4.7 Geology and Soils

Affected Environment

Geology

Regional Setting

The Battle Creek Salmon and Steelhead Restoration Project area is within the Cascade Range Physiographic Province, which borders the northern end of the Sacramento Valley on the east and northeast. The Cascade Province is a young volcano-tectonic province that separates the Sierra Nevada Range from the Klamath Mountains, and contains numerous stratovolcanoes. Stratovolcanoes, or composite volcanoes, are constructed of alternating layers of lava and pyroclastic deposits (mostly ash) along with dikes and sills. Tertiary to Quaternary age (Pliocene to Recent) volcanism within this province formed a constructional plateau that dominates geology within the project area and the surrounding region (Figure 4.7-1). This volcanic plateau is tilted slightly to the west and is deeply dissected by numerous west-southwest to west-northwest trending drainages, some of which are bounded by steep canyon walls.

The Sacramento Valley is situated to the west of the project area. The Valley is a complex structural trough, bordered on both its east and west margins by a series of normal faults, and farther to the west by a series of right-lateral strike-slip faults. Recent seismotectonic and neotectonic studies (Unruh et al. 1995) show the presence of active west-to-east directed thrust faulting at depth within, and west of, the Sacramento Valley.

In the northern part of the Sacramento Valley, broad open folds have been superimposed on trough sediments. Within the area between Red Bluff and Anderson, major fold axes trend east-west and are locally associated with normal faults of similar orientations (Cox 1971). The Battle Creek fault is one of these northeast-trending fault systems.

The most regionally extensive volcanic unit between Chico and Redding is the Tuscan Formation. The Tuscan Formation is a series of lahars (i.e., volcanic mudflows) composed of tuff breccia and lapilli tuff, with minor lava flows, flow breccia, airfall tuff, and reworked fluvial volcanic sediments of late Pliocene age. This unit has a maximum thickness of about 1,700 feet and once covered approximately 2,000 square miles (Lydon 1968).

Forcefully intruding into the Tuscan Formation are several Quaternary Age basaltic to andesitic volcanic centers with cinder cones, scoria, lava flows, and associated airfall and fluvial deposits. Felsic volcanism in the eastern part of the area produced flows of rhyolite and dacite, with local accumulations of airfall tuff and pyroclastics. During formation of the volcanic centers, large areas of the

basement tuff breccia underwent brittle fracture, and swarms of north to north-northwest and north-northeast trending fractures developed within it (Helley and Harwood 1985).

Local Setting

The project area has young volcanic centers bordering three of its sides: Black Butte to the north and northwest, Inskip Hill to the south and southwest, and Digger Butte to the east. Black Butte volcano borders the project area on the northwest, is within 3 miles of Wildcat Dam, and 7 miles of North Battle Creek Feeder Dam. This classically shaped volcanic cinder cone dominates the local landscape. Although its exact age is unknown, it probably formed about the same time as the cinder cones of Inskip Hill, Little Inskip Hill, and the Basalt Flows of Paynes Creek, which are dated by Helley and Harwood (1985) to have formed about 12,000 to 26,000 years ago. They also note that the twin volcanic cones of Digger Butte, about 4 miles east of the town of Manton, are about 450,000 years old or somewhat younger.

Farther east, but still within 20 miles, is the youngest volcanic center of significance to the project area, that of Mt. Lassen–Brokeoff Mtn.–Mt. Tehama. Mt. Lassen is the youngest volcano to have formed in the region. At a present day elevation of about 11,000 feet, it is one of the world's largest dacite volcanic domes. It formed over the past 2,000 years, with its most recent devastating eruption in the early 1900s. Schaffer (1999) states that there are 174 recorded eruptions for Mt. Lassen. He also notes that the most recent series of eruptions started on Memorial Day in 1914 and culminated with catastrophic eruptions in 1915 that destroyed a 1 by 3 mile area. From 1915 into 1917, eruptions became less frequent and from 1917 to the present, Mt. Lassen has been dormant. The dams on Battle Creek were built prior to the 1914–1917 eruptions of Mt. Lassen. There are no records stating that these structures were damaged by the volcanic eruptions.

Active faults are defined as those having had surface displacement within Holocene time (about the last 11,000 years). Potentially active faults are defined as faults having shown surface displacement during Quaternary time (the last 1.6 million years). According to the Fault-Rupture Hazard Zones in California (California Division of Mines and Geology 1999), no Alquist-Priolo Earthquake Fault Zones (i.e., active faults) pass through the Restoration Project area.

Shasta County has a low level of historic seismic activity. In the past 120 years, no substantial property damage or loss of life has been caused by earthquakes occurring within or near Shasta County. According to regional probabilistic ground shaking hazard maps (California Geological Survey 2003), the project area is subject to a 20 to 30% increase in earthquake-induced ground acceleration forces for a 10% probability of being exceeded in 50 years, a low probability relative to that of other portions of California.

Of particular significance to the project area is the regionally extensive, east-northeast trending Battle Creek fault zone. This structural zone comprises a

series of down-to-the-south normal faults with a composite length of more than 20 miles between the Sacramento River and Volta Powerhouse. The fault zone has an apparent vertical offset ranging from 130 feet on the west to more than 1,400 feet on the east (LaForge and Hawkins 1986). Battle Creek's channel runs essentially parallel to this fault system.

