list of early-action GHG
30 emission reduction measures.
- 31 • Before January 1, 2008, ARB had to identify the current level of GHG
32 emissions by requiring statewide reporting and verification of GHG
33 emissions from emitters and identify the 1990 levels of California GHG
34 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 CO₂e. The 2020 target requires the reduction of 169 MMT CO₂e, or approximately 30 percent below California’s projected “business-as-usual” 2020 emissions of 596 MMT CO₂e.

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 CO₂e 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 CO₂e, or approximately 22 percent from the state’s projected 2020 emission level of 545 MMT of CO₂e under a business-as-usual scenario (this is a reduction of 47 MMT CO₂e, or almost 10 percent, from 2008 emissions). ARB’s original 2020 projection was 596 MMT CO₂e, 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 CO₂e),
- the Low-Carbon Fuel Standard (15.0 MMT CO₂e),
- energy efficiency measures in buildings and appliances (11.9 MMT CO₂e), and
- a renewable portfolio and electricity standards for electricity production (23.4 MMT CO₂e).

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

1 population growth and the changing needs of their jurisdictions. (Meanwhile,
2 ARB is also developing an additional protocol for community emissions.) ARB
3 further acknowledges that decisions on how land is used will have large impacts
4 on the GHG emissions that will result from the transportation, housing,
5 industry, forestry, water, agriculture, electricity, and natural gas emission
6 sectors. The Scoping Plan states that the ultimate GHG reduction assignment to
7 local government operations is to be determined (ARB 2008). With regard to
8 land use planning, the Scoping Plan expects approximately 3.0 MMT CO_{2e} will
9 be achieved associated with implementation of SB 375, which is discussed
10 further below (ARB 2011).

11 **Executive Order S-13-08** Executive Order S-13-08, issued November 14,
12 2008, directs the California Natural Resources Agency, DWR, OPR, the
13 California Energy Commission, the State Water Resources Control Board, the
14 California Department of Parks and Recreation, and California’s coastal
15 management agencies to participate in planning and research activities to
16 advance California’s ability to adapt to the effects of climate change. The order
17 specifically directs agencies to work with the National Academy of Sciences to
18 initiate the first California sea-level-rise assessment and to review and update
19 the assessment every 2 years after completion; immediately assess the
20 vulnerability of California’s transportation system to sea level rise; and to
21 develop a climate change adaptation strategy for California.

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

29 **Governor’s Office of Planning and Research Technical Advisory** In June
30 2008, OPR published a technical advisory on CEQA and climate change to
31 provide interim advice to lead agencies regarding the analysis of GHGs in
32 environmental documents (OPR 2008). The advisory encourages lead agencies
33 to identify and quantify the GHGs that could result from a proposed project,
34 analyze impacts of those emissions to determine whether they would be
35 significant, and identify feasible mitigation measures or alternatives that would
36 reduce adverse impacts to a less than significant level. The advisory recognized
37 that OPR would develop, and the Natural Resources Agency would adopt,
38 amendments to the State CEQA Guidelines pursuant to SB 97. (See “California
39 Environmental Quality Act and SB 97,” above.)

40 The advisory provides OPR’s perspective on the emerging role of CEQA in
41 addressing climate change and GHG emissions. It recognizes that approaches
42 and methodologies for calculating GHG emissions and determining their
43 significance are rapidly evolving. OPR concludes in the technical advisory that

1 climate change is ultimately a cumulative impact, and that no individual project
2 could have a significant impact on global climate. Thus, projects must be
3 analyzed with respect to the incremental impact of the project when added to
4 other past, present, and reasonably foreseeable probable future projects. OPR
5 recommends that lead agencies undertake an analysis, consistent with available
6 guidance and current CEQA practice, to determine cumulative significance
7 (OPR 2008).

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

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

23 Agencies should then assess whether the emissions are “cumulatively
24 considerable” even though a project’s GHG emissions may be individually
25 limited. OPR states: “Although climate change is ultimately a cumulative
26 impact, not every individual project that emits GHGs must necessarily be found
27 to contribute to a significant cumulative impact on the environment” (OPR
28 2008). Individual lead agencies may undertake a project-by-project analysis,
29 consistent with available guidance and current CEQA practice (OPR 2008).

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

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

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

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

- 14 • Zero (all emissions are significant)
- 15 • 900 MT CO₂e per year (90 percent market capture for residential and
16 nonresidential discretionary development)
- 17 • 10,000 MT CO₂e per year (potential ARB mandatory reporting level
18 for cap-and-trade program)
- 19 • 25,000 MT CO₂e per year (ARB’s mandatory reporting level for the
20 statewide emissions inventory)
- 21 • Unit-based thresholds, based on identifying thresholds for each type of
22 new development and quantifying significance by a 90 percent capture
23 rate

24 **5.2.3 Regional and Local**

25 ***Shasta Lake and Vicinity and Upper Sacramento River (Shasta Dam to*** 26 ***Red Bluff)***

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

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

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

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

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

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

- 37 • **Rule 3:22: Asbestos** – No person shall use or apply serpentine material
38 for surfacing in California unless the material has been tested using
39 ARB Test Method 435 and determined to have an asbestos content of 5
40 percent or less. A written receipt or other record documenting the
41 asbestos content shall be retained by any person who uses or applies
42 serpentine material for at least 7 years from the date of use or

1 application, and shall be provided to the Air Pollution Control Officer,
2 or his or her designate, for review upon request.

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

6 *Criteria Pollutants* SCAQMD has adopted pollutant emission thresholds and
7 mitigation requirements that are used in the analysis of project impacts. The
8 thresholds and mitigation requirements are discussed below in Section 5.3.2,
9 “Criteria for Determining Significance of Effects.”

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

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

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

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

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

8 ***Lower Sacramento River and Delta and CVP/SWP Service Areas***

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

15 ***Global Study Area—Greenhouse Gases***

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

18 **5.3 Environmental Consequences and Mitigation Measures**

19 **5.3.1 Methods and Assumptions**

20 ***Criteria Air Pollutants***

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

38 SMAQMD's Road Construction Emissions Model, version 7.1.2 was used to
39 obtain exhaust emission rates for ROG, NO_x, PM₁₀, CO, and CO₂ for heavy
40 duty construction equipment that would be used for construction activities. The

1 model uses emission rates for heavy-duty construction equipment based on
2 OFFROAD 2007 and EMFAC 2011 (described separately below). Emission
3 rates for 2016 (the earliest year that construction would begin) were applied to
4 each piece of equipment based on the anticipated operation hours of equipment
5 by construction activity and CP.

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

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

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

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

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

1 **Toxic Air Contaminants and Odors**

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

4 **Global Warming**

5 Emissions of CO₂e from construction activities and from recreational visitors’
6 vehicles were calculated using emission factors for heavy duty construction
7 equipment from the SMAQMD’s Road Construction Emission Model and
8 CalEEMod 2011.1.1. Exhaust emissions from construction equipment were
9 summed by the various construction activities under each Comprehensive Plan.
10 Mobile source GHG emissions associated with recreational visitor trips were
11 estimated using the operational trip rates provided for each Comprehensive Plan
12 in CalEEMod. Data on emissions avoided by generation of electricity from
13 Shasta Dam were obtained from Chapter 5 of the Shasta Lake Water Resources
14 Investigation Plan Formulation Report (Reclamation 2007). GHG emissions
15 from cleared and burned vegetation were estimated using the Carbon Online
16 Estimator (COLE Development Group 2011). Indirect emissions from cement
17 production and CO₂ absorption by water and vegetation are discussed, but not
18 quantified.

19 **5.3.2 Criteria for Determining Significance of Effects**

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

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

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

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

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

18 **Table 5-3. Shasta County Air Quality Management District’s Air Quality**
 19 **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

PM₁₀ = respirable particulate matter

ROG = reactive organic gases

SCAQMD = Shasta County Air Quality Management District

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

- 1 • Apply SMM to all projects; this effort will help contribute to reducing
2 cumulative effects.
- 3 • Apply SMM and appropriate BMM when a project exceeds Level A
4 thresholds.
- 5 • Apply SMM, BMM, and special BMM when a project exceeds
6 Level B thresholds.
- 7 • If application of the above procedures will reduce project emissions
8 below Level B thresholds, the project can proceed with an
9 environmental determination of a mitigated negative declaration,
10 assuming that other project impacts do not require more extensive
11 environmental review.
- 12 • If project emissions cannot be reduced to below Level B thresholds,
13 emission offsets will be required. If, after applying the emissions
14 offsets, the project emissions still exceed the Level B threshold, an
15 environmental impact report will be required before the project can be
16 considered for action by the reviewing authority.

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

- 20 • Emissions of criteria air pollutants or precursors in Shasta County
21 during construction or long-term operations would exceed the
22 SCAQMD Level B thresholds of 137 pounds per day (lb/day) of ROG,
23 NO_x, or PM₁₀ and 500 lb/day of CO after the application of mitigation
24 measures.
- 25 • Emissions of criteria air pollutants or precursors in Tehama County
26 during construction or long-term operations would exceed 137 lb/day
27 of ROG, NO_x, or PM₁₀ after the application of mitigation measures.

