6.3 Geology, Geomorphology, and Soils

6.3 Geology, Geomorphology, and Soils

This section describes the geology, fluvial geomorphology, and soils in the vicinity of the Upper North Fork Feather River Hydroelectric Project (UNFFR Project) and evaluates whether the operation of the UNFFR Project under a new Federal Energy Regulatory Commission (FERC) license would result in impacts related to these resources. The following topic is not discussed in this section for the reason noted:

- **Rupture of Earthquake Faults:** No significant earthquake faults have been documented near the UNFFR Project.

The potential impacts of the Proposed UNFFR Project were evaluated in the *Final Environmental Impact Statement (EIS) for the Upper North Fork Feather River Project* issued by FERC (Federal Energy Regulatory Commission 2005). As allowed under Section 15150 of the CEQA Guidelines, the State Water Resources Control Board (State Water Board) is incorporating by reference certain sections of the Final FERC EIS, which analyzes the impacts of UNFFR Project operations on geology, geomorphology, and soils. Since neither Alternative 1 or Alternative 2 nor the supporting analyses were included in the FERC EIS, they are discussed in this section of the EIR with respect to geology, geomorphology, and soils.

6.3.1 Environmental Setting

Geology Setting

The North Fork Feather River watershed is commonly referenced as the boundary between two geomorphic provinces: the Cascade Range Province and the Sierra Nevada Province. The Cascade Range Province to the north is characterized by volcanoes, while the Sierra Nevada Province to the south is known for large granitic intrusive bodies surrounded by metamorphic rocks of marine origin (Earthworks Restoration Inc. and CH2M Hill 2007). The mountain ranges within these two provinces form a nearly continuous barrier between the Great Basin and the Central Valley of California. In the North Fork Feather River canyon, rocks of the southern Cascade Range overlay the much older rocks of the Sierra Nevada. This geologic contact is exposed at a number of locations, including along the Belden reach, downstream of Oak Flat powerhouse.

The history of volcanic activity in the southern Cascade Range dates back to the Miocene epoch (26 million years ago) and continues into the Holocene epoch (recent years). Mount Lassen, the southern termination of the Cascade Range, is situated approximately 25 miles northwest of Lake Almanor. Mount Lassen's most recent eruptive period began in 1914 and lasted several years; the largest eruption was in 1915, when Mount Lassen exploded, sending pumice and rock fragments down its northeastern slope and raining ash as far as 200 miles to the east. This eruption created the larger and deeper of the two craters seen today near the volcano's summit.

Rocks in the southern Cascade Range are Pliocene to Holocene in age (less than 6 million years old) and represent episodic volcanic activity, including basalt flows, volcaniclastic sediment deposits (e.g., tuff, breccia, volcanic ash), and localized cinder and hydrothermal deposits (California Division of Mines and Geology 1966). Sedimentary (e.g., glacially derived tills and moraines), lakebed, and floodplain deposits are also evident throughout the southern Cascade Range.

The Sierra Nevada was formed by the intrusion of granitic plutons into older Paleozoic and Mesozoic metavolcanic and metasedimentary rocks approximately 77 to 225 million years ago (California Division of Mines and Geology 1966). In a plate tectonic setting, the older Paleozoic and Mesozoic formations represent a series of oceanic volcanic arcs similar to what is today found in the South Pacific (Dickinson 2008, Ernst et al. 2008, Day and Bickford 2004). Over geologic time, these volcanic arcs moved by plate tectonics until they individually accreted to (glued to) the proto-North America continent Laurentia. These rocks are found in the North Fork Feather River watershed and are called the Feather River terrane. The Feather River terrane is thought to be a tectonic fossil of these volcanic arcs.

This tectonic evidence is similar to what is found in the eastern Klamath terrane, specifically within the Trinity subterrane. In the past several years, additional evidence substantiates a correlation between the Sierra Nevada and the Klamath Mountains Provinces (Snoke and Barnes 2006), and the Feather River terrane is thought to be an extension of the Trinity subterrane located within the eastern Klamath terrane to the northwest near Redding. The Feather River terrane continues southwards for about 90 miles (Hacker and Peacock 1990).

The intrusive process resulted in the local uplift and deformation of the overlying older rock, exposing the underlying granitic rocks. Continued uplift and erosion, accompanied by localized volcanic activity and extensive alpine glaciation during the Pleistocene (3.6 million years ago), created the present pattern of deep-walled valleys that characterize the Sierra Nevada. Massive Mesozoic granitic outcrops form the core of these mountains and are widely recognized for their dramatic relief and erosive nature.

Most of the rocks in the Sierra Nevada are much older than those found in the southern Cascade Range immediately to the north. Over time, the topography of the Sierra Nevada has been heavily influenced by multiple episodes of alpine glaciation, whereas the southern Cascade Range displays less evidence of alpine glaciation. The erosive nature and age of the Sierra Nevada rocks have resulted in locally extensive sedimentary deposits, including large deposits of glacial outwash and lakebed sediments associated with periodic episodes of glacial advance and retreat. In some locations, the boundary between the two mountain ranges is covered by deep volcanic deposits, and in other areas it is overlain by extensive glacial deposits (California Geological Survey 2002).

The landscape and geomorphic features evident in the general vicinity of the UNFFR Project are predominantly the result of volcanic activity, with some glacial influences. Downstream of Belden forebay, large outcrops of granitic rocks are exposed along the North Fork Feather River canyon. The rock formations around the northern, western, and southwestern sides of Lake Almanor consist of more recent Tertiary and Quaternary volcanic flows with minor amounts of volcanic ash and other materials formed by volcanic activity (e.g., pyroclastic flows or rock). On the northeastern, eastern, and southern shores, Paleozoic metasedimentary rocks are exposed, with minor amounts of metavolcanics (California Public Utilities Commission 2000). Alluvial deposits, including floodplain and lakebed sediments, overlay metamorphic rocks along the northwestern, southern, and eastern shores of Lake Almanor. Butt Valley reservoir and the surrounding area are underlain by Mesozoic metamorphic rocks of marine origin. These rocks are also exposed in the vicinity of the Caribou facilities and the Belden powerhouse near the confluence of Yellow Creek with the North Fork Feather River.