The Battle Creek fault zone is late Quaternary in age, cutting volcanic flows of the Basalt of Coleman Forebay (younger than 1.08+0.16 million years ago [m.a.]) and its faults are covered by basalt flows of Black Butte (26–12 thousand years ago [k.a.]) and andesite flows of Brokeoff Mountain (<0.45 m.a.) (Helley and Harwood 1985). A site-specific study of the fault, performed by Harlan Miller Tait Associates (1983), indicates the most recent fault movement to be 500 to 550 k.a. For this reason the Battle Creek fault system is considered inactive. Even though this is a major fault system, mapping by USGS shows the position of the faults to be well north of the specific project construction sites. The fault zone comes closest to the North Battle Creek Feeder Diversion Dam site, where it is approximately ½ mile to the north.

Broad open folds are present in local volcanic bedrock. One example of this is within a cliff-forming portion of the Tuscan Formation to the southwest of Coleman Diversion Dam. Here, the contact between two tuff breccia flow members allows the observer to note a broad, open fold with an axis trending to the east-northeast.

Basement rocks within the project area are comprised of Pliocene age (about 2.4 million years) tuff breccia and flow breccia emplaced as volcanic mudflow (lahar) deposits, volcanic derived stream (fluvial) deposits, and minor airfall lapilli tuff. Helley and Harwood (1985) mapped these rocks as Unit D of the Tuscan formation (Ttd). Work by Lydon (1968) indicates that the tuff breccia is at least 500 feet thick within the project area.

Quaternary age volcanic flows, with minor airfall tuff and fluvial deposits, unconformably overlie the Tuscan Formation. In some places, volcanic flows directly cover the Tuscan Formation (i.e., on the plateau above South Powerhouse) and in other places, fluvial sediments formed alluvial fans or streams cut channels into the Tuscan Formation prior to the onset of basaltic volcanism (i.e., on the plateau above Inskip Powerhouse).

The Tertiary/Quaternary Age Red Bluff Formation comprises regionally extensive pediment deposits that unconformably overlie tuff breccia of the Tuscan Formation, and are present as erosional remnants on plateaus and hills flanking the northern Sacramento Valley. Within the project area, the Red Bluff Formation is composed of poorly to well-indurated gravel, cobbles, and boulders in a clayey sand matrix and is locally capped by, or interbedded with, basalt flows.

Recent deposits of colluvium (a mixture of weathered rock, soil, and other usually angular material on a slope) are generally thin. Soil zones across the volcanic plateaus are poorly developed clayey gravel with sand and cobbles, and

are generally less than a few feet thick above fresh volcanic bedrock. However, weathering of the underlying basalt locally extends several feet to greater than 10 feet. Colluvium is generally deeper (a few feet to 20 feet) on hillsides and above terrace deposits. The soil is similar to that on the plateaus: poorly developed and composed of clayey gravel with sand, cobbles, and boulders.

There is no geomorphic evidence of landslides of significant size in the vicinity of proposed structure sites along South Fork Battle Creek. Outcrops of tuff breccia along this drainage form stable canyon slopes that are not prone to develop landslides.

Proposed construction sites along North Fork Battle Creek are located in deep canyons incised through several basalt flows. Along the creek there are numerous rockfall sites where 3- to 15-foot-diameter boulders have fallen from the canyon walls or where larger sections of the canyon wall have collapsed. A section of a 24-inch water pipeline from Wildcat Diversion Dam was damaged by such a rockfall in 1995 and was never rebuilt. All project sites within basalt canyons contain a certain risk of significant rockfall danger.

North Battle Creek Feeder Diversion Dam

The North Battle Creek Feeder Diversion Dam is situated in a steep canyon with a width of about 400 feet at the rim, narrowing to a creek bed of about 50 feet wide. The canyon walls are composed of several basalt flows, stacked one upon another. Parts of these flows are thick, hard, and massive while other parts are thin and intensely fractured rubble. All basalt flows from the rim of the canyon to the North Battle Creek Feeder Diversion Dam site are grouped together as Quaternary Basalt Unit 1 (Qb1). The only other significant geologic units in the canyon are Quaternary Colluvium (Qc) on the hillside, Quaternary Alluvium (Qal) in the present-day creek bed, and Quaternary Reservoir Sediment (Qrs) that is impounded behind the dam. Natural rockfall from the sides of the canyon have littered the creek bed and construction area with an abundance of large boulders 3 to 11 feet across. These boulders form an alternating series of rapids and small quiet pools along the river.

Typical joint patterns in local basalt flows create about 15% blocks of hard basalt greater than 6 feet across; about 20% blocks of basalt 3 to 6 feet across; about 30% blocks of basalt 1 to 3 feet across; about 20% cobble-size clasts loose to very loosely held together by finer scoria; about 10% angular to subangular, highly vesicular, fresh to moderately weathered, hard to soft, gravel-size clasts very loosely held together by finer scoria; and about 5% sand and finer material. Soft, red-brown, weathered scoria that can easily break down into fine material by mechanical weathering. Local zones are weathered to clay.