28 SCAQMD has not adopted a numeric significance criterion for GHGs generated
29 by nonindustrial projects. (However, two California air districts, the Bay Area
30 Air Quality Management District and the South Coast Air Quality Management
31 District, have adopted thresholds for GHG emissions generated by development
32 projects.) No numeric thresholds adopted by any air district or by ARB would
33 be applicable to the action alternatives. However, by adopting AB 32, the State
34 has established GHG reduction targets. Further, the State has determined that
35 GHG emissions, as they relate to global climate change, are a source of adverse
36 environmental impacts in California and should be addressed under CEQA. AB
37 32 did not amend CEQA, although the legislation identifies the myriad
38 environmental problems in California caused by global warming (Health and
39 Safety Code, Section 38501(a)). SB 97, in contrast, did amend CEQA by

1 requiring OPR to revise the State CEQA Guidelines to address the mitigation of
2 GHG emissions or their consequences (California Public Resources Code,
3 Sections 21083.05 and 21097).

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

- 7 • Whether the project has the potential to conflict with or is consistent
8 with the following plans to reduce or mitigate GHG emissions:
 - 9 – The six key elements of the *Climate Change Scoping Plan*
10 (described previously)
 - 11 – ARB’s 39 recommended actions in the *Climate Change Scoping*
12 *Plan*
 - 13 – Regulations or requirements adopted to implement a statewide,
14 regional, or local plan for the reduction or mitigation of GHG
15 emissions
- 16 • Whether the project is part of a plan that includes overall reductions in
17 GHG emissions
- 18 • Whether the relative amounts of GHG emissions over the life of the
19 project are small in comparison to the amount of GHG emissions for
20 major facilities that are required to report such emissions (25,000 MT
21 CO₂e per year)
- 22 • Whether the project has the potential to contribute to a lower carbon
23 future, through factors such as the following:
 - 24 – The design of the proposed project is inherently energy efficient
 - 25 – All applicable best management practices that would reduce GHG
26 emissions are incorporated into the project design
 - 27 – The project implements or funds its fair share of a mitigation
28 strategy designed to alleviate climate change
 - 29 – There are process improvements or efficiencies gained by
30 implementing the project

31 **5.3.3 Topics Eliminated from Further Consideration**

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

1 **5.3.4 Direct and Indirect Effects**

2 ***No-Action Alternative***

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

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

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

16 *Impact AQ-2 (No-Action): Long-Term Emissions of Criteria Air Pollutants and*
17 *Precursors During Project Operation* No long-term operational increases in
18 emissions of criteria air pollutants or precursors in the primary study area would
19 result from implementation of the No-Action Alternative. However, PM₁₀
20 emissions are expected to continue increasing through 2020 because of
21 increased growth in the area. This impact would be less than significant.

22 Under the No-Action Alternative, no changes to Reclamation's existing
23 operations in the primary study area would occur that would directly or
24 indirectly result in any increases in emissions of criteria air pollutants or
25 precursors in the primary study area. According to ARB, emission levels for
26 ROG, NO_x, and CO are trending downward from 1990 to 2020 in the project
27 area even with increased population growth (ARB 2009). More stringent
28 mobile-source emission standards, cleaner burning fuels, and new rules have
29 largely contributed to this decline. However, PM₁₀ emissions are expected to
30 continue increasing through 2020 because of increased growth in the area and
31 associated emissions (e.g., from travel on paved and unpaved roads). Thus, such
32 emissions will likely be worse in the future. Therefore, this impact would be
33 less than significant. Mitigation is not required for the No-Action Alternative.

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

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

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

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

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

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

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

25 **Global Study Area**

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

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

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

3 **Shasta Lake and Vicinity**

4 *Impact AQ-1 (CP1): Short-Term Emissions of Criteria Air Pollutants and*

5 *Precursors at Shasta Lake and Vicinity During Project Construction* Project
6 construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that
7 exceed applicable SCAQMD thresholds. This conclusion is based on detailed
8 calculations of estimated emissions for project elements and the simultaneous
9 occurrence thereof. Shasta County is a nonattainment area for the State ozone
10 and PM₁₀ standards. Thus, short-term emissions generated during construction
11 could contribute substantially to an existing or projected air quality violation.
12 This impact would be significant.

13 Construction emissions are described as “short-term” or temporary in duration
14 because they would cease when the dam raise and associated construction
15 projects are completed. The emissions of ozone precursors ROG and NO_x are
16 associated primarily with gas and diesel engine equipment exhaust from off-
17 road equipment and on-road vehicles. Off-road equipment anticipated in the
18 project includes construction equipment such as bulldozers, grader, water
19 trucks, and loaders. On-road vehicles include trucks that would bring materials
20 to the project site and haul excavated spoils and materials cleared from lands
21 away from the project site. An additional on-road source would be the vehicles
22 used by workers commuting to and from the project site. Engine equipment
23 exhaust also emits CO, PM₁₀, and PM_{2.5}. Refer to Attachment 1 to the *Air*
24 *Quality and Climate Technical Report* for all air quality modeling inputs and
25 outputs.

26 The primary sources of PM₁₀ and PM_{2.5} emissions are fugitive dust from site
27 preparation, vehicle travel on unpaved and paved roads, and storage piles.
28 Emissions vary as a function of such parameters as soil silt content, soil
29 moisture, wind speed, acreage of disturbance area, and vehicle miles traveled by
30 construction vehicles on- and off-site. Burning of cleared vegetation would be a
31 substantial source of particulate emissions. PM₁₀ and PM_{2.5} would also be
32 emitted during the materials handling processes associated with operation of a
33 concrete batch plant.

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

42 Emissions were calculated as described above in Section 5.3.1, “Methods and
43 Assumptions.” The results are shown in Table 5-4 for individual project

1 elements. (All air quality modeling inputs and outputs for the comprehensive
2 plans are presented in Attachment 1 to the *Air Quality and Climate Technical*
3 *Report*.) As seen in Table 5-4, ROG, NO_x, and PM emissions for several of the
4 individual project elements could exceed applicable Shasta County thresholds,
5 which would result in a significant impact. As shown in Figures 5-2 to 5-8,
6 maximum daily emissions (lb/day) for CP1 could reach 260 for ROG, 1,682 for
7 NO_x, 107 for PM₁₀ exhaust, 2,944 for PM₁₀ dust, 93 PM_{2.5} exhaust, 309 for
8 PM_{2.5} dust, and 1,125 for CO based on the worst-case simultaneous construction
9 of project elements as shown in detail in Attachment 1 to the *Air Quality and*
10 *Climate Change Technical Report*.

11 Particulate emissions from operation of a concrete batch plant are not included
12 in the above calculations. Batch plants must obtain operating permits from
13 Shasta County Air Pollution Control District. The granting of a permit would
14 assure that the impact of PM₁₀ and PM_{2.5} emissions from batch plant sources
15 would not exceed applicable thresholds.

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

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

24 **Table 5-4. Summary of Daily Short-Term Construction-Generated**
25 **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

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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
PM₁₀ = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

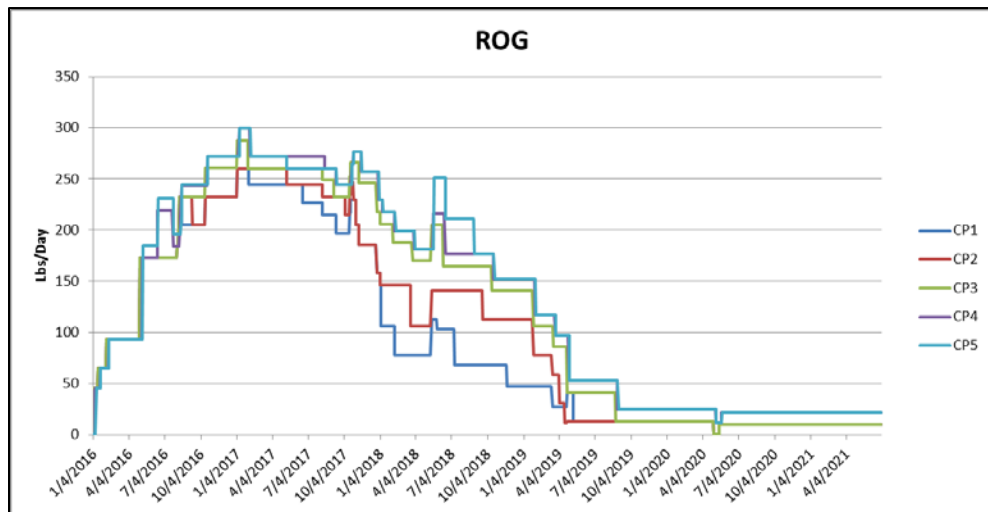
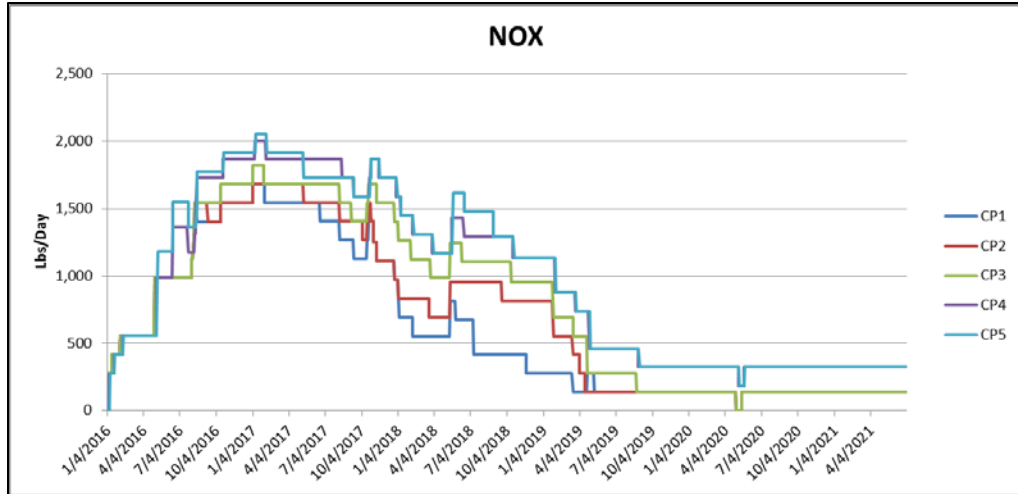