Geomorphology

The terrain in the North Fork Feather River watershed is as complex as the underlying geology. While the gentle slopes in the vicinity of Lake Almanor are controlled by the underlying volcanic terrain and deep soils of the southern Cascade Range, the steep, highly dissected terrain found along the Seneca and Belden reaches is indicative of metamorphic rocks of the Sierra Nevada. The Butt Creek watershed upstream of Butt Valley dam is representative of the southern Cascade Range; however, a noticeable change in slope and exposed rock is evident along lower Butt Creek below the dam.

Similar to the topographic distinctions observable in the uplands, river and stream channels in the general vicinity of the UNFFR Project exhibit characteristics representative of the two geomorphic provinces. Relative to channels in the Sierra Nevada, southern Cascade Range channels typically have lower stream gradients, smaller substrate sizes, higher base flows, and lower peak flows. They tend to rely more on spring flow than surface runoff due to the porosity of volcanic rocks. The role of large woody material also varies between channels in these two ranges.

Fluvial erosion and mass wasting in the North Fork Feather River canyon (e.g., landslides, rockslides) are the main geomorphic processes below the Canyon and Butt Valley dams (United States Forest Service 1997). Surface water runoff is rapid and flows primarily into the North Fork Feather River or its tributaries. Historically, streams flowing through Big Meadows (present day Lake Almanor) and Butt Valley followed shallow meandering channels through broad floodplains covered with riparian vegetation. Floodwaters would quickly overtop the banks of these channels and deposit sediment on the valley floor. Under present conditions, however, land use changes, including the conversion of valleys to reservoirs, have not only inundated large reaches of the North Fork Feather River and tributaries such as Butt Creek, but have changed the form and function of the North Fork Feather River in the Seneca and Belden reaches as well as downstream of the UNFFR Project.

Geomorphic Classification

Pacific Gas and Electric Company (PG&E) classified the North Fork Feather River and lower Butt Creek using the Level II classification process of the Rosgen Channel Classification System (Rosgen 1996). The Rosgen system uses five primary channel parameters to characterize the form and function of streams and rivers:

- Entrenchment describes the degree of vertical containment of a channel within its valley. This attribute is used to describe how a channel may enlarge its width during high flow events.
- Width-depth ratio is an index of the shape of the channel cross-section and is computed as the ratio of the bankfull width to mean bankfull depth. The channel shape affects the distribution of energy (e.g., velocity) within the channel and influences the efficiency of the channel in transporting sediment.
- Sinuosity characterizes the planform (how the channel is represented on a map) and is calculated as channel length to valley length.
- Water surface slope typically is expressed as channel gradient. It is determined along the longitudinal profile of the channel by measuring the differences in water surface

elevation over a length of channel. To varying degrees, the gradient of a channel represents the energy available to the channel and is directly related to channel hydraulics.

- Bed particle size influences the planform, cross-section shape, and longitudinal profile of the channel. It also affects the rate of sediment transport and the overall stability of the channel in response to changes in flow or sediment regimes.

In support of the UNFFR Project license application, a Level II geomorphic classification study was conducted for the North Fork Feather River and lower Butt Creek (Pacific Gas and Electric Company 2002). Fourteen study sites were assessed in the field: seven sites in the Seneca reach, five sites in the Belden reach, and two sites on lower Butt Creek. One Level II study site was selected to represent the channel geomorphic conditions for each probable channel type in the Seneca, Belden, and lower Butt Creek reaches. The resulting classifications are shown on Figure 6.3-1 at the end of this section. The geomorphic characteristics of each study site are presented in Tables 6.3-1 through 6.3-3.

Table 6.3-1. Modern Geomorphic Parameters at Sampling Sites in the Belden Reach

Location	Upstream of Siphon Crossing (9,200 ft*)	North Fork Campground (13,300 ft)	Queen Lily Campground (21,500 ft)	Queen Lily Campground (21,600 ft)	Downstream of Mosquito Creek (24,140 ft)	Downstream of Mosquito Creek (24,200 ft)	Downstream of Caribou Powerhouse (36,500 ft)
Rosgen Level II Type	C3	B3c	B3c	B3c	F3	F3	F3
Bankfull Width (ft)	60	70	45	49	74	76	92
Flood Prone Width (ft)	182	136	94	86	90	88	102
Mean Bankfull Depth (ft)	2.9	2.90	2.2	2.10	1.00	.70	1.30
Bankfull Area (ft^2)	172	203	101	102	71	56	116
Entrenchment Ratio (FPd/BW)	3.0	1.90	2.10	1.80	1.20	1.20	1.10
Width/Depth Ratio (BW/BD)	21	24	21	23	74	108	70
Slope (%)	1.00	0.70	0.70	0.70	1.50	1.50	1.70
Measured Sinuosity (aerials)	1.30	1.20	1.40	1.40	1.17	1.17	1.30
D50 (mm)	75	71	155	93	90	74**	140
D50 (class)	Small Cobble	Small Cobble	Large Cobble	Small Cobble	Small Cobble	Small Cobble	Large Cobble

Source: Pacific Gas and Electric Company 2002
BD = Bankfull Depth
BW = Bankfull Width
FPd = Flood Prone Width
mm - millimeter
*River stations measured in an upstream direction from the confluence with the of the North Fork Feather River and the East Branch of the North Fork Feather River
**Composite D50 pebble count result from left side (55mm) and right side (90mm)