At the dam, the reservoir sediment is estimated to be about 8 feet thick. Beneath the reservoir sediment, the natural creek bed hosts alluvium (Qal) with a much higher percentage of coarse alluvium, with a maximum size of about 10 feet. The depth to bedrock Qb1 basalt beneath reservoir sediment is unknown. It may

be a few feet below the top of the natural creek bed, or several feet below. Where present in the creek bed, bedrock is likely to be moderately to slightly fractured, hard basalt.

The reservoir sediment (Qrs), as seen on the surface of the creek bed, is composed primarily of about 20% 3- to 5-inch-diameter, hard, subangular to subrounded cobbles; about 45% 5- to 12-inch-diameter, hard, subangular to subrounded cobbles; about 15% hard, subrounded boulders; and the remainder less than 3 inches in diameter.

Other geologic conditions include a general lack of well-developed soil, large angular boulders within the stream channel, and steep canyon walls. These conditions are similar to those downstream at the Eagle Canyon and Wildcat Diversion Dam sites.

Eagle Canyon and Wildcat Diversion Dams

Located approximately 2 miles apart, Eagle Canyon and Wildcat Diversion Dams are located in the deep canyon of North Fork Battle Creek in geologically similar environments. At each site, there is an approximate 100- to 160-foot elevation difference between the rim of the canyon and the creek channel or dam site. Canyon walls are nearly vertical and several flows of basalt are exposed. All basalt flows from the rim of the canyon to the Eagle Canyon Dam site are grouped together as Quaternary Basalt Unit 2 (Qb2); and from the rim of the canyon to Wildcat Dam are grouped together as Quaternary Basalt Unit 3 (Qb3). The flows are composed of medium gray, vesicular olivine basalt. Most flows exhibit a 2- to 4-foot-thick top zone of highly vesicular, locally fractured basalt with flow textures. The middle zone is generally 6 to 15 feet thick and is composed of massive basalt with medium- to widely-spaced cooling joints and a blocky fracture. Flows near the top of the Eagle Canyon site have a massive (i.e., unfractured) zone up to 40 feet thick. The bottom few feet of each flow are generally composed of variably cemented basalt rubble.

The only other significant geologic units within the canyon are Qal in the present-day creek bed, and minor amounts of Qrs impounded behind each of the dams. Little to no soil is present on near-vertical canyon walls. Shallow soil cover is present on localized, discontinuous benches.

Vertical basalt cliffs or large angular basalt boulders border both sides of the canyon. Angular, 3- to 15-foot-diameter boulders randomly occur in the stream channel. Large boulders that have fallen from the sides of the canyon into the stream channel have not been transported downstream.

South Diversion Dam

Geology at the South Diversion Dam site was not mapped or studied in detail by Reclamation. Geologic site inspections observed Tuscan Formation tuff breccia outcrops on moderately steep canyon walls. The nearest overlying unit is Blue Ridge Rhyolite (Pleistocene age), which crops out along the north and northeast rims of the relatively open canyon. Soils above the tuff breccia and local colluvial deposits are generally shallow and poorly developed.

South Powerhouse and Inskip Diversion Dam

The primary rock type at the South Powerhouse and Inskip Diversion Dam is late Pliocene-age Tuscan Formation tuff breccia. This unit forms the basement rock and is composed of 40 to 60% hard volcanic clasts within a moderately hard to moderately soft tuff matrix. The rock is very durable and exhibits few significant joints or other fractures.

Tuff breccia is overlain near the inlet portal to the tunnel by Pleistocene-age basalt breccia. The basalt breccia consists of monolithologic (i.e., one rock type) basalt clasts and scoria. Small dikes or sills of basalt intrude the tuff breccia locally.

A 10- to 15-foot section of poorly to moderately consolidated terrace deposits overlies bedrock near the fish ladder/fish screen site. These deposits consist primarily of coarse gravel and cobbles, with minor sand and few boulders.

Colluvial deposits cover about 60% of the site. Although most of these deposits are less than 2 to 3 feet thick, deposits from 15 to 20 feet thick are present at the inlet of the proposed tunnel. The deposits are composed of unconsolidated to poorly consolidated sand, gravel, cobbles, and boulders up to 3 feet in diameter. A poorly developed soil zone composed of clayey gravel with sand is present in the upper 1 to 2 feet of colluvium.

Alluvial deposits within South Fork Battle Creek were deposited on a highly irregular bedrock surface. In several locations, bedrock crops out within the active creek channel. At other nearby locations the alluvial deposits are relatively thick, in excess of 20 feet. Active streambed deposits are generally coarse, with an abundance of gravel and cobbles, with minor sand and boulders.

Steep rock slopes and vertical relief from 10 to more than 20 feet are present in the creek channel immediately upstream of the South Powerhouse and downstream from Inskip Diversion Dam.

Inskip Powerhouse and Coleman Diversion Dam

Basement rock at the Inskip Powerhouse and Coleman Diversion Dam is Tuscan Formation tuff breccia that has similar properties to those described for the tuff breccia occurring near the South Powerhouse and Inskip Diversion Dam sites. The tuff breccia is generally very durable and erosion-resistant.

