3.3.1 Geology and Soils

The discussion of geology and soils is divided into four sections. The affected environment is discussed in Section 3.3.1.1, environmental effects of the Project are discussed in Section 3.3.1.2, unavoidable adverse effects are addressed in Section 3.3.1.3, and geology and soils-related measures or studies recommended by agencies but not adopted by SSWD are discussed in Section 3.3.6.4.

SSWD augmented existing, relevant, and reasonably available information regarding geology and soils by conducting one study: Study 3.3, *Instream Flow Study*. This study included habitat mapping, channel topography, substrate and cover type mapping and large woody material (LWM) observations that address aspects of channel morphology in the lower Bear River. The results of Study 3.3 are discussed throughout this section and all field data is provided in Appendix E1.

3.3.1.1 Affected Environment

This section describes existing geology and soils within the Project Area. Geology and soil conditions are summarized in the following sections: 1) geologic setting, 2) tectonic history, faulting and seismicity, 3) mineral resources, 4) soils, 5) physiography, 6) sedimentation, and 7) existing information.

3.3.1.1.1 Geologic Setting

The Project is located within the Sierra Nevada physiographic and geologic provinces. The geology within the region has evolved through many complex interactions within and beneath the earth's crust. These processes include plate tectonics, where continents are created and transferred by various mechanisms. Other smaller-scale local processes, such as mass wasting, weathering, erosion, and sedimentation also constantly change the landscape.

The geologic history of the region spans the period from the mid-Paleozoic, approximately 300-400 million yrs ago (Mya), to the present day. The deepest basement rocks were emplaced about 225 Mya. However, the deepest basement rocks are actually younger than many of the overlying metamorphic, volcanic, and sedimentary rocks exposed in the region. The basement rock and overlying rocks began to move westward with the formation of a subduction boundary on what was then the western margin of the North American land mass (Schweickert et al. 1984), located east of the present day Sierra Nevada.

Paleozoic and Mesozoic terrains were both accreted upon and subducted beneath the continent. Accretion occurred along the continental margin in long, linear strips, striking roughly parallel to the present day Sierra crest. The subduction zone supplied the mantle with new rock to a depth great enough for the subducting plate to melt. The resulting magma eventually rose as both surface volcanic rock and as subsurface granitic plutons. The granitic plutons compose much of the core of the current Sierra Nevada. Concurrent with the development of the plutons, the hot magma intruded into the folded sedimentary rocks, resulting in metamorphism and the creation of the famous Sierra Nevada gold deposits in the fractures (Forest Service 2002).

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The middle Tertiary was a time of volcanic eruptions that deposited lava, mudflows, pyroclastic flows, and ash throughout the Yuba and upper Bear River basin. These deposits filled many preexisting drainages such as the ancestral Bear River, as well as emplacing a cap of volcanic rock and volcanic debris on both the plutonic rocks and the eroded and intruded remnants of the preexisting early Mesozoic rocks. From 14 to 4 Mya, these tuffs were in turn buried by andesites, andesitic mudflows, and associated volcanic sedimentary rocks (PG&E, Piedmont 2003).

Subsequent to this latest orogeny of eruptions and mudflows, three late Quaternary glacial stages, each with multiple stages, occurred in the northwestern Sierra Nevada (James 2003, James et al. 2002). Glacial till and associated moraines extend west into the upper Bear River near the town of Alta (PG&E, Piedmont 2003).

Uplift along the eastern margin of the Sierra produced erosion through the beginning of the Tertiary Period (65 Mya), exposing the gold veins that had been created during the Mesozoic. These gold veins were eroded and the gold-laden sediments re-deposited throughout the ancestral Yuba River drainage, which ran approximately north to south. The "Tertiary River Gravels" are the source for much of the gold mined during the 19th century in the Yuba River drainage (Forest Service 2002), which also includes the Bear River. The ancestral headwaters of the Bear River were captured by the Yuba River (James 1995), yet were once a part of the Yuba. Because of the gold-laden gravels deposited, uplifted and subsequently exposed, the Bear River was one of the most heavily mined and modified drainages in the Sierra (James 2004).