Table 6.3-2. Modern Geomorphic Parameters at Sampling Sites in the Seneca Reach

Location	Upstream of Caribou Powerhouse, Along Anglers Trail (49,300 ft*)	China Bar (56,500 ft)	China Bar (57,000 ft)	Upstream of Muggins Creek (62,300 ft)	Seneca Resort (75,400 ft)	Seneca Resort (75,500 ft)	Downstream of Salmon Falls (84,500 ft)	Upstream of large Talus Slope (94,300 ft)	Skinner Flat (96,930 ft)	Skinner Flat (96,970 ft)	Skinner Flat (97,000 ft)
Rosgen Level II Type	B3	C3	C4	B3c	C3	C3	B3	B3	B3	B3	B3
Bankfull Width (ft)	57	55	119	68	116	98	42	67	108	84	97
Flood Prone Width (ft)	95	200	300	87	330	330	82	148	129	111	129
Mean Bankfull Depth (ft)	1.8	2.4	1.60	2.2	1.7	1.00	1.9	2.20	3.00	2.10	2.40
Bankfull Area (ft^2)	101	133	191	147	195	101	81	149	325	180	230
Entrenchment Ratio (FPW/BW)	1.7	3.60	2.52	1.3	2.90	3.40	2.00	2.20	1.20	1.30	1.30
Width/Depth Ratio (BW/BD)	32	23	74	31	68	98	22	31	36	40	40
Slope (%)	2.0	1.50	1.50	1.50	1.10	1.10	3.50	3.00	3.90	3.90	3.90
Measured Sinuosity (aerials)	1.3	1.60	1.60	1.30	1.10	1.10	1.30	1.10	1.20	1.20	1.20
D50 (mm)	120	**	22	64	85	92	160	175	220	**	**
D50 (class)	Small Cobble	Coarse Gravel**	Coarse Gravel	Small Cobble	Small Cobble	Small Cobble	Large Cobble	Large Cobble	Large Cobble	Large Cobble**	Large Cobble**

Source Pacific Gas and Electric Company 2002

*River stations measured in an upstream direction from the confluence of the North Fork Feather River with the East Branch of the North Fork Feather River

**No particles were sampled in the field. Particle class based upon visual estimates.

Table 6.3-3. Modern Geomorphic Parameters at Sampling Sites in Lower Butt Creek

Location	Upstream From Confluence with the North Fork Feather River (Site 800)	Downstream of Butt Valley Dam (Site 10,000)
Rosgen Level II Type	B4	A2a+
Bankfull Width (ft)	25	29
Flood Prone Width (ft)	54	43
Mean Bankfull Depth (ft)	1.1	1.2
Bankfull Area (ft^2)	27	34.5
Entrenchment Ratio (FPW/BW)	2.2	1.5
Width/Depth Ratio (BW/BD)	22.7	24.2
Slope (%)	3.5	12.7
Measured Sinuosity (aerials)	1.21	1.2
D50 (mm)	45	12
D50 (class)	Very Coarse Gravel	Medium Gravel

Source: Pacific Gas and Electric Company 2002

Hydraulic Characterization

Hydraulic conditions at six sites along the North Fork Feather River were evaluated in conjunction with the geomorphic characterization. The locations of these sites are shown on Figure 6.3-1 (Sites B1–B3 and S1–S3). Due to the short reach of lower Butt Creek, the study did not evaluate sites on lower Butt Creek.

The hydraulic study focused on estimating the magnitude of flows required to mobilize bed material and to transport sediments delivered to the North Fork Feather River channel. In part, this study was intended to evaluate the range of flows required to modify the amount and location of riparian vegetation that occurs within and adjacent to the channel. This study integrated Rosgen Level II classification data, hydraulic modeling, and values from empirically based sediment transport equations. The study included site identification, field data collection, observation during controlled releases of up to 700 cubic feet per second (cfs) (concurrent with aquatic habitat studies) during 2001, development and calibration of a hydraulic model and model runs of a range of flows to estimate hydraulic conditions, and, ultimately, comparison of modeled hydraulics with calculated requirements to mobilize the observed bed material. The hydraulic study also considered the results of tracer gravel and Belden forebay sedimentation studies.

Within the Seneca and Belden reaches, the range of hydraulic conditions represented by each of the study sites is highly variable. As a general approximation, the outcome of the hydraulic study indicates that 1,600 to 3,000 cfs is the range of flows necessary to mobilize the median-size bed material from the representative sites within the Seneca and Belden reaches (Table 6.3-4). Tracer gravel studies within these reaches suggest that small to moderate size gravels (as large as 50 mm) were generally mobilized at representative locations during the 700 cfs test releases. The study results also indicate that while gravel-sized material may be mobilized frequently (every other year) in the Belden reach, the gaps in the hydrologic record for the Seneca reach inhibit the ability to determine the frequency of gravel transport and mobility for that reach. The study also concluded that cobble-sized material (90 mm to 226 mm) may be mobilized and transported within the Seneca and Belden reaches with flows of approximately 2,300 cfs.

Table 6.3-4. Discharge Predicted to Initiate Motion of the Median Bed Particles

Site	Cross Section	D50 (mm)	Shields Curve[1]	Andrews Equation[2]	Rosgen	M-PM
B1	1	256[f]	—[e]	n.d.	—[e]	n.d.
	2	72[c]	1,600	n.d.	2,600	n.d.
	3	72	2,700	2,300	4,200	—[e]
	3	48[c]	500/1,400	700	2,400	—[e]
	4	128[f]	6,000[d]	n.d.	—[e]	n.d.
B2	1	256[f]	—[e]	n.d.	—[e]	n.d.
	2	160[c]	6,000[d]	n.d.	—[e]	n.d.
	3	60	600	1,500	1,000	3,400
	3	94[c]	1,700	3,500	2,900	—[e]
	4	90[f]	1,600	n.d.	2,300	n.d.
B3	1	256[f]	4,800	n.d.	—[e]	n.d.
	2	48	250	250	450	600
	2	56[c]	400	400	600	650
	2	90[c]	800	700	1,700	2,600
	3	91	6,000[d]	2,500	—[e]	—[e]
	3	55[c]	2,900	1,400	6,000	—[e]
	4	32[f]	700	n.d.	800	n.d.
S1	1	92	2,300	n.d.	1,900	n.d.
	2	78	—[e]	—[e]	3,000d	n.d.
	3	64[f]	—[e]	n.d.	2,100	n.d.
	4	78	3,500[d]	700	2,600d	—[e]
	4	22[c]	400	100	200	—[e]
S2	1	150	—[e]	n.d.	—[e]	—[e]
	1	120[c]	—[e]	n.d.	—[e]	—[e]
	1	84[c]	—[e]	n.d.	—[e]	—[e]
	2	128[f]	2,000	1,300	1,500	n.d.
	3	80	1,600	1,400	1,300	—[e]
S3	1	362[f]	2,400[d]	n.d.	—[e]	n.d.
	2	220[c]	2,300[d]	n.d.	3,000d	n.d.
	3	362[f]	2,600[d]	n.d.	—[e]	n.d.
	4	362[f]	1,700	n.d.	2,500	n.d.