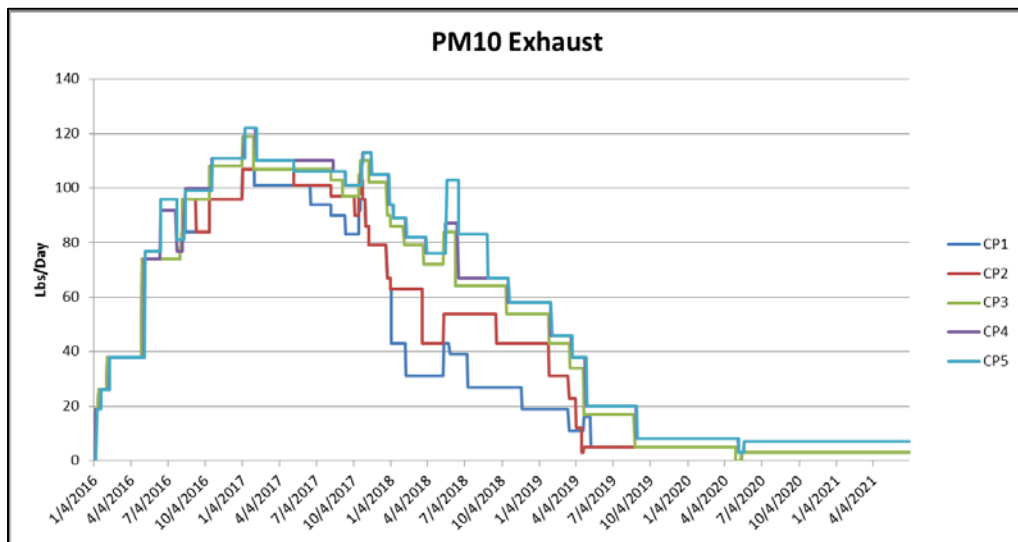
Figure 5-2. Maximum Daily Short-Term Construction-Generated Emissions of Reactive Organic Gases by Action Alternative (Pounds per Day)

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



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

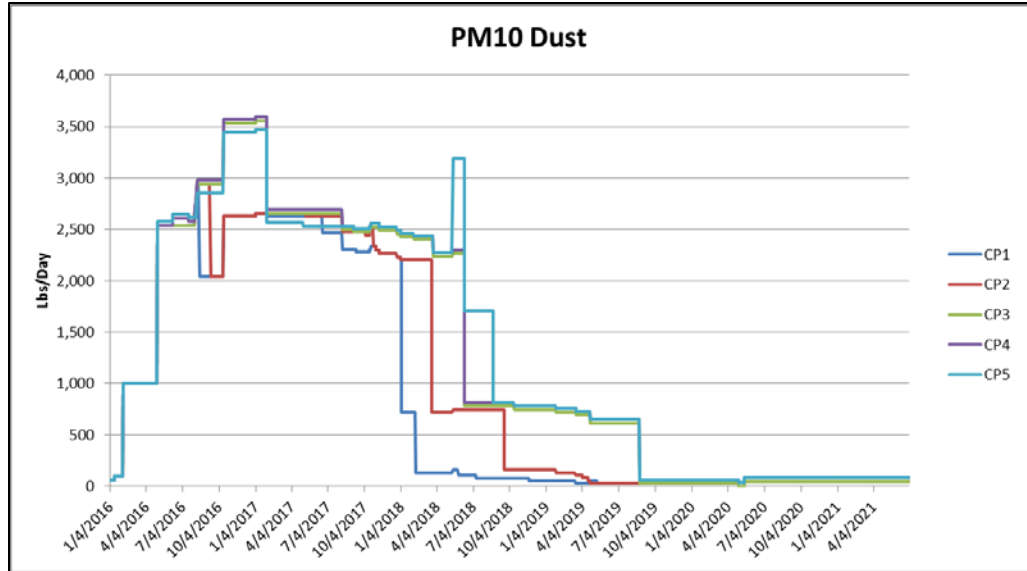


Figure 5-5. Maximum Daily Short-Term Construction-Generated Emissions of Respirable Particulate Matter Dust by Action Alternative (Pounds per Day)

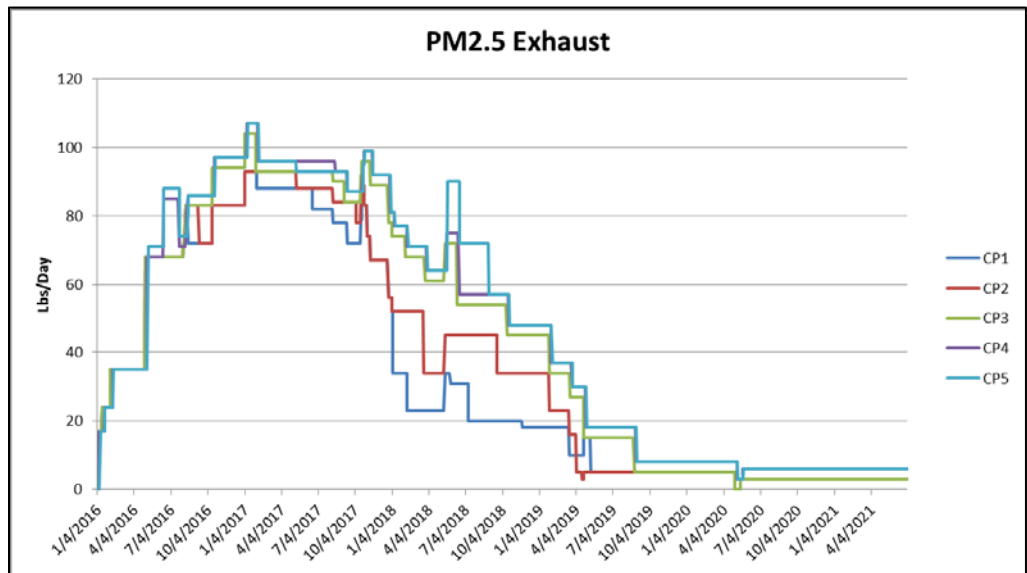


Figure 5-6. Maximum Daily Short-Term Construction-Generated Emissions of Fine Particulate Matter Exhaust by Action Alternative (Pounds per Day)

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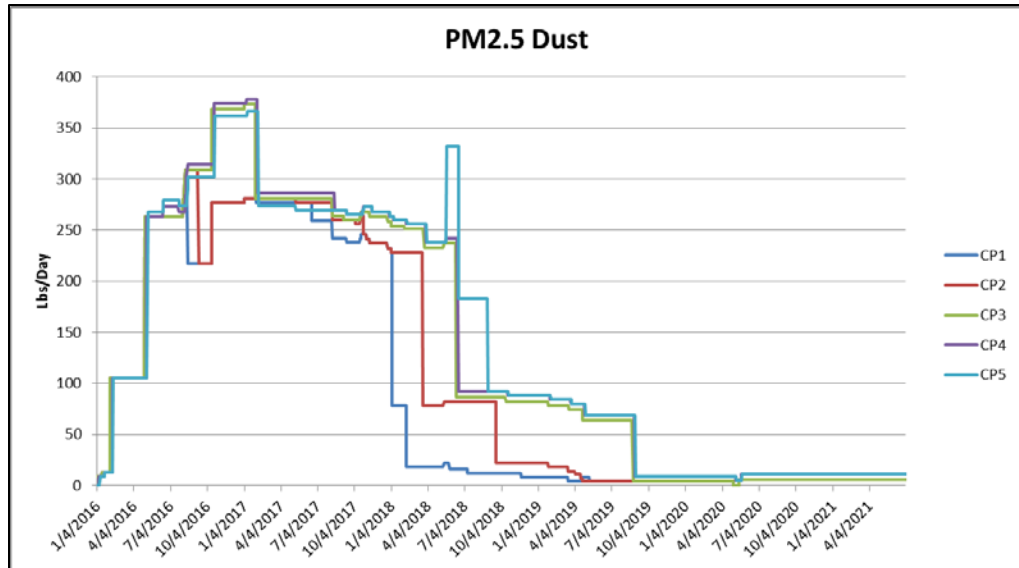