Specifically within the Project Area, downstream of the Camp Far West Reservoir, valley sediments are dominated by Quaternary alluvium (Figure 3.3.1-1), which comprises 64.9 percent of the Project Area (Table 3.3.1-1). Bedrock geology near the Reservoir is composed of Jurassic volcanic rocks, quartz diorite, and massive diabase of the Smartville Complex, and is the second-most common material at 22.4 percent. The Bear River arm of the Camp Far West Reservoir has an intrusive mafic dyke that strikes northwest across both the Bear River and Wolf Creek (Alpers et al. 2008).

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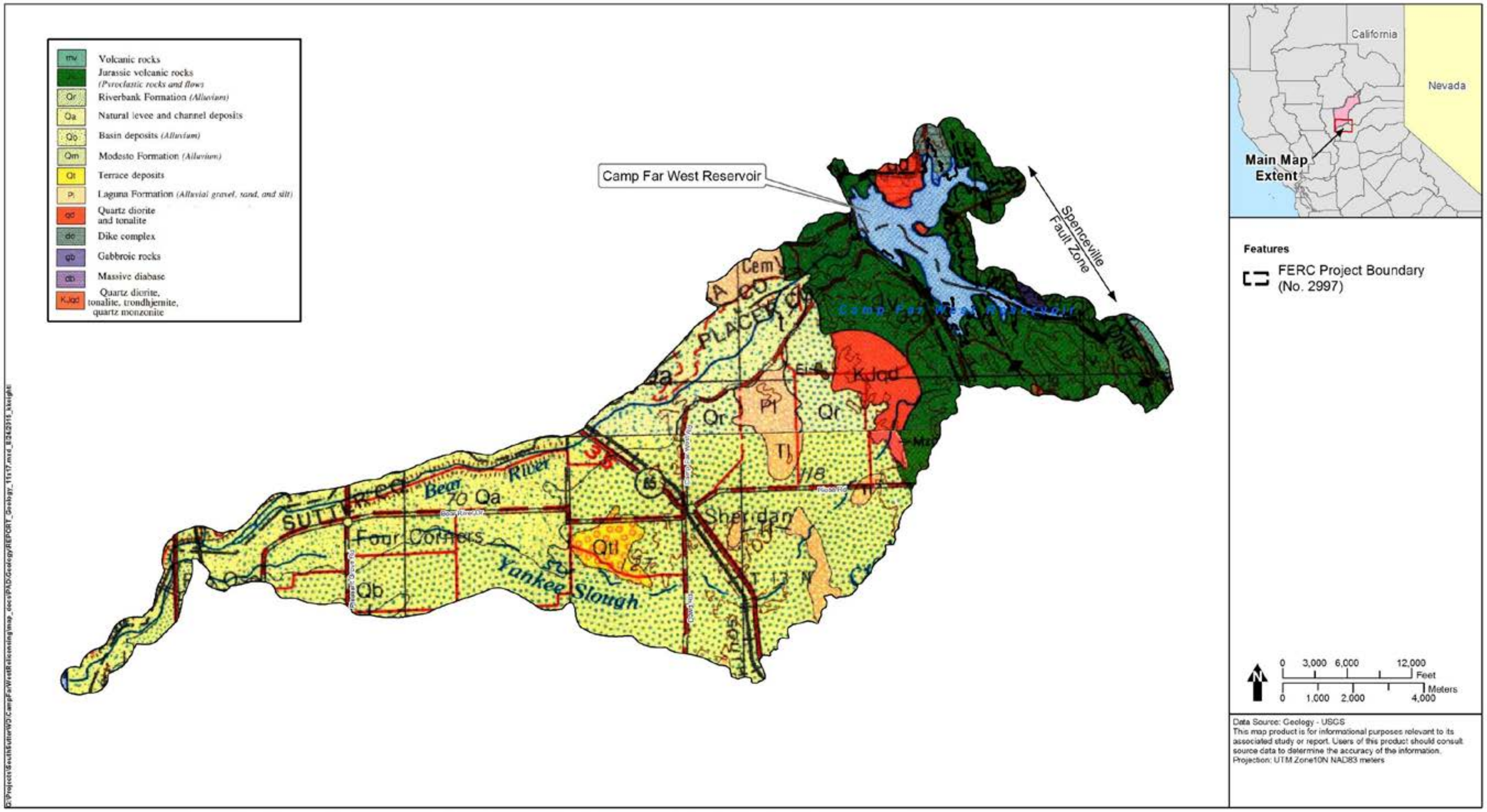