Source: Pacific Gas and Electric Company 2002
Notes: Discharges in cfs
n.d. = No data available for calculation of initiation motion with this method
B = Belden; S = Seneca
[1] Value of 0.47 is commonly used for bed-load transport equation
[2] Value of 0.03 used as indicator of incipient motion for gravel and cobble bed streams
[a] D50 determined from pebble count. All other median particle sizes are based on bulk sampling of surface material.
[b] Estimated based on extrapolation of the Shields curve
[c] Discharge needed to initiate motion is significantly greater than highest flow modeled and could not be extrapolated.
[d] D50 estimated from visual observations during cross section surveys and photographs

Geologic Hazards

Geologic hazards in the UNFFR Project vicinity are typically associated with seismic or volcanic activity. Hazards associated with geologic processes include liquefaction, seiches, and erosion. This section provides an overview of hazards that may occur in the UNFFR Project vicinity.

Seismic/Volcanic Activity

Seismic activity from faults or fault zones in the vicinity, including the Butt Creek fault zone, Keddie Ridge fault, and the Almanor fault zone, cause infrequent low to moderate levels of ground shaking (United States Geological Survey 2009). To the west, seismic activity associated with the Northern San Andreas fault zone and the Cascadia subduction zone could produce earthquakes of magnitude 8.5 or greater and result in ground shaking in the UNFFR Project vicinity. High-magnitude seismic events have a 10 to 20 percent probability of occurring every 50 years and causing exceedances of peak ground acceleration in the UNFFR Project vicinity (California Geological Survey 2007). On steeper terrain, the potential for landslides and rockfalls to be triggered by seismic events, precipitation, or a combination of these two factors increases.

The UNFFR Project vicinity is considered to be volcanically active; the last volcanic eruption was in 1915 when Mount Lassen erupted (Earthworks Restoration Inc. and CH2M Hill 2007). Active geothermal features associated with the greater Lassen hydrothermal system are found in the upper reaches of the North Fork Feather River watershed, and signs of potential volcanic activity continue to be exhibited in Lassen Volcanic National Park in the form of steam vents, hot springs, and bubbling pools of mud. An eruption of Mount Lassen could trigger landslides, release toxic gases, and produce pyroclastic flows that could quickly envelop areas miles from the actual volcano. The Chester/Lake Almanor region could be subject to lahars (landslides or mudflows of volcanic debris) and secondary flooding associated with volcanic activity (U.S. Geological Survey 2005).

Liquefaction

Liquefaction is a process whereby water-saturated granular soils are transformed to a liquid state during ground shaking. Loose to medium dense sands, gravels, and silts occurring below the water table are prone to liquefaction. The soils bordering the three activity areas are predominantly alluvial. These soils have the potential to undergo liquefaction; however, a detailed analysis of the potential for liquefaction was not conducted because the activities under consideration in these areas are not expected to affect the potential for liquefaction or be affected by liquefaction if it were to occur.

Seiches

A seiche is an oscillation or standing wave in a body of water confined in a basin. Seiches commonly arise from a sudden local change in atmospheric pressure accompanied by wind and occasionally tidal currents. They can also occur as a result of ground shaking caused by earthquakes or by the force of large landslides or debris flows entering a water body. Water bodies in the UNFFR Project capable of experiencing a large-scale seiche include Lake Almanor and Butt Valley reservoir. The hazards associated with a seiche would involve the overtopping or possible failure of Canyon and Butt Valley dams, with resulting modifications to the flow regime (i.e., flooding) of the Seneca and Belden reaches and potentially the North Fork Feather River downstream of the UNFFR Project. However, the likelihood of such an event is considered small.

Erosion

Shoreline erosion is evident along the southeastern shore of Lake Almanor near Canyon dam and along the western shore of the Almanor peninsula (Federal Energy Regulatory Commission 2005). A shoreline erosion study conducted by PG&E in 2000 found that approximately seven percent (7%) of the reservoir's shoreline has undergone substantial erosion, as evidenced by slope scars on the shoreline and sloughing of material into the water. Rip-rap has been installed in some areas to reduce the effects of erosion. Wind-generated waves and boat wakes have eroded steeper parts of the shoreline along the 4,500 foot contour (Lake Almanor's normal maximum water level is at 4,494 feet elevation (PG&E elevation datum), which could degrade water quality through turbidity and sedimentation as well as jeopardize cultural, recreational, and other sites along the shoreline. Fluctuating lake levels also contribute to shoreline erosion. Operation of off-highway vehicles along the exposed shoreline of Lake Almanor contributes to ongoing localized erosion in some areas.

Stetson Engineers inspected the Lake Almanor shoreline by boat on June 28, 2007 (Stetson Engineers 2010). The purpose of the field inspection was to evaluate shoreline conditions related to erosion activity from fluctuating lake levels. The field inspection focused on areas that demonstrated significant erosion, as documented during previous field inspections. Locations of active shoreline erosion were consistent with those previously documented by PG&E. Based on the 2007 inspection, shoreline erosion has not changed, which is likely because of PG&E's consistent operations.

Highly weathered or decomposed granite, which is erodible and prone to landslides, is found along portions of the North Fork Feather River canyon (California Department of Water Resources 2007). Landslides and slumping have occurred in the UNFFR Project vicinity, specifically along the steeper slopes of the canyon in the Belden reach. During periods of heavy precipitation, the potential for pipes, penstocks and tunnels, and other UNFFR Project facilities to be affected by surface erosion, landslides, or slumping increases. In 1984, heavy precipitation triggered a large rock slide that resulted in significant damage to the Caribou No. 2 switchyard and to the Caribou No. 1 penstock. In 1997, the slope traversed by the Caribou No. 2 penstock suffered noticeable and potentially disastrous erosion. Improvements have since been made to stabilize the area, and slope movement is monitored (California Public Utilities Commission 2000). The Belden 2 tunnel is known to have a crack, which is monitored regularly and repaired as needed (Pacific Gas and Electric Company 1999).

