CHAPTER 4.0

ENVIRONMENTAL SETTING

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4.0 ENVIRONMENTAL SETTING

4.0.1 Overview of the Project Vicinity and Project Area

4.0.1.1 Feather River Basin

The Feather River watershed is located at the north end of the Sierra Nevada. The watershed is bounded by the volcanic Cascade Range to the north, the Great Basin on the east, the Sacramento Valley on the west, and higher elevation portions of the Sierra Nevada on the south. The Feather River watershed upstream of Oroville Dam is approximately 3,600 square miles and comprises approximately 68 percent of the Feather River basin. Downstream of Oroville Dam, the basin extends south and includes the drainage of the Yuba and Bear Rivers (see Figure 3.1-1 in Chapter 3 of this DEIR). The Yuba River joins the Feather River near the City of Marysville, 39 river miles downstream of the City of Oroville, and the confluence of the Bear River and the Feather River is 55 river miles downstream of the City of Oroville. Approximately 67 miles downstream of the City of Oroville, the Feather River flows into the Sacramento River, near the town of Verona, about 21 river miles upstream of Sacramento. The Feather River watershed, upstream of the confluence of the Sacramento and Feather Rivers, has an area of about 5,900 square miles.

The upper watershed (upstream of the Oroville Facilities) includes the West Branch, Upper North Fork, Lower North Fork, South Fork, and Middle Fork Feather River and ten smaller tributary creeks that drain directly into Lake Oroville. This watershed drains an area of 3,611 square miles. The North Fork and Middle Fork watersheds comprise 3,222 square miles of this area, including portions of the foothill and mountain regions of the northern Sierra Nevada and southern Cascade Range. The South Fork and West Branch watersheds contain the additional 389 square miles. The upper watershed is ruggedly mountainous, bisected by deep canyons in the western third of the watershed. The central third of the watershed is a transition zone consisting of broad alluvial valleys surrounded and separated by high, steep peaks and ridges. The headwater areas of the eastern third consist of long, broad meadow systems separated by relatively low ridges. Elevations range from 922 feet at the crest of Oroville Dam to more than 10,400 feet at Mount Lassen. The major tributaries as well as the major forks of the Feather River (including the South Fork, East Branch North Fork, North Fork, and Middle Fork) generally flow from east to west.

The upper watershed of the Feather River is owned and managed by a variety of federal, State, and local entities, including USFS, BLM, DPR, DFG, Butte County, and the City of Oroville. The North Fork Feather River canyon serves as a major east-west transportation arterial (Union Pacific Railroad and State Route [SR] 70) and has extensive hydropower generation development, producing more than 1,750 megawatts of electricity. The Middle Fork Feather River upstream of Lake Oroville is federally designated as a Wild and Scenic River.