Figure 3.3.1-1. Generalized geologic map of the Project Vicinity.

Table 3.3.1-1. Description of generalized geologic rock types in the Project Vicinity.

Rock Type[1]	Area (acres)	Percent (%)	Description	Age
Quaternary Alluvium (Qr, Qb, Qa, Qt, Pl)	27,102	64.9%	Poorly consolidated gravels, sands and clays along river courses, levees, river banks, terraces adjacent to and within Dry Creek and Bear River downstream of the Project Area.	Quaternary – Pleistocene and Holocene
Laguna Formation	1,935	4.6%	Consolidated Alluvium – gravel sand and silt	Pliocene
Tailings	68	0.2%	Hydraulic and placer mining tailings	Recent, historical
Smartville Complex (Jv, qd, dc, gb)	9,352	22.4%	Pyroclastic rocks and flows, quartz diorite and tonalite, dike complex and gabbro that surround Camp Far West Reservoir.	Jurassic
Volcanic Rocks (mv)	1,432	3.4%	Undifferentiated rocks of the Smartville complex upstream of Camp Far West and dominate Wolf and Bear Creek drainages to Lake Combie.	Jurassic
Ultramafic and metasedimentary rocks	98	0.2%	Folded and faulted rocks near the Wolf Creek fault zone at the upper end of Wolf and Little Wolf Creeks.	Triassic
Water	1,775	4.3%	--	--
Total	**41,762**	**100%**	--	--

[1] Refer to Figure 3.3.1-1 for a description of each rock type.

3.3.1.1.2 Tectonic History, Faulting, and Seismicity

Uplift of the Sierra Nevada began approximately 3 to 5 Mya (Unruh 1991; Wakabayashi and Sawyer 2001; Henry and Perkins 2001), which is approximately synchronous with the uplift of the Carson Range, bordering the Tahoe basin on the east, at 3 Mya (Surpless et al. 2000). The uplift was accompanied by westward tilting of the range, stream incision, and downwarping of the Central Valley.

Most faults resulted from late Paleozoic and Mesozoic tectonic collisions. Faults that were reactivated in the late-Cenozoic are predominantly high-angle, northwest-trending, east-dipping, normal faults resulting from extensional stresses (Schwartz et al. 1977). Deformation is pronounced in bands of weak, ultramafic rock (Bennett 1983), as with the formations associated with the Wolf Creek Fault at the upper end of Wolf and Little Wolf Creeks.

The Spenceville Fault Zone trends northwest-southeast and occurs just to the east of Camp Far West Reservoir. The Wolf Creek Fault Zone bisects Wolf and Little Wolf creeks, and the Bear River downstream of Lake Combie, and several miles upstream of the Camp Far West Reservoir. The Wolf Creek Fault in the Bear River Basin is also known as the Highway 49 Lineament (Bennett 1983) and recognized as a southern extension of the Big Bend Fault (Rogers and Williams 1974). A historic seismicity map, prepared by NID for its proposed project site of the Centennial Reservoir upstream of Lake Combie on the Bear River (NID 2017) includes the Camp Far West Project area, reproduced as Figure 3.3.1-2.