Some of the UNFFR Project features and facilities occupy National Forest System lands managed by the Lassen and the Plumas National Forests. The Land and Resource Management Plans for these forests acknowledge the geologic instability presents hazards within the region of the UNFFR Project. Therefore, Department of Agriculture, United States Forest Service (USFS) roads, structures, and other management facilities and activities are designed to avoid unstable areas and prevent accelerated failure (United States Forest Service 1988, 1992).

Soils

Most of the soils that underlie UNFFR Project facilities in the North Fork Feather River watershed are in the Skalan-Holland-Deadwood soil association, with some areas in the Skalan-Deadwood-Kistirn complex, Tahand-Baileycreek complex, or Kinkel-Deadwood complex. The soil types in the three activity areas[1] include the Skalan family and the Skalan-Holland association near the Prattville intake; the Holland family and the Tahand-Baileycreek complex near Canyon dam; and the Kinkel-Deadwood complex, Holland soils, and Basic-Skalan-Kinkel complex near Butt Valley reservoir. The dominant soils along the North Fork Feather River between Canyon dam and the Belden powerhouse include the Skalan-Holland-Deadwood association, Kinkel-Deadwood families, Skalan-Deadwood-Kistirn families, and rock outcrop-Dubakella family. Soils along the river channel are primarily associated with glacial, alluvial, and lacustrine environments.

The Skalan-Holland-Deadwood soil association occurs on gently sloping to very steeply sloping topography (United States Forest Service 1994). The Skalan family of soils consists of deep, well to somewhat excessively drained soils on mountain side slopes, gently sloping hills, and undulating flats. Skalan soils are formed from weathered andesite and basalt flows and are typically composed of gravelly sandy loams. Depth to bedrock ranges between 34 and 60 inches, depending on slope and family association. On steeper slopes, the erosion hazard is moderate to high, but remains low on slopes of less than 35 percent. Skalan soils occur in the vicinity of the Prattville intake and Butt Valley dam on generally flat areas, as well as at other locations in the general vicinity of the UNFFR Project.

The Holland soils family consists of moderately deep to deep well-drained soils formed by weathered andesite and basalt flows (United States Forest Service 1994). In a few small areas, Holland soils are formed from metasediments and diatomaceous earth. Holland soils are found on volcanic flats, ridges, and mountain side slopes. In the general vicinity of the UNFFR Project, Holland soils occur in association with the Skalan family and are limited to 0 to 35 percent slopes. The erosion hazard of these soils is low, and the depth to bedrock is typically greater than 60 inches. Holland soils occur in the vicinity of the Prattville intake, Canyon dam, and Butt Valley dam, as well as in other locations in the UNFFR Project vicinity.

The UNFFR Project facilities occupy landscape positions that are underlain by soils of the Skalan-Deadwood association. Soils of the Deadwood family consist of about 30 percent of the association (United States Forest Service 1994). Deadwood soils are found on some of the steeper slopes in the general vicinity of the UNFFR Project. These soils are shallow and well to somewhat excessively drained. Formed from weathered metasediments, Deadwood soils in the UNFFR Project are found on escarpments, mountain side slopes, and ridges. In the general vicinity of the UNFFR Project, Deadwood soils have a moderate erosion potential. The Kinkel-Deadwood association is found in the vicinity of Butt Valley dam.

The Tahand-Baileycreek complex soils are derived from volcanic rock or ash and occur on 5 to 30 percent slopes (Natural Resources Conservation Service 2009). They are well drained, with bedrock between 20 and 60 inches below the surface. The soils have a moderate erosion potential. The Tahand-Baileycreek complex occurs in the vicinity of Canyon dam activity area.

6.3.2 Environmental Impacts and Mitigation Measures

Methodology

The analysis of geologic, geomorphic, and soils impacts is based on a review of existing literature and data and reconnaissance-level assessments of the local geologic and geomorphic

[1] Activity areas encompass areas surrounding and portions of Lake Almanor and Butt Valley reservoir where construction and ground-disturbing activities have the potential to occur.

conditions in the UNFFR Project vicinity. The impact analysis addresses the potential for the Proposed UNFFR Project and each alternative to expose the public or structures to geologic or geomorphic hazards, disturb soil, or result in indirect soil-related effects from erosion or other disturbance.

Thresholds of Significance

Impacts associated with geology, geomorphology, or soils would be significant if the Proposed UNFFR Project or an alternative would:

- result in substantial erosion or loss of topsoil;
- expose people, structures, or critical facilities to major geologic hazards (including seismicity, landslides, or liquefaction); or
- expose people or structures to unstable or expansive soil conditions.

Impacts and Mitigation Measures

This section discusses the anticipated impacts related to geology, geomorphology, and soils associated with the Proposed UNFFR Project and each alternative and identifies mitigation measures for significant impacts. Table 6.3-5 compares the final level of significance for each impact (with incorporation of mitigation measures if appropriate).

Table 6.3-5. Summary of Geologic, Geomorphic, and Soils (GGS) Impacts

IMPACT	PROPOSED UNFFR PROJECT	ALTERNATIVE 1	ALTERNATIVE 2
Impact GGS-1: Construction activities associated with the UNFFR Project could cause erosion in disturbed areas, resulting in increased sedimentation in the North Fork Feather River and reservoirs.	Less than significant with mitigation	Less than significant with mitigation	Less than significant with mitigation
Impact GGS-2: Implementation of the UNFFR Project could increase exposure of people and structures to geologic hazards, such as erosion, landslides, or rockslides.	Less than significant	Less than significant	Less than significant
Impact GGS-3: Implementation of the UNFFR Project could modify the channel morphology of the North Fork Feather River as a result of changes in flow.	Less than significant	Less than significant	Less than significant
Impact GGS-4: Implementation of the UNFFR Project could affect the location and severity of shoreline erosion along Lake Almanor.	Less than significant with mitigation	Less than significant with mitigation	Less than significant with mitigation

Impact GGS-1: Construction activities associated with the UNFFR Project could cause erosion in disturbed areas, resulting in increased sedimentation in the North Fork Feather River and reservoirs.