The tuff breccia is locally overlain by terrace deposits and colluvium that have a combined thickness of 5 to 20 feet, averaging less than 15 feet. The terrace deposits form a broad bench on the north side of South Fork Battle Creek and consist primarily of coarse gravel, cobbles, and boulders with minor sand and fines. The colluvium is mostly clayey gravel with sand, cobbles, and boulders. A soil zone rich in organic matter is well developed in the upper 2 to 3 feet of colluvium.

Alluvial deposits within the active creek channel have been deposited on an irregular surface of tuff breccia. A wedge of coarse-grained gravel and cobble deposits, approximately 15 feet thick, is backed up behind Coleman Diversion Dam. The depth of the alluvial deposits in the remainder of the channel has not been investigated.

A hillside sloping at approximately 20 degrees flanks the northern side of this site. Bedrock along the bottom two-thirds of the hillside is tuff breccia, locally covered by thin colluvium. Along the upper one-third of the hillside, the Quaternary-age and Tertiary-age Red Bluff Formation overlies the tuff breccia. The Red Bluff Formation is composed of poorly to moderately indurated gravel, cobbles, and boulders in a clayey sand matrix. The soil zone along this hillside is poorly developed, with an abundance of clayey gravel with sand and cobbles.

Inskip Powerhouse Penstock Bypass Site

The plateau at the Inskip Powerhouse penstock bypass is composed primarily of Basalt of Eagle Canyon, which is present as several thin flows of vesicular olivine basalt of Pleistocene age. The basalt is generally fresh and hard and is traversed by widely to very widely spaced joints, with local zones of moderate to intense weathering and closely to moderately spaced joints.

Along the western portion of the bypass alignment, the basalt flows overlie poorly to moderately indurated gravel, cobble, and boulder deposits of the Red Bluff Formation.

Approximately 60% of the pipeline and chute alignment will encounter shallow deposits of colluvium, 1- to 3-foot-thick overlying basalt. The colluvium consists of red clayey gravel and sand with cobbles and boulders. The soil is poorly developed to nonexistent across the plateau.

Soils

Based on Soil Conservation Service (1967 and 1974) mapping, the soils in the project area are generally underlain by volcanic rock or volcanic breccia. A number of the primary project element sites are mapped as areas of Rock land, which contain only scattered patches of very shallow soils.

Where appreciable soil materials are present, the Toomes and Supan series have been mapped. Toomes soils are on nearly level to very steep slopes, are well drained, and are shallow to very shallow over rock, rocky, and medium-textured. Supan soils are on undulating to steep slopes and are well drained, shallow over a clay subsoil, stony, and medium-textured. (Soil Conservation Service 1967 and 1974).

Because of the steep slopes in the project area, both the Toomes and Supan soils and the soil materials in mapped areas of Rock land are subject to rapid runoff rates. They generally have a moderate to severe hazard of water erosion when the vegetative cover has been removed. (Soil Conservation Service 1967 and 1974) Wind erosion hazard is expected to be low to moderate for the Toomes and Supan soil given the characteristic soil particle sizes.

Table 4.7-1 provides a summary of salient soil properties at the primary project sites.

Table 4.7-1. Summary of Soil Characteristics at Primary Project Sites

Project Element Site	Soil Mapping Unit	Runoff Rate	Wind Erosion Hazard with Vegetation Removed	Water Erosion Hazard with Vegetation Removed	Typical Thickness Over Rock or Restrictive Layer (inches)
Inskip Diversion Dam	Toomes very rocky loam, 30 to 50% slopes and Supan stony loam, 30 to 50% slopes	Rapid	Inferred to be low to moderate	High to Severe	8 to 20
Lower Ripley Creek Feeder	Toomes rocky loam, 10 to 30% slopes	Inferred to be medium	Inferred to be low to moderate	Inferred to be moderate	12 to 24
Soap Creek Feeder	Supan stony loam, 10 to 30% slopes	Medium	Inferred to be low to moderate	Moderate	20
South Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable

Project Element Site	Soil Mapping Unit	Runoff Rate	Wind Erosion Hazard with Vegetation Removed	Water Erosion Hazard with Vegetation Removed	Typical Thickness Over Rock or Restrictive Layer (inches)
Inskip Powerhouse/ Coleman Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable
Wildcat Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable
Eagle Canyon Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable
North Battle Creek Feeder Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable
New Access Road for North Battle Creek Feeder Diversion Dam	Rock land	Inferred to be high	Inferred to be low	Inferred to be moderate to high	Not applicable
New Access Road for Inskip Diversion Dam	Toomes very rocky loam, 30 to 50% slopes	Inferred to be rapid	Inferred to be low to moderate	Inferred to be high	12

Source: Soil Conservation Service 1967 and 1974.

Regulatory Setting

The following geology-related regulations apply to the Restoration Project.

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act was signed into law December 22, 1972, and went into effect March 7, 1973. The Act, codified in the Public Resources Code as Division 2, Chapter 7.5, has been amended 11 times. The purpose of this Act is to prohibit the construction of most structures for human occupancy across the traces of active faults and to thereby mitigate the hazard of fault rupture (Section 2621.5 of the Public Resources Code).