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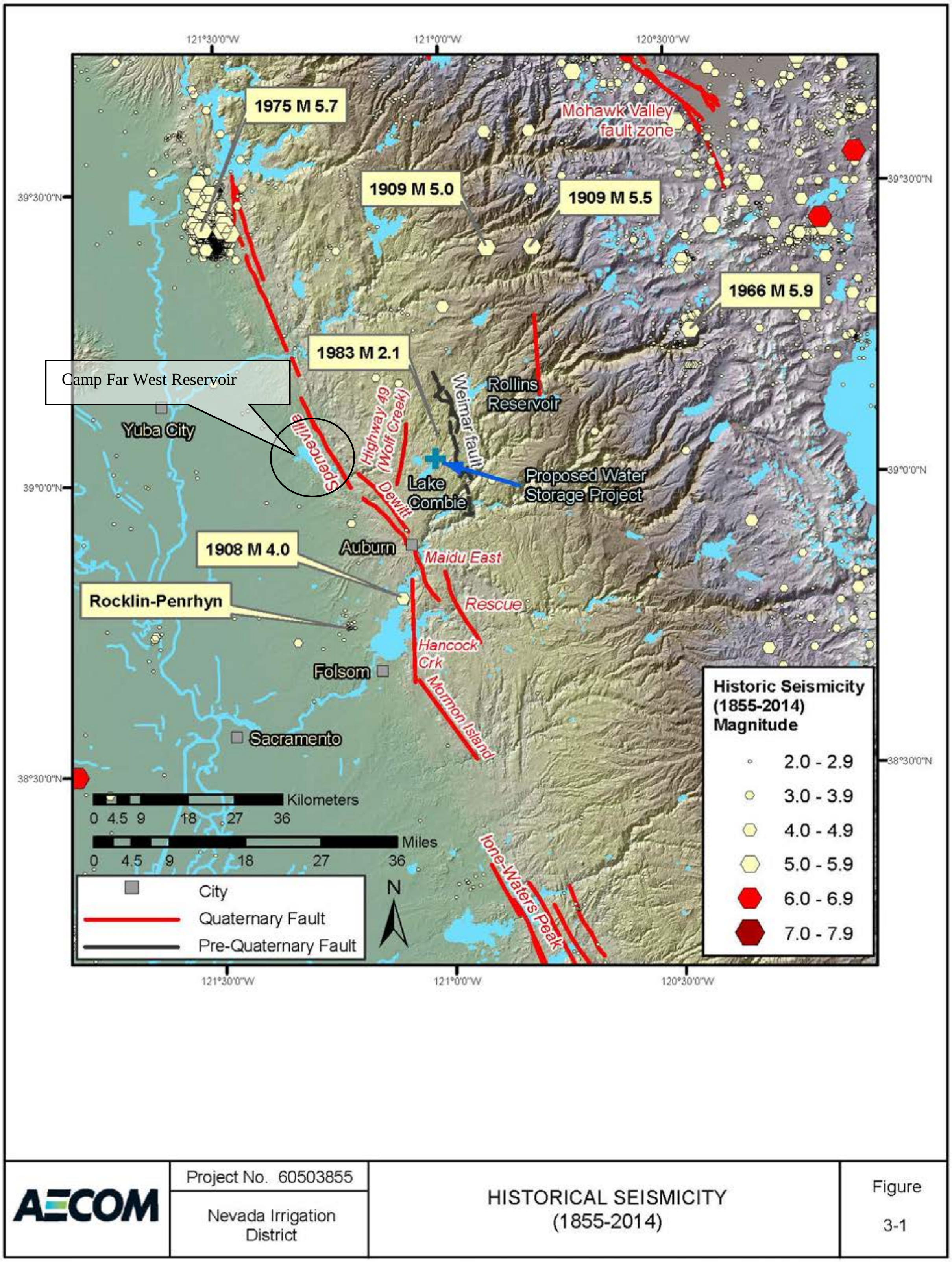

Figure 3.3.1-2. Historical seismicity in the surrounding area of the Project. Reproduced from NID Centennial Reservoir Project Geotechnical Engineering Report (NID 2017).

3.3.1.1.3 Mineral Resources

Six mines were found in the Project Vicinity, most of which were gold and copper mines, as shown in Figure 3.3.1-3 and Table 3.3.1-2.