Figure 5-7. Maximum Daily Short-Term Construction-Generated Emissions of Fine Particulate Matter Dust by Action Alternative (Pounds per Day)

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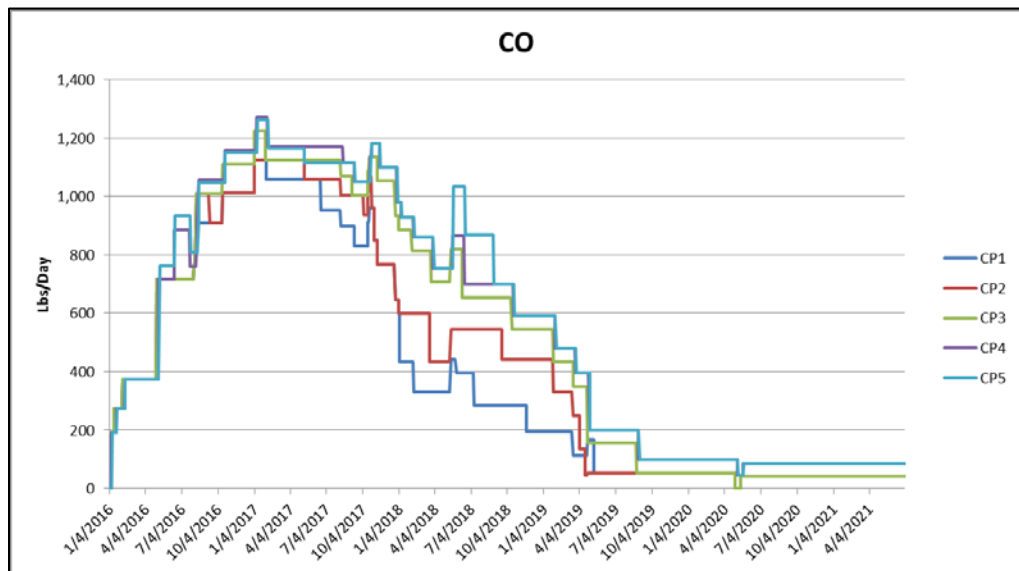


Figure 5-8. Maximum Daily Short-Term Construction-Generated Emissions of Carbon Monoxide by Action Alternative (Pounds per Day)

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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, PM₁₀, 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

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1 an existing or projected air quality violation. This impact would be less than
2 significant.

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

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

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

19 Enlarging Shasta Dam would include facilities to ensure that at least the existing
20 recreation capacity is maintained. CP1 would affect recreation participation by
21 increasing the reservoir's surface area and decreasing reservoir draw-down
22 during the peak recreation season. Table 5-5 compares user days (visitor days)
23 for each of the comprehensive plans to existing and future conditions. The
24 Modeling Appendix provides additional information on recreational visitation
25 estimates.

26 **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

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

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

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

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

14 **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
 PM₁₀ = respirable particulate matter
 ROG = reactive organic gases

15 Based on the above analysis, operation under CP1 would not result in ROG,
 16 NO_x, PM₁₀, or CO emissions that exceed applicable SCAQMD Level A
 17 thresholds. Consequently, long-term emissions during project operation under
 18 CP1 would not be anticipated to violate an air quality standard or contribute
 19 substantially to an existing or projected air quality violation. This impact would
 20 be less than significant. Mitigation for this impact is not needed, and thus not
 21 proposed.

1 *Impact AQ-3 (CPI): Exposure of Sensitive Receptors to Substantial Pollutant*
2 *Concentrations* Neither short-term construction nor long-term operational
3 sources would expose sensitive receptors to substantial concentrations of CO,
4 PM₁₀, PM_{2.5}, or TACs. This impact would be less than significant.

5 Pollutants of concern for exposure of sensitive receptors include CO, PM₁₀ and
6 PM_{2.5}, and TACs. Local exposure of CO may occur near severe congestion on
7 major roadways. The project is not anticipated to generate areas of severe
8 roadway congestion, nor would the project locate receptors near major
9 roadways; no local CO impact would occur.

10 Sensitive receptors could be exposed to substantial amounts of PM₁₀ and PM_{2.5}
11 if receptors were located near large areas of grading or earthmoving and dust
12 generation was not controlled. Similarly, substantial exposure to particulates
13 and other smoke-borne pollutants could result if receptors were near areas
14 where cleared brush would be burned. There are no sensitive receptors near the
15 dam raise areas; however, there may be sensitive receptors near the some of the
16 lands that would be cleared before inundation by the expanded reservoir. Dust
17 control measures would be required for all land clearing activities; these
18 measures would prevent most PM₁₀ and PM_{2.5} from reaching sensitive
19 receptors. Similarly, smoke control measures would be required by SCAQMD
20 Rule 2:7. The impact of exposure of sensitive receptors to PM₁₀ and PM_{2.5}
21 would be less than significant.

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

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

7 *Impact AQ-4 (CP1): Exposure of Sensitive Receptors to Odor Emissions*

8 Short-term construction and long-term operational sources would not expose
9 sensitive receptors to substantial odor emissions. This impact would be less than
10 significant.

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

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

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

28 **Upper Sacramento River (Shasta Dam to Red Bluff)**

29 *Impact AQ-5 (CP1): Short-Term Emissions of Criteria Air Pollutants and*
30 *Precursors Below Shasta Dam During Project Construction*

31 Gravel augmentation and habitat restoration in the upper Sacramento River proposed
32 under CP4 and CP5 would not be implemented under CP1. No other project
33 construction or long-term operation activities that would affect emissions of
34 criteria air pollutants and precursors are planned in the Shasta Dam-to-Red
35 Bluff area under CP1. Therefore, no impact would occur.

36 Gravel augmentation and habitat restoration (proposed under CP4 and CP5, as
37 described below) would not be implemented under CP1. No new facilities
38 would be constructed below Shasta Dam under this alternative, and no changes
39 in Reclamation's existing facilities or operations would occur that would
40 directly or indirectly result in any increases in criteria air pollutant emissions in

1 this portion of the primary study area. No impact would occur. Mitigation for
2 this impact is not needed, and thus not proposed.

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

7 **Global Study Area**

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

13 There are no established quantitative criteria under CEQA for determining a
14 significant impact related to GHG emissions. The criteria suggested by various
15 agencies principally address long-term emissions, and not the relatively short-
16 term emissions of construction activities. One of the more commonly suggested
17 mass emissions thresholds is 25,000 MT CO₂e per year. This value has been
18 selected because it is the threshold established for mandatory emissions
19 reporting for most sources in California under AB 32. Due to a longer than
20 usual period of construction, construction-generated emissions are amortized
21 over the lifetime of the project and added to operational emissions to determine
22 the overall level of GHG generation. Based on the modeling conducted,
23 construction of CP1 would result in 3,319 MT CO₂e/year amortized over the
24 project lifetime.

25 GHG emissions of sequestered carbon in removed vegetation were calculated at
26 3,156 MT CO₂e per year for CP1. This calculation assumes that all vegetation
27 removal, overstory removal, and relocation acreages (370 acres total) would be
28 covered in 70-year-old stands of forest vegetation (Ponderosa pine, Douglas-fir,
29 montane hardwood-conifer, and montane hardwood forest) and that all above-
30 ground vegetation would be disposed of in a manner that releases the
31 sequestered carbon into the atmosphere. All 370 acres would not be covered
32 with 70-year forest as used in the model (ages would vary) or release all carbon
33 to the atmosphere. Also, most utilities would be relocated in roadways, but
34 separate relocation (and additional disturbance) was assumed in the estimated
35 relocation acreages. This approach was applied to ensure that underestimating
36 would not occur.

37 With implementation of CP1, increased activity by recreational visitors to the
38 Shasta Lake area would result in additional vehicle trips and estimated CO₂e
39 emissions of 296 MT/year under existing conditions and 337 MT/year under
40 future conditions based on the same assumptions described above (Table 5-5).
41 Increasing the size of Shasta Dam and Shasta Lake would result in the ability to
42 increase hydropower generation at Shasta generating facilities. Generation of

1 electricity by hydropower reduces the need for fossil-fuel generation of
 2 electricity and the GHG emissions that would occur with that generation.

3 For existing conditions, raising Shasta Dam by 6.5 feet and implementing the
 4 operational strategy for CP1 would result in a net increase in CVP/SWP power
 5 generation of 2.7 gigawatt-hours (GWh) per year (Table 5-7). This net
 6 generation estimate accounts for the energy required for pumping the increased
 7 water supplies. Fossil-fuel generation of 2.7 GWh of energy would produce an
 8 estimated 2,400 MT of CO₂e, also shown in Table 5-7. Therefore, the increased
 9 generation of electricity at Shasta Dam would reduce the need to build facilities
 10 for fossil-fueled generation of 2.7 GWh per year in the global study area.

11 For future conditions, raising Shasta Dam by 6.5 feet and implementing the
 12 operational strategy for CP1 would result in a net decrease in CVP/SWP power
 13 generation of 2.2 GWh per year (Table 5-7). Fossil-fuel generation of 2.2 GWh
 14 of energy would produce an estimated 1,900 MT of CO₂e, also shown in Table
 15 5-7. Therefore, the overall net generation decrease would increase the need to
 16 build facilities for fossil-fueled generation of 2.2 GWh per year in the global
 17 study area.