4.0.1.2 Project Area

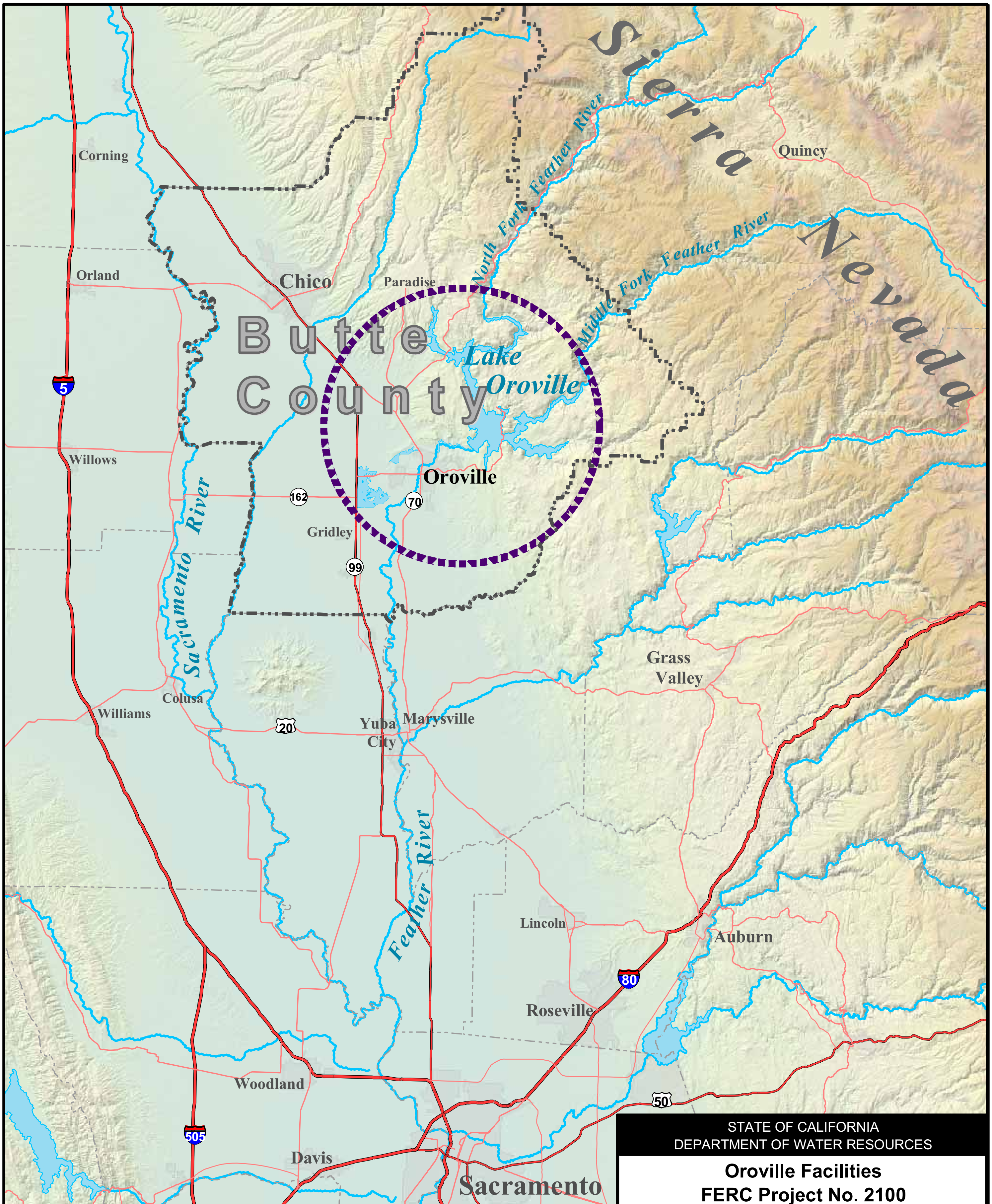
The Oroville Facilities are located on the Feather River in the foothills of the Sierra Nevada in Butte County (Figure 4.0-1). Oroville Dam is located 5 miles east of the City of Oroville and about 130 miles northeast of San Francisco.

The West Branch, North Fork, South Fork, and Middle Fork Feather River are the primary rivers that form the reservoir at Lake Oroville. Prior to construction of Oroville Dam, the Middle and South Forks joined 5.4 river miles above the Oroville Dam site, and were then joined by the North Fork 3 river miles below their confluence. Their confluence is now Lake Oroville, a 3.54-million-acre-foot (maf) reservoir that is one component of the Oroville Facilities. About half of the flow into Lake Oroville comes from the North Fork Feather River. The average annual inflow, dependent on annual precipitation, into Lake Oroville is approximately 4 maf. Outflow from the Oroville Facilities typically varies from spring seasonal highs that average about 8,000 cubic feet per second (cfs) to about 3,500 cfs in November.

Downstream of Oroville Dam, the Feather River flows can be diverted into the Thermalito Complex and the Feather River Fish Hatchery, and used to maintain instream flows in the Low Flow Channel (LFC) of the Feather River. Some of the water diverted to the Thermalito Complex is returned to the Feather River approximately 6 miles downstream of Oroville Dam. The Feather River, downstream of the Thermalito Afterbay Outlet and the confluence of the LFC, is generally known as the lower Feather River. The lower Feather River flows through a variety of habitat types, agriculture, and urban areas until its confluence with the Sacramento River. The flows in the lower Feather River are maintained relatively constant through regulation of the Thermalito Afterbay Outlet.