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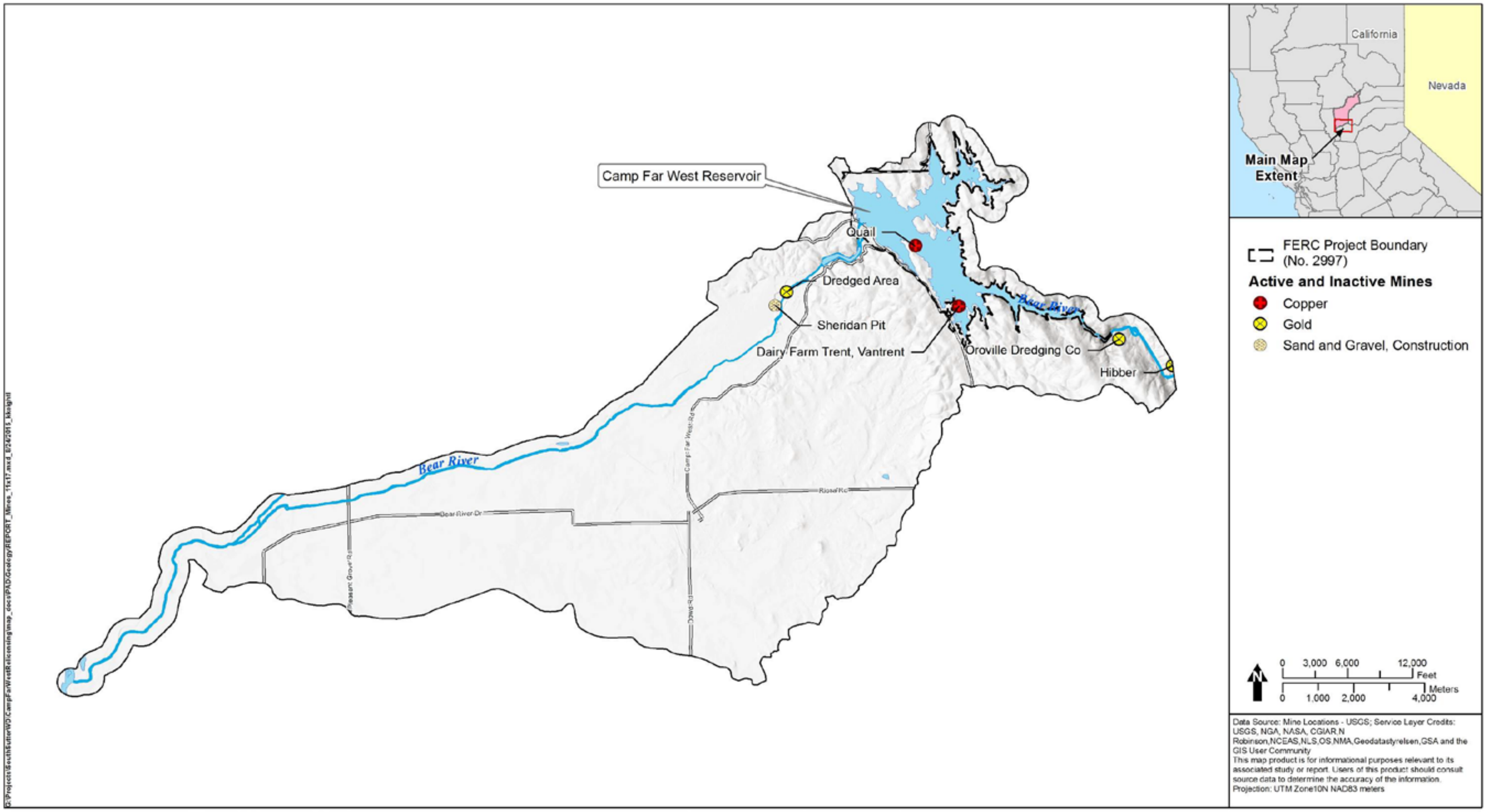

Figure 3.3.1-3. Active and inactive mines in the Project Vicinity.