18 **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 ₂ e 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 ₂ e 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

19 The results of the above analysis show that CP1 would result in short-term
 20 emissions of GHG for the years of construction, followed by long-term benefits
 21 of GHG reduction through generation of electricity at Shasta Dam for existing
 22 conditions. The results of the above analysis show that CP1 would result in
 23 short-term emissions of GHG for the years of construction, followed by a long-
 24 term effect of GHG increase for future conditions. The GHG emissions from
 25 construction activities would be temporary in duration and mitigated to the
 26 extent feasible; therefore, such emissions would not conflict with State or
 27 regional planning efforts or emit GHG in excess of mandatory reporting
 28 standards. GHG emissions from long-term operations would likely have a net
 29 benefit as a result of increased hydroelectric generation and would thus also not
 30 conflict with planning efforts or mandatory reporting thresholds. This impact

1 would be less than significant. Mitigation for this impact is not needed, and thus
2 not proposed.

3 In addition to the effects described above, the loss of vegetation presently in the
4 area that would be inundated would likely result in a loss of CO₂ absorption by
5 that vegetation, as well as increased emissions of decomposing material present
6 in the lake as a result of increases volume. There may be some offset to this
7 effect with increased surface area of Shasta Lake for absorption. These effects
8 are speculative and infeasible to quantify at this time.

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

11 **Shasta Lake and Vicinity**

12 *Impact AQ-1 (CP2): Short-Term Emissions of Criteria Air Pollutants and*
13 *Precursors at Shasta Lake and Vicinity During Project Construction* Project
14 construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that
15 exceed applicable SCAQMD thresholds. This conclusion is based on detailed
16 calculations of estimated emissions for project elements and the simultaneous
17 occurrence thereof. Shasta County is a nonattainment area for the State ozone
18 and PM₁₀ standards. Thus, short-term emissions generated during construction
19 could contribute substantially to an existing or projected air quality violation.
20 This impact would be significant.

21 CP2 includes a dam raise of 12.5 feet. This impact would be similar to Impact
22 AQ-1 (CP1) as the same type of construction equipment and activities would be
23 involved. Emissions were calculated as described above in Section 5.3.1,
24 “Methods and Assumptions.” The results are shown in Table 5-8 for individual
25 project elements. (All air quality modeling inputs and outputs for the
26 comprehensive plans are presented in Attachment 1 to the *Air Quality and*
27 *Climate Technical Report*.) As shown in Table 5-8 (similar to CP1), ROG, NO_x,
28 and PM emissions for several of the individual project elements could exceed
29 applicable Shasta County thresholds, which would result in a significant impact.
30 As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for CP2
31 (similar to CP1), could reach much higher levels based on the worst-case
32 simultaneous construction of project elements as shown in detail in Attachment
33 1 to the *Air Quality and Climate Change Technical Report*. For the same
34 reasons as described for CP1, this impact would be significant. Mitigation for
35 this impact is proposed in Section 5.3.5.

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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
PM₁₀ = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

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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, PM₁₀, 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.

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

8 Based on the above analysis, operation under CP2 would not result in ROG,
9 NO_x, PM₁₀, or CO emissions that exceed applicable SCAQMD Level A
10 thresholds. Consequently, long-term emissions during project operation under
11 CP2 would not violate an air quality standard or contribute substantially to an
12 existing or projected air quality violation. This impact would be less than
13 significant. Mitigation for this impact is not needed, and thus not proposed.

14 **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

PM₁₀ = respirable particulate matter

ROG = reactive organic gases

15 *Impact AQ-3 (CP2): Exposure of Sensitive Receptors to Substantial Pollutant*
16 *Concentrations* Neither short-term construction nor long-term operational
17 sources would expose sensitive receptors to substantial concentrations of CO,
18 PM₁₀, PM_{2.5}, or TACs. This impact would be less than significant.

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

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

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

3 **Upper Sacramento River (Shasta Dam to Red Bluff)**

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

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

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

17 **Global Study Area**

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

23 This impact would be similar to Impact AQ-6 (CP1) for construction and
24 operations. Based on the modeling conducted, construction of CP2 would result
25 in 3,807 MT CO₂e/year amortized over the project lifetime. GHG emissions of
26 sequestered carbon in removed vegetation were calculated at 5,031 MT CO₂e
27 per year for CP2 (590 acres total). Increased activity by recreational visitors to
28 the Shasta Lake area would result in additional vehicle trips and estimated CO₂
29 emissions of 622 and 507 MT CO₂e per year for existing conditions and future
30 conditions, respectively.

31 For existing conditions, raising Shasta Dam by 12.5 feet and implementing the
32 operational strategy for CP2 would result in a net increase in CVP/SWP power
33 generation of 15.0 GWh per year (Table 5-7). Fossil-fuel generation of 15.0
34 GWh of energy would produce an estimated 13,400 MT CO₂, also shown in
35 Table 5-7. Thus, CP2 would reduce the need to build facilities for fossil-fueled
36 generation of 15.0 GWh per year in the global study area.

37 For future conditions, raising Shasta Dam by 12.5 feet and implementing the
38 operational strategy for CP2 would result in a net increase in CVP/SWP power
39 generation of 0.9 GWh per year (Table 5-7). Fossil-fuel generation of 0.9 GWh
40 of energy would produce an estimated 800 MT of CO₂e, also shown in Table 5-

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

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

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

22 ***Shasta Lake and Vicinity***

23 *Impact AQ-1 (CP3): Short-Term Emissions of Criteria Air Pollutants and*
24 *Precursors at Shasta Lake and Vicinity During Project Construction* Project
25 construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that
26 exceed applicable SCAQMD thresholds. This conclusion is based on detailed
27 calculations of estimated emissions for project elements and the simultaneous
28 occurrence thereof. Shasta County is a nonattainment area for the State ozone
29 and PM₁₀ standards. Thus, short-term emissions generated during construction
30 could contribute substantially to an existing or projected air quality violation.
31 This impact would be significant.

32 CP3 includes a dam raise of 18.5 feet. This impact would be similar to Impact
33 AQ-1 (CP1) as the same type of construction equipment and activities would be
34 involved. Emissions were calculated as described above in Section 5.3.1,
35 “Methods and Assumptions.” The results are shown in Table 5-6 for individual
36 project elements. (All air quality modeling inputs and outputs for the
37 comprehensive plans are presented in Attachment 1 to the *Air Quality and*
38 *Climate Technical Report*.) As shown in Table 5-10 (similar to CP1), ROG,
39 NO_x, and PM emissions for several of the individual project elements could
40 exceed applicable Shasta County thresholds, which would result in a significant
41 impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for
42 CP3 (similar to CP1), could reach much higher levels based on the worst-case
43 simultaneous construction of project elements as shown in detail in Attachment
44 1 to the *Air Quality and Climate Change Technical Report*. For the same

1 reasons as described for CP1, this impact would be significant. Mitigation for
2 this impact is proposed in Section 5.3.5.

3 **Table 5-10. Summary of Daily Short-Term Construction-Generated**
4 **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
PM₁₀ = respirable particulate matter
ROG = reactive organic gases
TCD = temperature control device
UPRR = Union Pacific Railroad

1 *Impact AQ-2 (CP3): Long-Term Emissions of Criteria Air Pollutants and*
 2 *Precursors During Project Operation* Long-term project operation is not
 3 anticipated to result in ROG, NO_x, PM₁₀, or CO emissions that exceed
 4 applicable SCAQMD thresholds. Thus, long-term operational emissions would
 5 not be anticipated to violate an air quality standard or contribute substantially to
 6 an existing or projected air quality violation. This impact would be less than
 7 significant.

8 Long-term operational emissions would come from stationary, area, and mobile
 9 sources. This impact would be the same as Impact AQ-2 (CP1) for stationary
 10 and area sources and similar to Impact AQ-2 (CP1 and CP2) for mobile sources.
 11 With CP3, there would be an annual increase of 216,000 and 205,000 visitor
 12 days under existing and future conditions, respectively, as was shown in Table
 13 5-5, resulting in 384 and 364 average daily trips under existing and future
 14 conditions, respectively. The associated daily emissions are shown in Table 5-
 15 11. Overall trip levels would be greater than under CP1 and CP2, but emissions
 16 would remain below significance thresholds.

17 **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
- PM₁₀ = respirable particulate matter
- ROG = reactive organic gases

18 Based on the above analysis, operation under CP3 would not result in ROG,
 19 NO_x, PM₁₀, or CO emissions that exceed SCAQMD Level A thresholds.
 20 Consequently, long-term emissions during operation under CP3 would not
 21 violate an air quality standard or contribute substantially to an existing or
 22 projected air quality violation. This impact would be less than significant.
 23 Mitigation for this impact is not needed, and thus not proposed.

24 *Impact AQ-3 (CP3): Exposure of Sensitive Receptors to Substantial Pollutant*
 25 *Concentrations* Neither short-term construction nor long-term operational

1 sources would expose sensitive receptors to substantial concentrations of CO,
2 PM₁₀, PM_{2.5}, or TACs. This impact would be less than significant.