Proposed UNFFR Project and Alternatives 1 and 2

Pages 3-222 to 3-239 of Section 3.3.5 of the Final FERC EIS contain descriptions of the 30 recreational facilities and improvements to be implemented under the Proposed UNFFR Project as well as both Alternative 1 and Alternative 2. These descriptions, without FERC's environmental effects analysis, are hereby incorporated into this EIR by reference. The 30 recreational facilities and improvements make up the majority of the construction activities associated with the Proposed UNFFR Project and the alternatives. The construction activities associated with these recreational facilities and improvements will be located near Lake Almanor, Butt Valley reservoir, and various reaches of the North Fork Feather River.

In addition to these recreational facilities and improvements, PG&E has also proposed the removal of the Gansner Bar fish barrier and potentially the NF-9 gage weir as part of the Proposed UNFFR Project and, subsequently, both alternatives. The Gansner Bar fish barrier is located in the Belden reach of the North Fork Feather River approximately 0.2 mile upstream of the confluence with the East Branch of the North Fork Feather River, and the NF-9 gage weir is located in lower Butt Creek between Butt Valley dam and its confluence with the North Fork Feather River. PG&E proposed the removal of the Gansner Bar fish barrier as a condition of its new license. A monitoring plan will be developed, in consultation with the California Department of Fish and Wildlife (formerly known as the California Department of Fish and Game), the State Water Board, the USFS, and United States Fish and Wildlife Service, to determine if the NF-9 gage weir is an obstacle to upstream fish passage. If monitoring data confirms that the NF-9 gage weir is preventing or limiting upstream fish passage, PG&E has agreed to remove it or modify it in order to provide upstream fish passage.

Access to the Prattville intake and Canyon dam activity areas would be along existing roads and staging areas would be located in previously disturbed areas, requiring little vegetation removal. However, the construction of thermal curtains at the Caribou intakes would require a new road to access the west shore of Butt Valley reservoir.

Construction activities associated with the Proposed UNFFR Project and each alternative have the potential to disturb soils and lakebed deposits, primarily in the three activity areas. The State Water Board must be conservative in making its determination of impacts associated with the Proposed UNFFR Project and either alternative in order to ensure the continued protection of designated beneficial uses and compliance with water quality objectives. Due to the location and nature of each construction activity, the potential for the UNFFR Project or alternatives to cause erosion that could result in increased sedimentation in the rivers and reservoirs is **significant without mitigation**.

Mitigation Measure

Mitigation Measure GGS-1: Approval of Construction Activities by the State Water Board (Turbidity and Total Suspended Solids)

Prior to construction, PG&E shall submit detailed plans outlining all construction activities to the State Water Board for review and written approval. Each plan will contain a detailed description of the proposed activities, activity boundaries, potential environmental impacts, pollutants of concern, and selection of appropriate best management practices (BMPs) that will be implemented. The following measures, or their equivalent, shall be required in the water quality certification for construction activities:

- Preservation of existing vegetation will be implemented, where appropriate, to minimize the amount of exposed erodible soil and to reduce the need for soil stabilization practices.

- Areas that will be disturbed as a result of construction activities will be stabilized with soil stabilization BMPs. Soil stabilization is a source control measure that is designed to keep soil particles from detaching and becoming transported in runoff. Stabilization practices may include both soft surface protection systems and hard surface protection systems. Soil stabilization BMPs implemented in the activity areas may consist of hydro-seeding, vegetation planting, mulch, geotextiles, plastic covers, erosion control blankets, and soil binders. Effective soil cover shall be provided for inactive areas and all finished slopes, open space, and backfill. Inactive areas of construction are areas of construction activity that have been disturbed and are not scheduled to be re-disturbed for at least 14 days.

- Sediment controls are structural measures that are intended to complement and enhance soil stabilization BMPs and reduce sediment discharges from construction activity. The sediment controls that will be considered for the construction activities associated with the UNFFR Project will be designed to intercept and filter out soil particles that may become detached and transported in runoff as a result of construction activities. Sediment control BMPs such as silt fences, fiber rolls, temporary flow conveyance systems, sediment basins, and check dams shall be considered. Effective perimeter controls will be required. All construction entrances and exits will be stabilized.

- Wind has the potential to transport erodible soil particles that are not stabilized or controlled with sediment control or soil stabilization practices. Standard dust control practices will be implemented during construction. Stockpile management BMPs such as plastic covers and perimeter controls (silt fences and/or fiber rolls) will be implemented to protect stockpiles that have the potential to erode as a result of wind.

- Construction activities that meet the conditions of the General Permit for Stormwater Discharges Associated with Construction and Land Disturbance Activities (Construction General Permit; Water Quality Order 2009-0009-DWQ and NPDES No. CAS000002, as amended by Order No. 2010-0014-DWQ and 2012-0006-DWQ) will be required to comply with it.

- Construction activities will not cause an increase in turbidity downstream of the construction area greater than those identified in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan). Waters shall be free of changes in turbidity that cause nuisance or adversely affect the water for beneficial uses. Increases in turbidity shall not exceed background levels (natural turbidity measured Nephelometric Turbidity Units [NTUs] prior to the start of and construction activities) by more than Basin Plan thresholds outlined below or as amended thereto:

Background Level or Natural Turbidity	Downstream Turbidity (after starting construction)
Less than 1 NTU	Total turbidity shall not exceed 2 NTU
Between 1 and 5 NTU	Increases shall not exceed 1 NTU
Between 5 and 50 NTU	Increases shall not exceed 20 percent
Between 50 and 100 NTU	Increases shall not exceed 10 NTUs
Greater than 100 NTU	Increases shall not exceed 10 percent

The location and frequency of monitoring shall be determined in consultation with the State Water Board prior to the commencement of construction activities. If monitoring shows that turbidity has exceeded the water quality objective, construction will cease and the violation will be reported immediately to the State Water Board's Deputy Director for Water Rights (Deputy Director) and the Executive Officer for the Central Valley Regional Water Board. Construction may not re-commence without the permission of the Deputy Director.