The mean annual discharge of the Oroville Facilities into the Feather River is in excess of 3.0 maf. In addition, mean annual releases to the Feather River Service Area (FRSA) from the Oroville Facilities total just under 1.0 maf. Hence the total mean annual discharge from the Oroville Facilities is approximately 4.0 maf. These waters are used for a variety of beneficial uses including recreation, coldwater aquatic habitat, hydropower generation, irrigation, and domestic and municipal water supply. The Oroville Facilities are a critical part of the SWP, providing much of the system's water collection and storage, flood management, and power production capacity.

At full pool (elevation 900 feet above mean sea level [msl]), Lake Oroville has a perimeter of approximately 167 miles and a surface area of approximately 15,400 acres.



Source: CA Spatial Information Library GIS / USGS DEM 30m / EDAW 2004

10 5 0 10 20 Miles

Original Scale 1 : 760,320
1" = 12 miles

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Oroville Facilities
FERC Project No. 2100

FIGURE 4.0-1

Project Vicinity

Prepared by: PJ -- EDAW, Inc.
Date 11/16/04
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When the reservoir elevation is minimum pool elevation, 640 feet, the shoreline perimeter decreases to approximately 107 miles and the reservoir surface area is approximately 5,796 acres. The areal extent between the shoreline at full pool level and the shoreline at minimum pool level at 640 feet (i.e., areal extent of the fluctuation zone) is approximately 9,550 acres.

4.0.2 Contents of This Chapter

The rest of this chapter summarizes the project area's affected environment. A brief description of the affected environment is provided for each resource area. These sections use the best data available to define existing conditions for each of the following resource areas:

- Geology, Soils, and Paleontological Resources;
- Surface Water Quantity and Quality;
- Groundwater Quantity and Quality;
- Aquatic Resources;
- Terrestrial Resources (wildlife resources and botanical resources, including federally and State listed species);
- Land Use;
- Recreational Resources;
- Cultural Resources;
- Population, Housing, and Public Services;
- Environmental Justice;
- Aesthetic Resources (visual resources and noise);
- Air Quality;
- Agricultural Resources;
- Traffic and Road Maintenance; and
- Public Health and Safety.

To help define existing project operations, complex modeling was undertaken for the January 2005 PDEA for the Oroville Facilities (DWR 2005) with input from members of the ALP Collaborative. CALSIM II, HYDROPS™, WQRRS, and PHABSIM modeling was conducted to simulate project operations and related hydrology effects and is described further in Appendix C of the PDEA (DWR 2005). This modeling helped the Collaborative better understand Oroville Facilities and SWP operations under numerous scenarios.

Supporting information for this chapter can be found in the PDEA (DWR 2005) and in the study plan reports that document the results of the various technical studies conducted as part of the collaborative process. The study plan reports can be found at DWR's Oroville Facilities Relicensing public website, http://orovillerelicensing.water.ca.gov.