California Surface Mining and Reclamation Act

The California Surface Mining and Reclamation Act (Pub. Res. Code Section 2710 et seq.) establishes statewide mineral conservation policies that are implemented by counties and cities through local surface mining ordinances. The ordinances apply to surface mining operations and would not be applicable to the proposed project. Nonetheless, these policies discourage local governments from allowing new incompatible uses (essentially defined as permanent, urban uses) in areas identified by the state geologist as containing mineral resources that are either locally important or of statewide value.

Uniform Building Code

The Uniform Building Code (UBC) is updated periodically by the International Conference of Building Officials. The UBC is a standard reference in California for earthquake and seismic design measures.

Environmental Consequences

Summary

Significant geology or soils impacts are associated with the No Action Alternative. The Action Alternatives (Five Dam Removal, No Dam Removal, Six Dam Removal, and Three Dam Removal) would result in significant water and wind erosion impacts. However, implementing the appropriate mitigation measures described below would reduce these impacts to a less-than-significant level. Disturbance would be limited to areas associated with construction, modification, or removal activities, including streambeds, stream banks, temporary and permanent access roads, staging areas, and Hydroelectric Project dam site facilities, conveyances, and appurtenant facilities. Reclamation will implement mitigation measures to reduce significant impacts to a less-than significant level.

Impact Significance Criteria

Based on Appendix G of the State CEQA Guidelines, the project would have a significant effect on the environment if it would:

- Expose people or structures to major geologic hazards, including earthquakes, ground failure, or similar hazards.
- Result in substantial soil erosion or the loss of topsoil.

- Be located on a geologic unit or soil that is unstable or would become unstable and could potentially result in a landslide, lateral spreading, subsidence, liquefaction, or collapse.

Impact Assessment

As applicable, the General Environmental Protection Measures listed in the introduction to this chapter shall be utilized for this resource. In addition, specific mitigation measures for geology and soils are identified below.

No Action Alternative

No geological or soil impacts are expected to occur from implementation of the No Action Alternative.

Five Dam Removal Alternative (Proposed Action)

Impact 4.7-1 Significant—Potential accelerated water and wind erosion from construction activities.

Extensive vegetation removal and ground disturbance would result from implementation of the Five Dam Removal Alternative. This disturbance would result from clearing, grading, blading, graveling, and related activities needed to facilitate construction of fish screens and ladders, as well as the removal of Wildcat, South, Soap Creek Feeder, Lower Ripley Creek Feeder, and Coleman Diversion Dams. Specifically, construction activities would expose soils to erosion at the following types of construction sites and facilities:

- Access roads, which would include intersection and turnout improvements from main roads, the construction of new roads at the North Battle Creek Feeder and Inskip Diversion Dam/South Powerhouse Dam sites, blading and graveling existing unimproved access roads, and other needed improvements at 13 separate sites.
- Staging areas, which include the clearing and grading of 14 to 17 separate sites ranging from 0.5 to 7.5 acres in size. These areas would typically be situated at the rims of canyons overlooking dam sites, near dam sites, or at the terminal points of access roads.
- Conveyances, which would include canals requiring excavation, backfilling, or realignment, overflow wasteways, bypass pipelines, chutes, canals, stilling basins, tailrace connectors, channels, tunnels, sluiceway chutes, and other water conveyances at 10 to 12 sites needed for completing Restoration Project hydraulic improvements.
- Appurtenant facilities, which include screen boxes, channel and gate structures, sediment trap basins, tailrace dikes and wasteways, tailrace access

ramps, borrow areas, and other facilities at 12 to 14 other sites needed to complete Restoration Project hydraulics.

- Dam site facilities, which would include dams to be removed or improved with fish screens and ladders, cofferdams, and other immediate construction activities within or adjacent to the eight dam sites, usually in-water.

These activities are individually and collectively significant because they could result in substantial soil erosion or the loss of topsoil. Because construction would take 3 years to complete and because construction contractors would be allowed a certain level of flexibility regarding construction methods and, to some extent, the locations for some of these activities, the actual extent and severity of these impacts would remain uncertain until construction has begun. Implementing the following mitigation measures would reduce this significant impact to a less-than-significant level.

Mitigation Measure for Impact 4.7-1. The construction contractor will implement an erosion and sediment control plan at each site where soils will be disturbed and or exposed by construction activities. Each plan will include appropriate erosion and sediment control BMPs to control accelerated erosion, slope instability, and sedimentation that could result from clearing, grading, and other ground-disturbing activities during construction. These activities, which would be included in the Storm Water Pollution Prevention Plan, to be prepared by Reclamation, may include but not be limited to:

- minimizing the amount of vegetation removal and soil disturbance to the extent practicable;
- spraying water on exposed soils to minimize wind erosion and dust during construction;
- avoiding the disturbance of steep slopes whenever feasible;
- constructing fill slopes of a 2:1 (i.e., horizontal:vertical) ratio or flatter;
- constructing V-ditches above cut and fill slopes to divert water from newly exposed slope faces, if appropriate;
- using temporary and permanent stabilization practices, such as temporary and permanent seeding, mulching, erosion control blankets, or aggregate surfacing;
- installing fiber rolls or silt fences downslope of disturbed areas to control sediment;
- constructing temporary or permanent sedimentation basins as needed;
- selectively removing, stockpiling, and replacing topsoil as a medium for revegetation (this measure should be implemented where more than 6 inches of topsoil is removed);
- stabilizing drainage channels using rock lining or similar natural materials;

- stabilizing borrow areas with temporary and ultimately permanent vegetation; and
- monitoring the BMPs and making repairs as required so that disturbed areas are adequately stabilized, as defined by the erosion and sediment control plans.