Because dredging can cause an increase in turbidity, exceptions to the above limits may be considered. In those cases, an allowable zone of dilution within which turbidity in excess of the limits may be tolerated will be defined for the operation and approved by the Deputy Director. Exceptions are not allowed without the written approval of the Deputy Director.

As part of its review, the State Water Board will require additional mitigation measures, as necessary, to prevent impacts to water quality objectives or designated beneficial uses.

Significance after Mitigation

Implementation of Mitigation Measure GGS-1 would reduce the impact to a **less than significant** level.

Impact GGS-2: Implementation of the UNFFR Project could increase exposure of people and structures to geologic hazards, such as erosion, landslides, or rockslides.

Proposed UNFFR Project and Alternatives 1 and 2

Neither the Proposed UNFFR Project nor the two alternatives would increase the potential for geologic hazards or increase exposure of people or structures to these hazards. Existing hazards in the area from volcanic and seismic activity would continue to pose hazards to the public, UNFFR Project facilities, and the environment, but the potential for damage to the proposed UNFFR Project facilities from these hazards is considered low.

The Prattville and Caribou intakes thermal curtains, which would be part of both Alternatives 1 and 2, would be anchored to the nearly level lake bottoms and would move with the fluctuating lake levels to minimize the potential for damage to the curtains. The thermal curtains would not affect the geology of the area or geomorphology of the lakes or river. The Caribou intakes thermal curtain would not affect Belden forebay or the Belden reach downstream because the volume of flow released into Belden forebay would be similar to current conditions. These measures would not increase the exposure of the public to geologic hazards.

Under Alternative 1, modification to the Canyon dam intake structure would allow an increase in flow released through the dam into the Seneca reach (up to 250 cfs) from mid-June through mid-September, and flow volumes in the Seneca and Belden reaches would be modified under Alternatives 1 and 2 based on the flow schedule presented in Chapter 4. Some channel scouring could occur during initial high-flow releases, which could result in localized erosion within or adjacent to the bed and banks of the Seneca and Belden reaches.

Landslides and rockslides occur periodically in the North Fork Feather River canyon under current conditions, posing a safety hazard to anglers, rafters, and others. These hazards tend to be isolated events that are attributable to a combination of environmental factors and would not necessarily be increased by the proposed flow modifications in the Seneca or Belden reaches. PG&E provides warnings to the public when high volumes of flow are released through the dams and powerhouses.

In conclusion, neither the Proposed UNFFR Project nor either alternative would expose people or structures to geologic hazards or substantially increase the potential for these hazards; therefore, impacts related to geologic hazards would be **less than significant**.

Impact GGS-3: Implementation of the UNFFR Project could modify the channel morphology of the North Fork Feather River as a result of changes in flow.

Proposed UNFFR Project and Alternatives 1 and 2

Under the Proposed UNFFR Project and either alternative, the flow schedule for the Seneca and Belden reaches would be modified, with a goal of increasing the minimum flow.

Under the Proposed UNFFR Project, pulse flows are required in January, February, and March if the water year type for that month indicates that the water year is anticipated to be either normal or wet. Additionally, per the FERC Staff Alternative in the Final FERC EIS, pulse flows may be required in March of dry years if a flow of high enough magnitude has not occurred in the preceding January or February to ensure that some geomorphic and sedimentological processes occur in the bypass reaches during all water year types. The magnitudes of all pulse flows depend on the water year type and month and have the potential to mobilize gravels in the Seneca and Belden reaches. Implementation of a gravel monitoring plan will include an evaluation of gravel movement during pulse flows in the Seneca and Belden reaches. The gravel monitoring Plan will be implemented as specified in the 2004 Settlement Agreement. Emphasis will be placed on monitoring the movement and recruitment of spawning-sized gravel in the Belden and Seneca reaches. If data from the gravel monitoring indicate that the pulse flow regime could be improved to enhance the availability and distribution of spawning gravel or enhance riparian function, the pulse flows can be revised as set forth in the 2004 Settlement Agreement. Although flows would increase in the Seneca and Belden reaches, changes in the river morphology would be similar to the current variable conditions, and pulse flows would be implemented in a way that benefits the geomorphic processes along the North Fork Feather River. Impacts would be **less than significant**.

Under Alternative 1, up to 250 cfs of flow would be released into the Seneca reach through Canyon dam during summer months; this additional flow would not be released under Alternative 2. Although a 250 cfs release would be substantially higher than the current flow discharged from Canyon dam, it is well below the flows required to mobilize gravels and cobbles in the Seneca and Belden reaches. A 250 cfs release is also well below the thresholds required to influence the size or configuration of gravel bar and floodplain features in either reach.

Overall, flow releases to the Seneca and Belden reaches would be similar to the current pattern; however, increased water would flow through these reaches during the typically dry summer months. The flows could transport sediment and woody debris along the channel and deposit these materials downstream in the Belden forebay or other reservoirs. Channel size would not likely be affected in the Seneca reach where the canyon is steep and has less potential for erosion. The channel size in the Belden reach could change in areas where the floodplain is broader, but such changes would be similar to current changes as the river flows increase and decrease. Although flows would increase in the Seneca and Belden reaches, changes in the North Fork Feather River morphology would be similar to current variable conditions. Impacts would be **less than significant**.

Impact GGS-4: Implementation of the UNFFR Project could affect the location and severity of shoreline erosion along Lake Almanor.

Proposed UNFFR Project and Alternatives 1 and 2

Section 3.3.1.2 of the Final FERC EIS, pages 3-83 to 3-86, contains a discussion and analysis of the effects of the Proposed UNFFR Project on the location and severity of shoreline erosion along Lake Almanor. These effects are also similar to those which would be experienced under either alternative as the thermal curtains at Prattville and Caribou intakes would not require changes in operation of the intake facilities, Lake Almanor, or Butt Valley reservoir and would not increase the potential for shoreline erosion from wave action or fluctuating lake levels. This section of the Final FERC EIS is incorporated into this EIR by reference. While the level of analysis is adequate for the UNFFR Project, the State Water Board disagrees with FERC's conclusion findings that no adverse impacts could occur.