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4.1 GEOLOGY, SOILS, AND PALEONTOLOGICAL RESOURCES

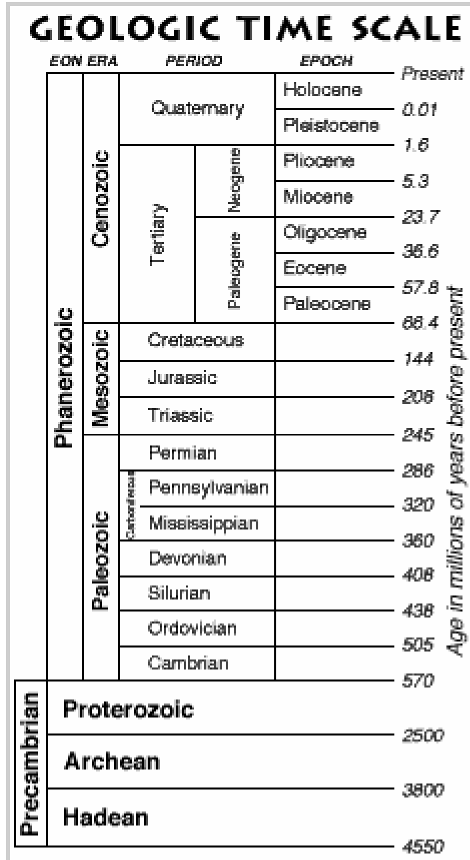
4.1.1 Regional Geology

4.1.1.1 Geologic Conditions

Approximately 85 percent of the upstream project area—the Feather River watershed above Thermalito Diversion Dam—is located within the metamorphic belt of the Sierra Nevada Geomorphic Province. The remaining 15 percent is located within the Cascade Range Geomorphic Province. The area downstream of Thermalito Diversion Dam is within the Sacramento Valley portion of the Great Valley Geomorphic Province. The Sierra Nevada Geomorphic Province consists of granitic intrusions, andesitic flows and breccia, basalt, metamorphic rocks, ultramafic rocks, and unconsolidated sedimentary deposits. The mountainous western slope of the Sierra Nevada ramps upward relatively gently from the Great Valley Geomorphic Province and is incised by southwest trending, steep-sloped river canyons, such as the Feather River Canyon, that are more than 3,000 feet deep. Highly weathered or decomposed granite, which is erodible and prone to landslides, is found in the eastern watershed and along portions of the North Fork Feather River canyon.

The Cascade Range Geomorphic Province extends about 500 miles from southern British Columbia to south of Lassen Peak and includes 495 square miles of the Feather River watershed, from Lassen Peak to Lake Almanor. Rocks of this province include Pliocene to Holocene age tuff, breccia, volcanic ash, lava flows, and basaltic to rhyolitic lahars. (See Figure 4.1-1 for the time frames associated with each eon, era, period, and epoch in the geologic time scale.)

The Great Valley Geomorphic Province is a narrow, elongated, asymmetrical, north-northwest trending basin that extends for about 450 miles between the Sierra Nevada and Coast Ranges Geomorphic Provinces. The northern portion is known as the Sacramento Valley (Norris and Webb 1990). The valley floor is an alluvial plain of unconsolidated Holocene deposits that overlie more consolidated alluvial and lacustrine deposits of Quaternary to Jurassic age. Below these sedimentary deposits are shales and sandstones of the Cretaceous Great Valley Sequence and upper Jurassic bedrock of metamorphic and igneous rocks associated in the east with the Sierra Nevada and in the west with the Coast Ranges (Norris and Webb 1990).



Source: NPS Website

Figure 4.1-1. The geologic time scale.

4.1.1.2 Regional Faulting and Seismicity

The project area is located in northeastern California, an area that has historically experienced relatively low seismic activity. Overall, the Sierra Nevada and Central Valley move collectively as an independent block, the eastern margin of which is formed by faults of the Sierra Nevada Fault Zone. Two fault types offset rocks in the watershed: high-angle reverse faults in the Sierra Nevada Geomorphic Province and normal faults in the Sierra Nevada and Cascade Range Geomorphic Provinces.

The dominant structure of the Sierra Nevada metamorphic belt and the project area is the Foothills Fault System. This series of north-northwest trending, east-dipping reverse (compressional) faults was formed during the late Jurassic era when subduction along the western continental margin resulting in the Nevadan orogeny (mountain-building event). The Foothills Fault System, though considered relatively quiet seismically, is important given the system's influence on the geologic structure of the project region. Seismicity on these faults has been reactivated in the late Cenozoic era (Wong 1992).

4.1.1.3 Volcanic Activity

Lassen Peak, considered to be one of the few active volcanoes in the continental United States, is located about 98 miles north of the City of Oroville. The last series of volcanic eruptions at Lassen Peak, between 1914 and 1917, deposited volcanic ash over a fairly wide area surrounding the cone. Localized mudflows were also deposited in stream valleys around the volcanic cone. There is no record of any significant ash or mud deposit reaching Butte County within historic time.

Although geologic hazards do exist in the area of Lassen Volcanic National Park, a review of historical and geological data suggests that the possibility of mudflows, flowing avalanches, or volcanic activity endangering the people of Butte County is very remote. Lassen Peak is being studied and monitored by the U.S. Geological Survey for seismic and volcanic activity. According to Professor E. H. Williams of the University of California, Berkeley, the monitoring system in place could provide an early warning of a potential volcanic eruption.