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

5 *Impact AQ-4 (CP3): Exposure of Sensitive Receptors to Odor Emissions*
6 Short-term construction and long-term operational sources would not expose
7 sensitive receptors to substantial odor emissions. This impact would be less than
8 significant.

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

11 **Upper Sacramento River (Shasta Dam to Red Bluff)**

12 *Impact AQ-5 (CP3): Short-Term Emissions of Criteria Air Pollutants and*
13 *Precursors Below Shasta Dam During Project Construction* Gravel
14 augmentation and habitat restoration in the upper Sacramento River proposed
15 under CP4 and CP5 would not be implemented under CP3. No other project
16 construction or long-term operation activities that would affect emissions of
17 criteria air pollutants and precursors are planned in the Shasta Dam-to-Red
18 Bluff area under CP3. Therefore, no impact would occur.

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

21 **Lower Sacramento River and Delta and CVP/SWP Service Areas** No
22 effects on climate and air quality are expected to occur in the lower Sacramento
23 River and Delta and CVP/SWP service areas under CP3; therefore, potential
24 effects in those geographic regions are not discussed further in this DEIS.

25 **Global Study Area**

26 *Impact AQ-6 (CP3): Generation of Greenhouse Gases* Project construction
27 and operational activities would result in emission of a less than significant
28 quantity of GHGs. Overall, implementation of CP3 would result in beneficial
29 effects on GHG emissions because generation of electricity at Shasta Dam
30 would increase. This impact would be less than significant.

31 This impact would be similar to Impact AQ-6 (CP1) for construction and
32 operations. Based on the modeling conducted, construction of CP3 would result
33 in 4,350 MT CO₂e/year amortized over the project lifetime. GHG emissions of
34 sequestered carbon in removed vegetation were calculated at 7,164 MT CO₂e
35 per year for CP3 (840 acres total). Increased activity by recreational visitors to
36 the Shasta Lake area would result in additional vehicle trips and estimated
37 emissions of 819 and 776 MT CO₂e per year for existing conditions and future
38 conditions, respectively.

1 For existing conditions, raising Shasta Dam by 18.5 feet and implementing the
2 operational strategy for CP3 would result in a net increase in CVP/SWP power
3 generation of 71.2 GWh per year, as was shown in Table 5-7. Fossil-fuel
4 generation of 71.2 GWh of energy would produce an estimated 63,600 MT of
5 CO₂, also shown in Table 5-7. Thus, CP3 would reduce the need to build
6 facilities for fossil-fueled generation of 71.2 GWh per year in the global study
7 area.

8 For future conditions, raising Shasta Dam by 18.5 feet and implementing the
9 operational strategy for CP3 would result in a net increase in power generation
10 of 70.2 GWh per year, as was shown in Table 5-7. Fossil-fuel generation of 70.2
11 GWh of energy would produce an estimated 62,700 MT of CO₂, also shown in
12 Table 5-7. Thus, CP3 would reduce the need to build facilities for fossil-fueled
13 generation of 70.2 GWh per year in the global study area.

14 Thus, the results of the above analysis show that CP3 would result in short-term
15 emissions of GHG for the years of construction, followed by long-term benefits
16 of GHG reduction through generation of electricity at Shasta Dam. The
17 magnitude of the GHG “savings” for each year of operation would be
18 approximately 51,267 and 50,410 MT CO₂e for existing conditions and future
19 conditions, respectively, considering construction emissions amortized over the
20 project lifetime. The GHG emissions from construction activities would be
21 temporary in duration and mitigated to the extent feasible; therefore, such
22 emissions would not conflict with State or regional planning efforts or emit
23 GHG in excess of mandatory reporting standards. GHG emissions from long-
24 term operations would likely have a net benefit as a result of increased
25 hydroelectric generation and would thus also not conflict with planning efforts
26 or mandatory reporting thresholds. This impact would be less than significant.
27 Mitigation for this impact is not needed, and thus not proposed.

28 ***CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply***
29 ***Reliability***

30 ***Shasta Lake and Vicinity***

31 *Impact AQ-1 (CP4): Short-Term Emissions of Criteria Air Pollutants and*
32 *Precursors at Shasta Lake and Vicinity During Project Construction* Project
33 construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that
34 exceed applicable SCAQMD thresholds. This conclusion is based on detailed
35 calculations of estimated emissions for project elements and the simultaneous
36 occurrence thereof. Shasta County is a nonattainment area for the State ozone
37 and PM₁₀ standards. Thus, short-term emissions generated during construction
38 could contribute substantially to an existing or projected air quality violation.
39 This impact would be significant.

40 CP4 includes a dam raise of 18.5 feet. This impact would be similar to Impact
41 AQ-1 (CP1) as the same type of construction equipment and activities would be
42 involved. Emissions were calculated as described above in Section 5.3.1,
43 “Methods and Assumptions.” The results are shown in Table 5-12 for individual

1 project elements. (All air quality modeling inputs and outputs for the
2 comprehensive plans are presented in Attachment 1 to the *Air Quality and*
3 *Climate Technical Report*.) As shown in Table 5-12 (similar to CP1), ROG,
4 NO_x, and PM emissions for several of the individual project elements could
5 exceed applicable Shasta County thresholds, which would result in a significant
6 impact. As shown in Figures 5-2 to 5-8, maximum daily emissions (lb/day) for
7 CP4 (similar to CP1), could reach much higher levels based on the worst-case
8 simultaneous construction of project elements as shown in detail in Attachment
9 1 to the *Air Quality and Climate Change Technical Report*. For the same
10 reasons as described for CP1, this impact would be significant. Mitigation for
11 this impact is proposed in Section 5.3.5.

12 **Table 5-12. Summary of Daily Short-Term Construction-Generated**
13 **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

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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

PM₁₀ = respirable particulate matter

ROG = reactive organic gases

TCD = temperature control device

UPRR = Union Pacific Railroad

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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, PM₁₀, 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.

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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.

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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
 PM₁₀ = respirable particulate matter
 ROG = reactive organic gases

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Based on the above analysis, operation under CP4 would not result in ROG, NO_x, PM₁₀, 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.

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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, PM₁₀, PM_{2.5}, or TACs. This impact would be less than significant.

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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.

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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.

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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.

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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

1 to emissions of ROG, NO_x, and PM₁₀ from project construction. Habitat
2 restoration activities proposed for the upper Sacramento River would also add
3 ROG, NO_x, and PM₁₀ emissions. However, these emissions separately and
4 combined would add negligible amounts to annual emission levels. This impact
5 would be less than significant.

6 Gravel Augmentation proposed under CP4 would add an additional 1 lb/day of
7 ROG, 16 lb/day of NO_x, and 1 lb/day of PM₁₀ to project construction emission
8 levels. Emissions from gravel augmentation would be from gravel material
9 hauling consisting of approximately 18 trips per day, 40 miles round trip to sites
10 identified to the south along the Sacramento River. Gravel augmentation would
11 only occur for 2 months out of the year; therefore, these emissions would add
12 negligible amounts to annual emission levels.

13 Habitat restoration in the upper Sacramento River proposed under CP4 would
14 add an additional 6.7 lb/day of ROG, 50.1 lb/day of NO_x, and 12.4 lb/day of
15 PM₁₀ to project construction emission levels. During habitat restoration,
16 emissions would be generated from potentially removing vegetation from the
17 Sacramento River's side channel, removing noxious invasive plant species from
18 the area, minor grading, and hauling away waste materials (approximately 25
19 trips per day). Restoration activities would occur for only 2 months for a total of
20 44 8-hour work days; therefore, these emissions would add negligible amounts
21 to annual emission levels.

22 The combined emissions from gravel augmentation and habitat restoration
23 activities would be 7.7 lb/day of ROG, 76 lb/day of NO_x, and 13.4 lb/day of
24 PM₁₀. These emissions are below SCAQMD's Level A thresholds of 25 lb/day
25 of ROG, 25 lb/day of NO_x, and 80 lb/day of PM₁₀. This impact would be less
26 than significant. Mitigation for this impact is not needed, and thus not proposed.

27 **Lower Sacramento River and Delta and CVP/SWP Service Areas** No
28 effects on climate and air quality are expected to occur in the lower Sacramento
29 River and Delta and CVP/SWP service areas under CP4; therefore, potential
30 effects in those geographic regions are not discussed further in this DEIS.

31 **Global Study Area**

32 *Impact AQ-6 (CP4): Generation of Greenhouse Gases* Project construction
33 and operational activities would result in emission of a less than significant
34 quantity of GHGs. Overall, implementation of CP4 would result in beneficial
35 effects on GHG emissions because generation of electricity at Shasta Dam
36 would increase. This impact would be less than significant.

37 This impact would be similar to Impact AQ-6 (CP1) for construction and
38 operations. Based on the modeling conducted, construction of CP4 would result
39 in 5,112 MT CO₂e/year amortized over the project lifetime. GHG emissions of
40 sequestered carbon in removed vegetation were calculated at 7,164 MT CO₂e
41 per year for CP3 (840 acres total). Increased activity by recreational visitors to

1 the Shasta Lake area would result in additional vehicle trips and estimated
2 emissions of 1,376 and 1,403 MT CO₂e per year for existing conditions and
3 future conditions, respectively.