Impact 4.7-2 Less than Significant—Construction workers could be exposed to falling rocks.

Dam removal and potential blasting activities could expose construction workers to safety hazards, including injury or loss of life from falling rocks along North Fork Battle Creek. Construction contractors will enforce applicable federal, state, and local safety standards during all dam removal and construction activities. Accordingly, as part of Restoration Project implementation, Reclamation has committed to the following measures as worded in the construction specifications for the project:

- Do not require anyone employed in performance of the contract (including subcontracts) to work under conditions that are unsanitary, hazardous, or dangerous to the employee's health or safety.
- Under no circumstances will onsite work, including mobilization, be permitted until the safety program has been considered acceptable by the contracting officer's representative.
- Fully participate in a Contractor Safety Program Review meeting, according to the Reclamation's Safety and Health Standards, Section 3.4.1, prior to mobilization. Include subcontractor management representatives.
- The minimum work crew at any time on the construction site will consist of no less than two people and be in accordance with other contractual obligations.
- Develop job hazard analyses for each distinct phase of work under the contract. Work will not begin on the phase of work until a job hazard analysis is acceptable to onsite agency personnel. Activities involving hazardous materials shall have the appropriate Material Safety Data Sheet(s) attached to the job hazard analysis.
- In addition to complying with requirements listed under the clause entitled "Accident Prevention," fully comply with Reclamation's Safety and Health Standards. One copy of this handbook will be provided at no charge for use in connection with the specifications in accordance with the notice titled "Notice of Safety and Health Requirements and Safety Handbook Availability—Reclamation." Additional copies may be obtained from the Superintendent of Documents, item stock No. 024-003-00178-3, phone No. (202) 512-1800. Construction Safety and Health Standards promulgated by the Secretary of Labor may be obtained from any regional or area office of the Occupational Safety and Health Administration of the U.S. Department of Labor.

- Be cognizant of and ensure compliance with requirements set forth in the paragraphs above. Contractor's responsibility applies to all operations, including those of the contractor's subcontractors. When violations of safety and health requirements contained in these specifications or referred standards are called to the contractor's attention by the contracting officer or the contracting officer's representatives, immediately correct the condition. Either oral or written notice shall be deemed sufficient.
- When the contractor fails or refuses to promptly correct a compliance directive, the contracting officer or the contracting officer's representative may issue an order to stop all or any part of the work. When satisfactory corrective action is taken, an order to resume work will be issued. The contractor shall not be entitled to extension of time, nor to claim for damage or to additional compensation by reason of either the directive or the stop order. Failure of the contracting officer or the contracting officer's representative to order discontinuance of any or all of the contractor's operations shall not relieve the contractor of the responsibility for the safety of personnel and property.
- Maintain an accurate record of, and report to the contracting officer's representatives in the manner prescribed by the contracting officer, all cases of death, occupational diseases, or traumatic injury to employees or the public involved, and property damage in excess of $2,500 occurring during the performance of work under this contract.
- The rights and remedies of Reclamation provided in this section are in addition to any other rights and remedies provided by law or under this contract. In the event there is a conflict between requirements contained in Reclamation's Safety and Health Standards, specification paragraphs, contractor's approved safety program, referenced safety and health codes, and standards, or the U.S. Department of Labor Construction Safety and Health Standards, promulgated under Section 107 of the Contract Work Hours and Safety Standards Act (40 U.S.C. 327 et seq), as amended, the more stringent requirement shall prevail.

Implementation of these measures, especially the daily monitoring of rockfall hazards and strict adherence to safety precautions associated with the removal of workers prior to and during all blasting, would not eliminate the potential for a rockfall hazard resulting in injury or loss of life. However, strict implementation of these measures resulting in an awareness of rockfall hazards would reduce this significant impact to a less-than-significant level.

No Dam Removal Alternative

Impact 4.7-3 Significant—Potential accelerated water and wind erosion from construction activities.

Extensive vegetation removal and ground disturbance would result from implementation of the No Dam Removal Alternative. This disturbance would result from clearing, grading, blading, graveling, and related activities needed to

facilitate construction of the fish screens and ladders. This impact is similar to Impact 4.7-1 described under the Five Dam Removal Alternative.

Specific construction activities that would expose soils to erosion are listed under Impact 4.7-1. Because construction would take 3 years to complete and because construction contractors would be allowed a certain level of flexibility regarding construction methods and, to some extent, the locations for some of these activities, the actual extent and severity of these impacts would remain uncertain until construction has begun. However, implementing the mitigation measures for Impact 4.7-1 would reduce this significant impact to a less-than-significant level.