4.1.2 Project Geology

4.1.2.1 Upstream of Oroville Dam

As mentioned previously, the western metamorphic belt of the Sierra Nevada Geomorphic Province underlies a significant portion of the project watershed. These rocks range in age from Ordovician to Cretaceous (see Figure 4.1-1), and extend from Lake Almanor in the north to about Mariposa in the south (Norris and Webb 1990). This metamorphic belt is defined largely by a collective system of faults, the Foothills Fault System, which formed initially during the tectonic evolution of the region (Carlson 1990).

Most of the lower watershed consists of rocks of the western metamorphic belt, including metamorphosed gabbroic, diabase, and granitic rocks, that are exposed south and east of Lake Oroville. These assemblages are derived primarily from a volcanic island arc that became attached to the continental margin during the Jurassic Period (approximately 200 million years ago) and are identified locally as the Smartville Ophiolite Complex. Most of the Smartville Ophiolite Complex consists of basaltic to andesitic volcanic and volcaniclastic rocks, shown on geologic maps of the area as "mv" and "Jv" (Figures 4.1-2 and 4.1-2a). These rocks include the Foothill Melange-Ophiolite belt (Carlson 1990), with an almost continuous, 3-mile-wide band of ultramafic Mesozoic rocks crossing the watershed from northwest to southeast. These rocks consist largely of serpentinite, but also include peridotite, pyroxenite, and talc schist. Serpentinite is a moderately soft, green alteration product of ultramafic igneous rock prominent in the central portion of the watershed. It is generally associated with fault zones and may contain asbestos. These rocks are structurally weak and prone to landslides.

Geologic Legend

Symbol	Description
Qls	landslide
Qal	recent deposits (undifferentiated) -- alluvium, colluvium, terrace and fan deposits, dredge tailings and fill.
Cg	gravels -- bedded and flat-lying conglomerate, sand and silt. The conglomerate is weakly cemented, matrix is reddish-brown, clasts are mostly locally derived metamorphic, intrusive and volcanic rocks. The sand and silt is often cross-bedded and lensoid.
Tt	Tuscan Formation - gently dipping basaltic to andesitic flows, mudflow breccia, tuff, volcanic sandstone and conglomerate.
Tl	Lovejoy Formation -- gently dipping, dark, fine-grained olivine basalt.
Mi	intrusive rocks -- medium to coarse grained diorite, granodiorite and trondhjemite in plutons, dikes and plugs.
Ti, Tag, Tot	Ione Formation -- bedded and gently dipping, buff to reddish, quartz-rich sandstone, claystone and siltstone, plus minor conglomerate, shale and lignite. Tag: "Auriferous Gravel" member -- white quartz and chert-rich pebble conglomerate, quartz-rich sandstone, siltstone and relect ash. Tot: "Oroville Tuff" member -- bedded, white to buff, andesitic mudflow, tuff, volcanic sandstone and minor conglomerate.
Kc	Chico Formation -- well bedded, brown to buff, fossiliferous arkose with minor pebble conglomerate.
Jm	Monte de Oro Formation -- well bedded, steeply dipping, dark buff to gray, foliated, slightly metamorphosed, fossiliferous graywacke and minor conglomerate.
Js	Smartville ophiolite -- dark gray to green gray, steeply-dipping, strongly foliated, metamorphosed, basaltic to diabasic volcaniclastic sediment, pillow lava, breccia, dikes and sills; gabbroic to felsic screen rocks occur within sheeted dikes; gabbroic plugs are rare.
Ja	arc complex rocks -- Ja : dark to light blue green, poorly foliated, metamorphosed, andesitic to basaltic agglomerate, tuff breccia and tuff. Ja s dark, well foliated, metamorphosed argillite and graywacke.
m, ma, ls, ms, mv	melange -- m: undifferentiated. m : metavolcanic rock, dark, fine-grained, basaltic flows (?) m : metavolcanic rock (arc derived) dark to light blue green, slightly metamorphosed andesitic agglomerate and tuff breccia. m : metasedimentary rock, dark to light colored, strongly foliated slate, phyllite, graywacke, conglomerate, plus minor chert and marble. ls: limestone.
sp	serpentine -- dark to light green, highly sheared, commonly associated with faults; includes minor metagabbro.

contact - dashed where approximately located, dotted where concealed.

fault - dashed where approximately located, dotted where concealed.

fault - questioned

Cenozoic faults shown in red.

thrust fault - dashed where approximately located, teeth on upper plate.