4 For existing conditions, raising Shasta Dam by 18.5 feet and implementing the
5 operational strategy for CP4 would result in a net increase in CVP/SWP power
6 generation of 81.1 GWh per year (Table 5-7). Fossil-fuel generation of 81.1
7 GWh of energy would produce an estimated 72,400 MT CO₂ (Table 5-7). Thus,
8 CP4 would reduce the need to build facilities for fossil-fueled generation of
9 81.1 GWh per year in the global study area.

10 For future conditions, raising Shasta Dam by 18.5 feet and implementing the
11 operational strategy for CP4 would result in a net increase in CVP/SWP power
12 generation of 76.1 GWh per year (Table 5-7). Fossil-fuel generation of 76.1
13 GWh of energy would produce an estimated 67,900 MT CO₂ (Table 5-7). Thus,
14 CP4 would reduce the need to build facilities for fossil-fueled generation of
15 76.1 GWh per year in the global study area.

16 Thus, the results of the above analysis show that CP4 would result in short-term
17 emissions of GHG for the years of construction, followed by long-term benefits
18 of GHG reduction through generation of electricity at Shasta Dam. The
19 magnitude of the GHG “savings” for each year of operation would be
20 approximately 58,748 and 54,221 MT CO₂e for existing conditions and future
21 conditions, respectively, considering construction emissions amortized over the
22 project lifetime. The GHG emissions from construction activities would be
23 temporary in duration and mitigated to the extent feasible; therefore, such
24 emissions would not conflict with State or regional planning efforts or emit
25 GHG in excess of mandatory reporting standards. GHG emissions from long-
26 term operations would likely have a net benefit as a result of increased
27 hydroelectric generation and would thus also not conflict with planning efforts
28 or mandatory reporting thresholds. This impact would be less than significant.
29 Mitigation for this impact is not needed, and thus not proposed.

30 **CP5 – 18.5-Foot Dam Raise, Combination Plan**

31 **Shasta Lake and Vicinity**

32 *Impact AQ-1 (CP5): Short-Term Emissions of Criteria Air Pollutants and*
33 *Precursors at Shasta Lake and Vicinity During Project Construction* Project
34 construction could result in short-term emissions (e.g., ROG, NO_x, and PM) that
35 exceed applicable SCAQMD thresholds. This conclusion is based on detailed
36 calculations of estimated emissions for project elements and the simultaneous
37 occurrence thereof. Shasta County is a nonattainment area for the State ozone
38 and PM₁₀ standards. Thus, short-term emissions generated during construction
39 could contribute substantially to an existing or projected air quality violation.
40 This impact would be significant.

41 CP5 includes a dam raise of 18.5 feet. This impact would be similar to Impact
42 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

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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

PM₁₀ = respirable particulate matter

ROG = reactive organic gases

TCD = temperature control device

UPRR = Union Pacific Railroad

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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, PM₁₀, 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.

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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.

1

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
 PM₁₀ = respirable particulate matter
 ROG = reactive organic gases

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3
4
5
6
7

Based on the above analysis, operation under CP4 would not result in ROG, NO_x, PM₁₀, 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.

8
9
10
11

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, PM₁₀, PM_{2.5}, or TACs. This impact would be less than significant.

12
13

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.

14
15
16
17

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.

18
19

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.

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24

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 PM₁₀ from project construction.

1 However, these emissions would add negligible amounts to annual emission
2 levels. This impact would be less than significant.

3 This impact would be the same as Impact AQ-5 (CP4) and would be less than
4 significant. Mitigation for this impact is not needed, and thus not proposed.

5 **Lower Sacramento River and Delta and CVP/SWP Service Areas** No
6 effects on climate and air quality are expected to occur in the lower Sacramento
7 River and Delta and CVP/SWP service areas under CP5; therefore, potential
8 effects in those geographic regions are not discussed further in this DEIS.

9 **Global Study Area**

10 *Impact AQ-6 (CP5): Generation of Greenhouse Gases* Project construction
11 and operational activities would result in emission of a less than significant
12 quantity of GHGs. Overall, implementation of CP4 would result in beneficial
13 effects on GHG emissions because generation of electricity at Shasta Dam
14 would increase. This impact would be less than significant.

15 This impact would be similar to Impact AQ-6 (CP1) for construction and
16 operations. Based on the modeling conducted, construction of CP5 would result
17 in 5,199 MT CO₂e/year amortized over the project lifetime. GHG emissions of
18 sequestered carbon in removed vegetation were calculated at 7,164 MT CO₂e
19 per year for CP3 (840 acres total). Increased activity by recreational visitors to
20 the Shasta Lake area would result in additional vehicle trips and estimated
21 emissions of 754 MT CO₂e per year.

22 For existing conditions, raising Shasta Dam by 18.5 feet and implementing the
23 operational strategy for CP5 would result in a net increase in CVP/SWP power
24 generation of 23.6 GWh per year, as was shown in Table 5-7. Fossil fuel
25 generation of 23.6 GWh of energy would produce an estimated 21,000 MT
26 CO₂, also shown in Table 5-7. Thus, CP5 would reduce the need to build
27 facilities for fossil-fueled generation of 23.6 GWh per year in the global study
28 area.

29 For future conditions, raising Shasta Dam by 18.5 feet and implementing the
30 operational strategy for CP5 would result in a net increase in CVP/SWP power
31 generation of 4.2 GWh per year, as was shown in Table 5-7. Fossil fuel
32 generation of 4.2 GWh of energy would produce an estimated 3,800 MT CO₂,
33 also shown in Table 5-7. Thus, CP5 would reduce the need to build facilities for
34 fossil-fueled generation of 4.2 GWh per year in the global study area.

35 Thus, the results of the above analysis show that CP5 would result in short-term
36 emissions of GHG for the years of construction, followed by long-term benefits
37 of GHG reduction through generation of electricity at Shasta Dam for existing
38 conditions. The magnitude of the GHG “savings” for each year of operation
39 would be approximately 7,883 MT CO₂e for existing conditions and a GHG
40 “deficit” of 9,226 MTCO₂e for future conditions considering construction

1 emissions amortized over the project lifetime. The GHG emissions from
2 construction activities would be temporary in duration and mitigated to the
3 extent feasible; therefore, such emissions would not conflict with State or
4 regional planning efforts or emit GHG in excess of mandatory reporting
5 standards. GHG emissions from long-term operations would likely not conflict
6 with planning efforts or mandatory reporting thresholds. This impact would be
7 less than significant. Mitigation for this impact is not needed, and thus not
8 proposed.

9 **5.3.5 Mitigation Measures**

10 Table 5-16 presents a summary of mitigation measures for air quality and
11 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

1 **No-Action Alternative**

2 No mitigation measures are needed for this alternative.

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

5 No mitigation is needed for Impacts AQ-2 (CP1), AQ-3 (CP1), AQ-4 (CP1),
6 AQ-5, and AQ-6 (CP1). Mitigation is provided below for the remaining impact
7 of CP1 on air quality.

8 **Mitigation Measure AQ-1 (CP1): Implement Standard Measures and Best**
9 **Available Mitigation Measures to Reduce Emissions Levels** Reclamation
10 (referred to below as “the project applicant” or “the applicant”) and its primary
11 construction contractor(s) will implement the mitigation measures listed below
12 to reduce emissions of criteria air pollutants and precursors generated during
13 construction.

14 *Standard Mitigation Measures* The following SCAQMD standard mitigation
15 measures are applicable to all projects.

16 *PM10 Controls*

- 17 • Alternatives to open burning of vegetative material on the project site
18 shall be used by the project applicant unless otherwise deemed
19 infeasible by SCAQMD. Among suitable alternatives is chipping,
20 mulching, or conversion to biomass fuel.

- 21 • The applicant shall be responsible for ensuring that all adequate dust
22 control measures are implemented in a timely and effective manner
23 during all phases of project development and construction.

- 24 • All material excavated, stockpiled, or graded shall be sufficiently
25 watered to prevent fugitive PM₁₀ dust emissions from leaving the
26 property boundaries and causing a public nuisance or a violation of an
27 ambient air standard. Watering shall occur at least twice daily with
28 complete site coverage, preferably in the mid-morning and after work is
29 completed each day.

- 30 • All areas (including unpaved roads) with vehicle traffic shall be
31 watered periodically or dust palliatives applied for stabilization of
32 fugitive PM₁₀ dust emissions.

- 33 • All on site vehicles shall be limited to a speed of 15 miles per hour on
34 unpaved roads.

- 35 • All land clearing, grading, earthmoving, or excavation activities on a
36 project shall be suspended when winds are expected to exceed 20 miles
37 per hour.

- 1 • All inactive portions of the development site shall be seeded and
2 watered until a suitable grass cover is established.

- 3 • The applicant shall be responsible for applying Shasta County
4 Department of Public Works–approved nontoxic soil stabilizers
5 (according to manufacturers’ specifications) to all inactive construction
6 areas (previously graded areas that remain inactive for 96 hours) in
7 accordance with the Shasta County Grading Ordinance.