Shoreline erosion has been, and will continue to be, an ongoing concern at Lake Almanor, specifically in the vicinity of Canyon dam and the Almanor peninsula, as fluctuating lake levels and wave action would continue to result in some degree of shoreline erosion. The magnitude and patterns of erosion would not be different than those currently occurring at the lake; neither the UNFFR Project nor either alternative would modify lake operations in a way that would increase erosion. Water levels and the timing of the withdrawal of water from the lake under the alternatives would be similar to existing reservoir management practices (Stetson Engineers 2010). However, given the length of the license and lack of required mitigation, the State Water Board believes that the effects of the UNFFR Project or either alternative on the location and severity of shoreline erosion along Lake Almanor has the potential to be **significant without mitigation**.

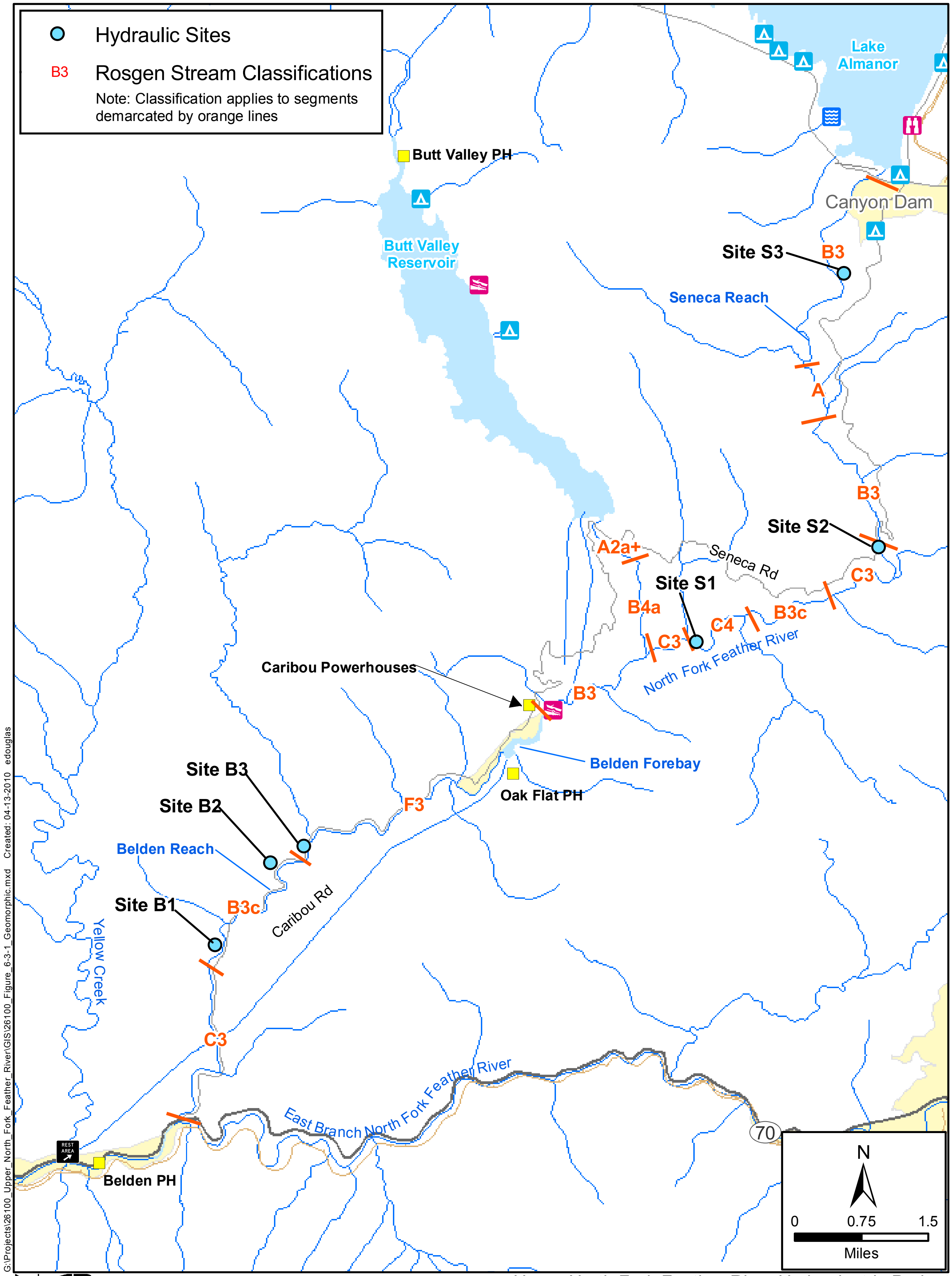
Mitigation Measure

Mitigation Measure GGS-4: Update and Implement Shoreline Management Plan and Shoreline Erosion Monitoring

PG&E shall update the Shoreline Management Plan (SMP) for Lake Almanor in consultation with the State Water Board, USFS, California Department of Fish and Wildlife (CDFW; formerly known as the California Department of Fish and Game), Plumas County, and the Maidu Community. A final SMP shall then be submitted to the State Water Board for approval. The SMP must include a comprehensive shoreline monitoring program. The results of the shoreline monitoring surveys would allow for the evaluation of impacts and would indicate the need for further erosion control measures. If monitoring indicates the need for further erosion control measures, PG&E shall again update the SMP in consultation with the State Water Board, USFS, CDFW, Plumas County, and the Maidu Community. An amended SMP shall be submitted to the State Water Board for approval and will be implemented by PG&E upon receiving all required approvals.

Significance After Mitigation

Mitigation Measure GGS-4 would reduce the uncertainty associated with the UNFFR Project and its effects on the shoreline erosion at Lake Almanor. Additionally, it will allow for adaptive management of any impacts of shoreline erosion that may arise from PG&E's operation of the UNFFR Project. Implementation of this mitigation measure would reduce the potential impact to a **less than significant** level.



North State Resources, Inc.

Upper North Fork Feather River Hydroelectric Project

Figure 6.3-1
Geomorphic Classifications and Hydraulic Sites