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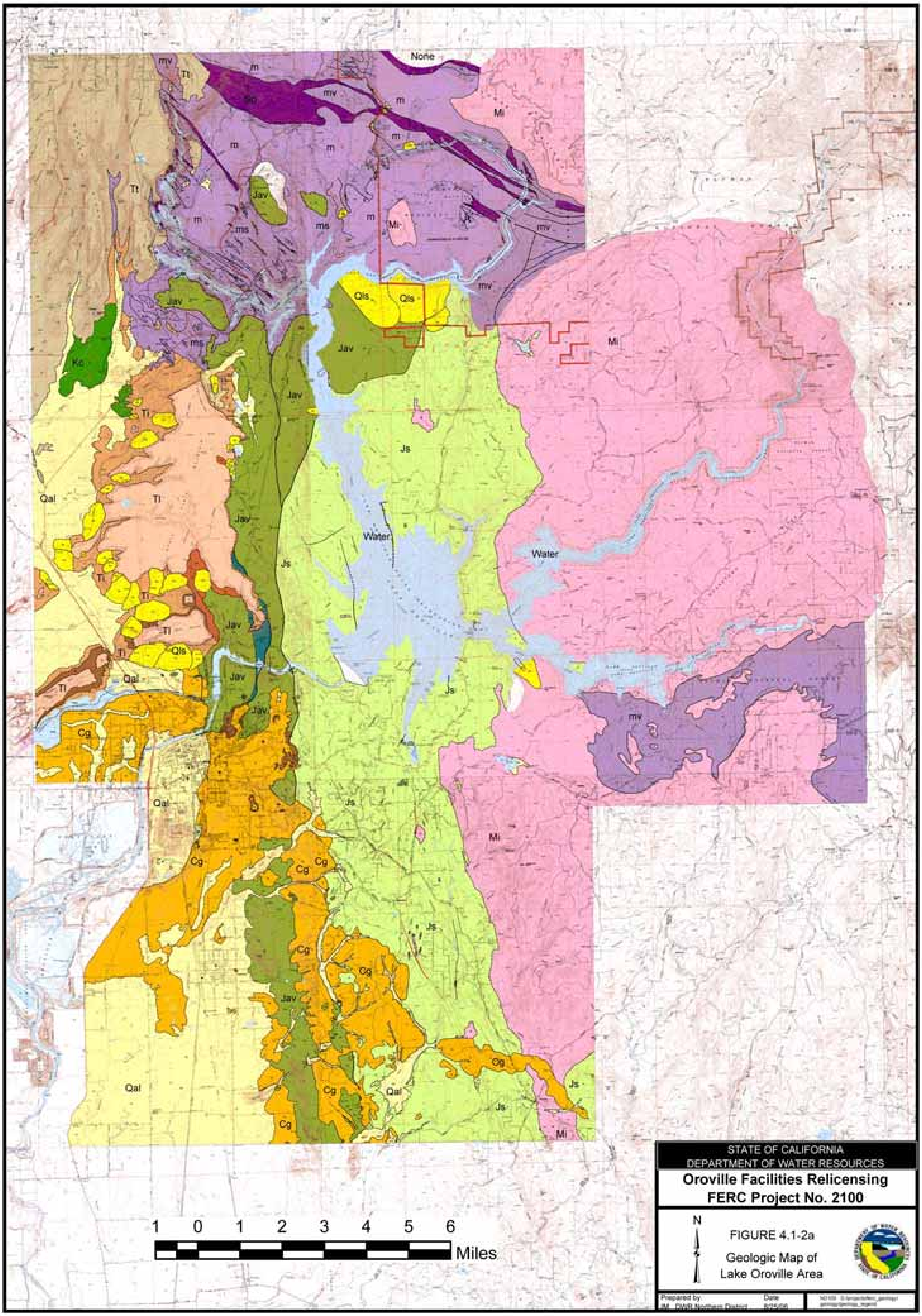
Geologic Legend
Figure 4.1-2
Geologic Map of
Lake Oroville Area