Impact 4.7-4 Less than Significant—Construction workers could be exposed to falling rocks.

Installation of fish screens and ladders could expose construction workers to safety hazards, including injury or loss of life from falling rocks along North Fork Battle Creek. This impact is similar to Impact 4.7-2 described above under the Five Dam Removal. Construction contractors will enforce applicable federal, state, and local safety standards during all dam removal and construction activities. Accordingly, as part of Restoration Project implementation, Reclamation has committed to the measures identified above under Impact 4.7-2, as worded in the construction specifications for the project. Implementation of these measures, especially the daily monitoring of rockfall hazards, would not eliminate the potential for a rockfall hazard resulting in injury or loss of life. However, strict implementation of these measures resulting in an awareness of rockfall hazards would reduce this significant impact to a less-than-significant level.

Six Dam Removal Alternative

Impact 4.7-5 Significant—Potential accelerated water and wind erosion from construction activities.

Extensive vegetation removal and ground disturbance would result from implementation of the Six Dam Removal Alternative. This disturbance would result from clearing, grading, blading, graveling, and related activities needed to facilitate construction of the fish screens and ladders, as well as the removal of Eagle Canyon, Wildcat, South, Soap Creek Feeder, Lower Ripley Creek Feeder, and Coleman Diversion Dams. This impact is similar to Impact 4.7-1 described under the Five Dam Removal Alternative.

Specific construction activities that would expose soils to erosion are listed under Impact 4.7-1. Because construction would take 3 years to complete and because construction contractors would be allowed a certain level of flexibility regarding construction methods and, to some extent, the locations for some of these activities, the actual extent and severity of these impacts would remain uncertain until construction has begun. However, implementing the mitigation measures for Impact 4.7-1 would reduce this significant impact to a less-than-significant level.

Impact 4.7-6 Less than Significant—Construction workers could be exposed to falling rocks.

Dam removal and potential blasting activities could expose construction workers to safety hazards, including injury or loss of life from falling rocks along North Fork Battle Creek. This impact is similar to Impact 4.7-2 described above under the Five Dam Removal. Construction contractors will enforce applicable federal, state, and local safety standards during all dam removal and construction activities. Accordingly, as part of Restoration Project implementation, Reclamation has committed to the measures identified above under Impact 4.7-2, as worded in the construction specifications for the project. Implementation of these measures, especially the daily monitoring of rockfall hazards and strict adherence to safety precautions associated with the removal of workers prior to and during all blasting, would not eliminate the potential for a rockfall hazard resulting in injury or loss of life. However, strict implementation of these measures resulting in an awareness of rockfall hazards would reduce this significant impact to a less-than-significant level.

Three Dam Removal Alternative

Impact 4.7-7 Significant—Potential accelerated water and wind erosion from construction activities.

Extensive vegetation removal and ground disturbance would result from implementation of the Three Dam Removal Alternative. This disturbance would result from clearing, grading, blading, graveling, and related activities needed to facilitate construction of the fish screens and ladders, as well as the removal of Eagle Canyon, Wildcat, and Coleman Diversion Dams. This impact is similar to Impact 4.7-1 described under the Five Dam Removal Alternative.

Specific construction activities that would expose soils to erosion are listed under Impact 4.7-1. Because construction would take 3 years to complete and because construction contractors would be allowed a certain level of flexibility regarding construction methods and, to some extent, the locations for some of these activities, the actual extent and severity of these impacts would remain uncertain until construction has begun. However, implementing the mitigation measures for Impact 4.7-1 would reduce this significant impact to a less-than-significant level.