- 8 • All trucks hauling dirt, sand, soil, or other loose material shall be
9 covered or maintain at least 2 feet of freeboard (i.e., minimum vertical
10 distance between top of the load and the trailer) in accordance with the
11 requirements of California Vehicle Code Section 23114. This provision
12 shall be enforced by local law enforcement agencies.

- 13 • All material transported off site shall be either sufficiently watered or
14 securely covered to prevent a public nuisance.

- 15 • During initial grading, earthmoving, or site preparation, the project
16 shall be required to construct a paved (or dust palliative–treated) apron,
17 at least 100 feet in length, onto the project site from the adjacent paved
18 road(s).

- 19 • Paved streets adjacent to the development site shall be swept or washed
20 at the end of each day to remove excessive accumulations of silt and/or
21 mud that may have accumulated as a result of activities on the
22 development site.

- 23 • Adjacent paved streets shall be swept (water sweeper with reclaimed
24 water recommended) at the end of each day if substantial volumes of
25 soil materials have been carried onto adjacent public paved roads from
26 the project site.

- 27 • Wheel washers shall be installed where project vehicles and/or
28 equipment enter and/or exit onto paved streets from unpaved roads.
29 Vehicles and/or equipment shall be washed before each trip.

- 30 • Before final occupancy, the applicant shall reestablish ground cover on
31 the construction site through seeding and watering in accordance with
32 the Shasta County Grading Ordinance.

- 33 *Streets*
- 34 • The project shall provide for temporary traffic control as appropriate
35 during all phases of construction to improve traffic flow as deemed
36 appropriate by the Shasta County Department of Public Works and/or
37 the California Department of Transportation.

- 1 • Construction activities shall be scheduled that direct traffic flow to off-
2 peak hours as much as practicable.

3 *Energy Conservation* For any new or relocated structures, the following
4 features will be incorporated as much as practicable:

- 5 • The project shall provide for the use of energy-efficient lighting,
6 including controls, and process systems such as water heaters, furnaces,
7 and boiler units.
- 8 • The project shall use a central water heating system featuring the use of
9 low-NO_x hot water heaters.

10 *Best Available Mitigation Measures* None of the SCAQMD BAMMs are
11 appropriate for the project. Therefore, the following measures will be
12 incorporated into the project:

- 13 • The project applicant will prepare and submit to SCAQMD for
14 approval a plan demonstrating that the heavy-duty (equal to or greater
15 than 50 horsepower) off-road vehicles to be used in the construction
16 project, including owned, leased, and subcontractor vehicles, shall
17 achieve a project-wide fleet-average 20 percent NO_x reduction and 45
18 percent particulate reduction compared to the most recent ARB fleet
19 average at time of construction. Acceptable options for reducing
20 emissions may include use of late-model engines, low-emission diesel
21 products, alternative fuels, engine retrofit technology, after-treatment
22 products, and/or other options as they become available.
- 23 • The project applicant will locate all construction equipment
24 maintenance and staging areas at the farthest distance possible from
25 nearby sensitive land uses.
- 26 • Idling of diesel-powered vehicles and equipment will not be permitted
27 during periods of nonactive vehicle use. Diesel-powered engines will
28 not be allowed to idle for more than 5 consecutive minutes in a 60-
29 minute period when the equipment is not in use, occupied by an
30 operator, or otherwise in motion, except under the following
31 conditions:
 - 32 – When equipment is forced to remain motionless because of traffic
33 conditions or mechanical difficulties over which the operator has no
34 control
 - 35 – When it is necessary to operate auxiliary systems installed on the
36 equipment, only when such system operation is necessary to
37 accomplish the intended use of the equipment

- 1 – To bring the equipment to the manufacturer’s recommended
- 2 operating temperature
- 3 – When the ambient temperature is below 40°F or above 85°F
- 4 – When equipment is being repaired

5 Implementation of the above mitigation measure would reduce ROG, NO_x, and
6 PM₁₀ emissions from on-site heavy-duty equipment exhaust by approximately 5
7 percent, 20 percent, and 45 percent, respectively, and fugitive PM₁₀ dust
8 emissions by 75 percent. However, NO_x emissions generated during
9 construction would still exceed the SCAQMD Level B threshold of 137 lb/day.
10 Thus, this impact would be significant and unavoidable.

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

13 No mitigation is needed for Impacts AQ-2 (CP2), AQ-3 (CP2), AQ-4 (CP2),
14 AQ-5, and AQ-6 (CP2). Mitigation is provided below for the remaining impact
15 of CP2 on air quality.

16 **Mitigation Measure AQ-1 (CP2): Implement Standard Measures and Best**
17 **Available Mitigation Measures to Reduce Emissions Levels** This mitigation
18 measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons
19 described above under Mitigation Measure AQ-1 (CP1), this impact would be
20 significant and unavoidable.

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

22 No mitigation is needed for Impacts AQ-2 (CP3), AQ-3 (CP3), AQ-4 (CP3),
23 AQ-5, and AQ-6 (CP3). Mitigation is provided below for the remaining impact
24 of CP3 on air quality.

25 **Mitigation Measure AQ-1 (CP3): Implement Standard Measures and Best**
26 **Available Mitigation Measures to Reduce Emissions Levels** This mitigation
27 measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons
28 described above under Mitigation Measure AQ-1 (CP1), this impact would be
29 significant and unavoidable.

30 ***CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply***
31 ***Reliability***

32 No mitigation is needed for Impacts AQ-2 (CP4), AQ-3 (CP4), AQ-4 (CP4),
33 AQ-5, and AQ-6 (CP4). Mitigation is provided below for the remaining impact
34 of CP4 on air quality.

35 **Mitigation Measure AQ-1 (CP4): Implement Standard Measures and Best**
36 **Available Mitigation Measures to Reduce Emissions Levels** This mitigation
37 measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons
38 described above under Mitigation Measure AQ-1 (CP1), this impact would be
39 significant and unavoidable.

1 **CP5 – 18.5-Foot Dam Raise, Combination Plan**

2 No mitigation is needed for Impacts AQ-2 (CP5), AQ-3 (CP5), AQ-4 (CP5),
3 AQ-5, and AQ-6 (CP5). Mitigation is provided below for the remaining impact
4 of CP5 on air quality.

5 **Mitigation Measure AQ-1 (CP5): Implement Standard Measures and Best**
6 **Available Mitigation Measures to Reduce Emissions Levels** This mitigation
7 measure is identical to Mitigation Measure AQ-1 (CP1). For the reasons
8 described above under Mitigation Measure AQ-1 (CP1), this impact would be
9 significant and unavoidable.

10 **5.3.6 Cumulative Effects**

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

19 Growth is likely to occur throughout the primary and extended study areas and
20 some future projects are reasonably foreseeable, but substantial increases in
21 emissions of criteria air pollutants or precursors in the primary and extended
22 study areas are unlikely to make a cumulatively considerable contribution to an
23 overall cumulatively significant impact on air quality. For cumulative effects of
24 climate change on other resource areas, please see the “Cumulative Effects”
25 sections in other chapters of this DEIS.

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

28 Under the project alternatives (CP1 – CP5), construction activities would result
29 in short-term emissions of ROG, NO_x, and PM₁₀ that without mitigation would
30 exceed applicable SCAQMD thresholds. After implementing the best available
31 and all feasible mitigation measures, ROG and PM₁₀ emissions would not
32 exceed applicable thresholds; and in combination with past, present, and
33 reasonably foreseeable future projects, would not result in an overall
34 cumulatively significant impact. Therefore, with mitigation, these emissions
35 would not be cumulatively considerable. Emissions of NO_x, however, would
36 still exceed the applicable SCAQMD threshold after implementation of the best
37 available mitigation measures. These emissions would be cumulatively
38 considerable, and this would be a cumulatively significant and unavoidable
39 impact.

40 Operation of any of the action alternatives would not result in cumulatively
41 considerable emissions of ROG, NO_x, and PM₁₀. Also, neither short-term
42 construction nor long-term operational sources would expose sensitive receptors

1 to substantial concentrations of CO, PM₁₀, PM_{2.5}, TACs, or odors. None of
2 these emissions would be cumulatively considerable contributions to a
3 significant cumulative impact of ROG, NO_x, and PM₁₀.

4 ***Lower Sacramento River and Delta and CVP/SWP Service Areas***

5 The project alternatives would not generate any short-term or long-term air
6 pollutant emissions in the extended study area. Therefore, there would be no
7 cumulative air quality impact.

8 ***Global Study Area—Climate Change***

9 As discussed in Section 5.1, “Affected Environment,” of this chapter, climate
10 change is a global phenomenon. All GHG emissions are considered cumulative.
11 The impact analyses for Impacts AQ-6 (CP1), AQ-6 (CP2), AQ-6 (CP3), AQ-6
12 (CP4), and AQ-6 (CP5), in Section 5.3.4, “Direct and Indirect Effects,” of this
13 chapter are cumulative analyses. All five project alternatives (CP1–CP5) would
14 result in short-term cumulative impacts that would be less than the suggested
15 significance threshold for this cumulative effect, and therefore are considered to
16 not make a cumulatively considerable incremental contribution to a significant
17 cumulative impact, and would have beneficial long-term effects. For cumulative
18 effects of climate change on other resource areas, please see the “Cumulative
19 Effects” sections in other chapters of this DEIS.

20