Prepared by: AMG DWR Northern District
Date 2/08/03
ND109 D:/projects/ferc_geology/geology/geology_legend


None
mv
Tt
m
Sp
mv
Mi
Jav
ms
Mi
mv
Qls
Kc
Ti
Qal
Js
Water
Jav
Ti
Qls
Cg
Qal
Mi
Js
Cg
Jav
Cg
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Mi
1 0 1 2 3 4 5 6
Miles
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FIGURE 4.1-2a
Geologic Map of
Lake Oroville Area
Prepared by:
Date

Gabbroic ("gb") and diabase ("db") rocks south and east of Lake Oroville may represent the basement upon which this Jurassic volcanic arc was formed. Within the last 100 million years, Cretaceous dikes, sills, and plutons of the Nevadan mountain-building period (i.e., the Merrimac, Bald Rock, and Swedes Flat plutons) intruded these older rock units.

4.1.2.2 Downstream of Oroville Dam

Scattered sedimentary and volcanic deposits (superjacent series) blanket the older bedrock units (subjacent series) of the region, mostly along the boundary between the Sierra Nevada and Cascade Range Geomorphic Provinces and the Great Valley Geomorphic Province west of Lake Oroville. From oldest to youngest, these superjacent units include the marine Chico formation from the upper Cretaceous, the fluviatile Ione formation ("Ei") and auriferous gravels ("Tag") of the Eocene Epoch, the extrusive volcanic Lovejoy basalt ("Mlb") of the late Oligocene to early Miocene, and volcanic flows ("Pv") and volcaniclastic rocks of the Tuscan formation ("Ptu") of the late Pliocene. Late Tertiary and Quaternary units include alluvial terrace and fan deposits of the Plio-Pliestocene Laguna formation ("Pl"), the Riverbank ("Qr") and Modesto ("Qm") formations of the Pleistocene, riverbed sediments ("Q") of the Holocene, and historic dredge and mine tailings ("t") from 20th century mining activities. The geologic units that outcrop along the Feather River downstream of the Fish Barrier Dam are described below.

The Plio-Pleistocene Laguna formation consists of interbedded, semiconsolidated, reddish-yellow to tan-green alluvial gravel, sand, and silt. It is about 150 feet thick and has been correlated with the Tehama formation of the northern Sacramento Valley. The ancestral west-flowing Feather, Yuba, Bear, and American Rivers deposited the formation. The Laguna formation is exposed in a number of riverbanks, but it can be seen only during low flows in the lower bank. Laguna deposits are believed to comprise resistant outcrops that form the ledge and rapids along the Feather River at Shanghai Bend. The presence of the Laguna formation in the lower riverbank is believed to be the primary reason that banks mapped as the Modesto and Riverbank formations are so erosion resistant.

The Pleistocene Riverbank formation, believed to range between 130,000 and 450,000 years old, has been divided into lower and upper members. Both members consist of weathered reddish gravel, sand, and silt and form planar terraces on both sides of the river. The lower member is somewhat more consolidated and erosion resistant. Both members are typically deposited on benches underlain by Laguna, Ione, and older deposits. In places, the Riverbank formation forms the edge of the Feather River meander belt, but it has not been identified in any eroding banks.

The Pleistocene Modesto formation, estimated to range between about 12,000 and 42,000 years old, is a set of terrace deposits that is younger than the Riverbank formation but also composed of lower and upper members. These terrace deposits consist of tan to light gray gravelly silt, sand, and clay and lie topographically above the Holocene river deposits. The lower member is distinguished by a clay-rich horizon formed from a soil layer. The upper and lower members constrain the meander belt on both sides of the Feather River for most of its valley length. The Modesto formation is exposed in a number of riverbanks as far south as the Sutter Bypass. In places, the Laguna formation underlies the Modesto and may be partially responsible for the greater erosion resistance of these banks.

Alluvium is a general description of undifferentiated Holocene river sediments and may include floodplain, point bar, channel, and other deposits found in the Feather River meander belt. Stream channel deposits occur in active channels of the Feather, Bear, and Yuba rivers and tributary streams and are transported by present-day hydraulic conditions. These deposits contain clay, silt, sand, gravel, cobbles, and boulders in various layers and mixtures that reflect conditions at the time of deposition. Between 1855 and the early 20th century, upstream hydraulic mining caused a large increase in riverbed sedimentation; as a result, the lower Feather River became covered in a thick deposit of fine clay-rich, light yellow-brown slickens (i.e., pulverized matter from a quartz mill, or the lighter soil of hydraulic mines). These slickens have been buried by more recent floodplain deposits but are evident in eroding banks along most of the river.