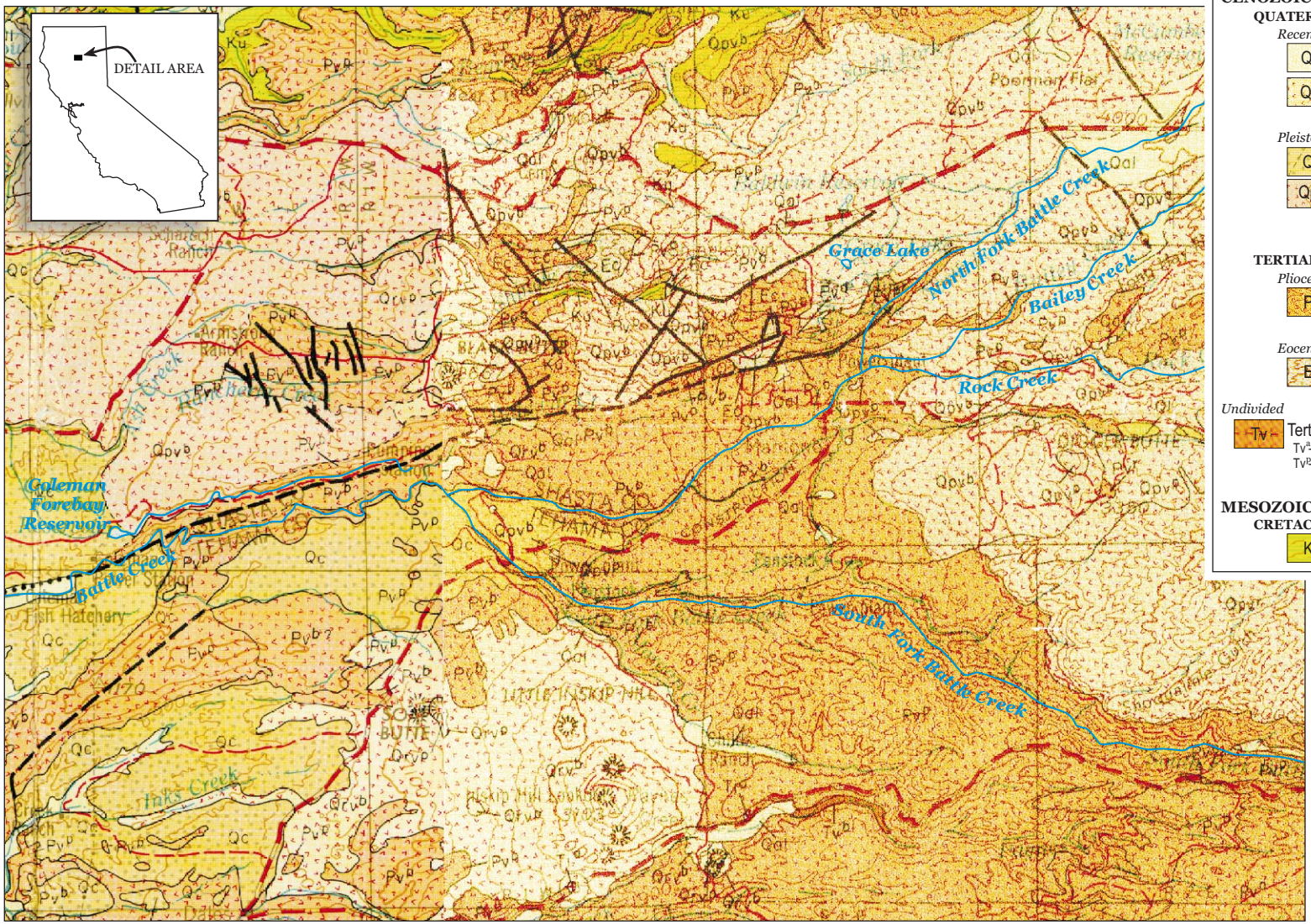
Impact 4.7-8 Less than Significant—Construction workers could be exposed to falling rocks.

Dam removal and potential blasting activities could expose construction workers to safety hazards, including injury or loss of life from falling rocks along North Fork Battle Creek. This impact is similar to Impact 4.7-2 described above under the Five Dam Removal. Construction contractors will enforce applicable federal, state, and local safety standards during all dam removal and construction activities. Accordingly, as part of Restoration Project implementation, Reclamation has committed to the measures identified above under Impact 4.7-2, as worded in the construction specifications for the project. Implementation of these measures, especially the daily monitoring of rockfall hazards and strict

adherence to safety precautions associated with the removal of workers prior to and during all blasting, would not eliminate the potential for a rockfall hazard resulting in injury or loss of life. However, strict implementation of these measures resulting in an awareness of rockfall hazards would reduce this significant impact to a less-than-significant level.

Cumulative Impacts

Implementation of the Restoration Project, in combination with other past, present, and reasonably foreseeable projects (including those mentioned in Chapter 6), would not result in cumulative impacts on geologic and soil resources. Engineering feasibility studies and planning for Restoration Project construction have accounted for past impacts to geologic and soil resources and incorporated these considerations into the alternative feasibility planning and subsequent descriptions. There are no other present or reasonably foreseeable projects that would potentially affect geologic and soil resources in areas to be disturbed by Restoration Project construction activities. The impacts associated with the Coleman National Fish Hatchery improvements are unknown at this point. Any future environmental documentation associated with Coleman National Fish Hatchery improvements would disclose environmental impacts.



CENOZOIC

QUATERNARY

Recent

Qal Alluvium

Qrv Pleistocene volcanic: Qpv^{r}--rhyolite; Qpv^{a}--andesite; Qpv^{b}--basalt; Qpv^{p}--pyroclastic rocks

Pleistocene

Qc Pleistocene nonmarine

Qpv Pleistocene volcanic: Qpv^{r}--rhyolite; Qpv^{a}--andesite; Qpv^{b}--basalt; Qpv^{p}--pyroclastic rocks

TERTIARY

Pliocene

Pv Pliocene volcanic: Pv^{r}--rhyolite; Pv^{a}--andesite; Pv^{b}--basalt; Pv^{p}--pyroclastic rocks

Eocene

Ec Eocene nonmarine

Undivided

Tv Tertiary volcanic: Tv^{r}--rhyolite; Tv^{a}--andesite; Tv^{b}--basalt; Tv^{p}--pyroclastic rocks

MESOZOIC

CRETACEOUS

Ku Upper Cretaceous marine

N

0 2500

FEET

Source: Geologic Map of California, Olaf P. Jenkins Edition, Westwood and Redding Sheets

Figure 4.7-1

Regional Geology