Dredge tailings are large piles of gravels and cobbles generated by commercial gold mining activities that are found adjacent to the Feather River between the cities of Oroville and Gridley. Large floating dredges were once employed to process riverbed material, extract the gold, and deposit the remaining gravels in long piles along the riverbank. A large amount of the dredge tailings in the Oroville Wildlife Area was used to construct Oroville Dam.

4.1.2.3 Regional Faulting and Seismic Setting

The Oroville Facilities Project area has historically experienced relatively low seismic activity. The only known active fault (movement within the last 35,000 years) near the project area is the Cleveland Hill fault. This approximately 5.5-mile-long fault is located about 3 miles south of Oroville Dam. The Cleveland Hill fault ruptured on August 1, 1975, causing a 5.7 Richter magnitude earthquake felt in the City of Oroville. Other historic seismic events in the project area include a magnitude 4.6 earthquake that occurred near Chico on May 24, 1966, and a magnitude 5.7 earthquake located about 20 miles east of Chico that occurred on February 8, 1940. With the exception of these seismic events, most of the significant Quaternary and historic regional seismic activity is concentrated on faults located more than 60 miles to the north, east, and southeast of the project area.

Conditionally active faults (movement within the last 35,000–1.6 million years) include the Oregon Gulch fault, which passes through Lake Oroville, and the Paynes Peak and Prairie Creek fault zones, located to the south of Lake Oroville. Investigations into the Oregon Gulch fault have shown no evidence of Quaternary displacement. Evidence of small-scale, Cenozoic-era fault movements on the Paynes Peak and Prairie Creek fault zones has been identified.

According to the California Geological Survey (CGS), faults that have displaced soils within Holocene time (younger than 11,000 years) are classified as active. Faults that have produced earthquakes within Quaternary time (the last 2–3 million years) are classified as potentially active. The following faults within a 62-mile radius of Oroville Dam are considered by CGS to be active:

- Cleveland Hill Fault—See description above.
- Indian Valley Fault—This fault is approximately 7 miles long and is located about 48 miles northeast of Oroville Dam.
- Dunnigan Hills Fault—This fault is about 12 miles long and is located approximately 53 miles southwest of Oroville Dam. No historical earthquakes of magnitude 5.0 or greater have occurred on the Dunnigan Hills fault.

Faults in the project area are shown in Figure 4.1-3. Investigation performed by DWR following the 1975 Oroville earthquake indicated that the Cleveland Hill fault could be traced to within 1.4 miles of the Bidwell Canyon Saddle Dam. From this point, the Swain Ravine fault zone, which shows evidence of displacement during the last 10,000–100,000 years, appears to extend northward into Bidwell Canyon. Field investigations indicated that the fault zone apparently terminates in Lake Oroville.

The Oregon Gulch fault trends north to south through the project area, extending from southward from the West Fork Feather River to a point south of Lake Oroville where it is obscured by late Cenozoic surficial deposits. Investigations of the Oregon Gulch fault showed no evidence of Quaternary displacement.

4.1.2.4 River Geomorphology

<u>Conditions Upstream of Oroville Dam</u>

In the lower two-thirds of the Feather River watershed, both the Middle and North Forks of the Feather River flow in deeply incised canyons with little or no floodplain. In the upper one-third of the watershed, streams historically flowed in shallow meandering channels with broad floodplains covered with riparian vegetation. Floodwaters would quickly overtop the banks and deposit sediment on the valley floor. Under present conditions, however, land use changes have caused many of the headwater streams to lose their meander patterns, instead forming sharp V-shaped channels devoid of vegetation with tall, easily eroded banks.

The upper Feather River watershed (outside the Oroville Facilities FERC Project boundary) is producing high yields of sediment because of accelerated erosion. A U.S. Soil Conservation Service report, *East Branch North Fork Feather River Erosion*