Table 3.3.1-2. Mines in the Project Vicinity.

Site Name	Major	Minor	Operation	Status	Previous Name
Dairy Farm (Trent, Vantrent)	Copper, Gold	Silver	Unknown	Past Producer	--
Hibber	Gold	Copper	Unknown	Past Producer	--
Dredged Area	Gold	--	Placer	Unknown	--
Oroville Dredging Company	Gold	--	Placer	Unknown	--
Quail	Copper	Silver (trace)[1]	Unknown	Occurrence	--
Sheridan Pit	Sand and gravel	--	Surface	Producer	Sheridan Plant

[1] Not specifically defined in the database, but is assumed to be less than a "minor" component.

One of the main mines near Camp Far West Reservoir and within the FERC Project Boundary is the inactive Dairy Farm Mine (Trent Mine and Vantrent Mine). The deposit from which copper, zinc, and gold were derived is part of the Foothill Copper-Zinc Belt, which extends along the western slope of the Sierra Nevada in eastern California (Heyl 1948). Open pit and underground mining began during the 1860s and continued in the early 1900s and 1930s. The pit created during the 1920s and 1930s extends more than 150 ft below the surface, which is inundated by the Camp Far West Reservoir during high levels, yet is hydraulically isolated at low pool elevation (Alpers et al. 2008). Underground mining followed the massive-sulfide deposit to a total depth of at least 500 ft; the deposit was 10 to 60 ft thick and more than 600 ft long. In 1915, 350 tons of ore were mined per day (Waring 1919). A cyanide plant with a capacity of 100 tons per day was active on the site prior to 1915. In the 1930s, gold was recovered from the oxidized portion of the deposit (Clark 1963).

The Quail Mine is also located within the FERC Project Boundary on the shores of the Camp Far West Reservoir. It is listed as a "site" with an occurrence (i.e., presence or concentration) of copper (primary) and silver (tertiary). The USGS Mineral Resources Data System has no information as the operation type, mining method or yrs of production. It is a non-significant deposit (USGS MRDS, information downloaded April 2018)

The auriferous gravels of the Bear River were mined extensively by hydraulic mining methods in the mid to late 1800s. In addition, there was underground mining of lode gold-quartz vein deposits in the Grass Valley mining district, which drains into Wolf Creek (Alpers et al. 2008) upstream of the Project Area. Much of the fluvial deposits of hydraulic mine waste in the Bear River watershed remain to this day (James 1991, 1993, 1999).

The dredging industry was an important aspect of placer mining in the early 1900s. A small district was worked for some time near Camp Far West on the Bear River above Wheatland. However, the gravels were too low grade and operations were suspended (Lindgren 1911).

There is one active quarry site downstream of the Project Area on the Bear River, the Sheridan Pit that is mined for sand and gravel along the Bear River in both Placer and Yuba counties. Cemex Construction is expanding the existing Patterson Sand and Gravel Mine operation over a 38-year span (Placer County 2015). Currently, the company is permitted through 2028 to operate the mining operation on 326 ac at 8705 Camp Far West Road. The 448-ac proposed expansion is immediately south and west of the existing operation on the Bear River floodplain (Foster 2005).

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3.3.1.1.4 Soils

Soil associations in the Project Area are shown in Table 3.3.1-3 and Figure 3.3.1-4.

Table 3.3.1-3. Soil associations in the Project Vicinity.

Soil No.	Soil Association	Acres	Percent of Total
s855	Sycamore-Shanghai-Nueva-Columbia	11,552	28
s840	Sobrante-Rock outcrop-Auburn	9,088	22
s870	Tisdale-Kilaga-Conejo	13	<1
s825	San Joaquin	6,799	16
s8369	Water	2,071	5
s821	Redding-Corning	8,533	20
s839	Xerofluvents-Ramona-Kilaga-Cometa	1,912	5
s817	Sierra-Caperton-Andregg)	1,794	4
Total	**8**	**41,762**	**100%**

Source: NRCS 2018.

The Project Vicinity soil distribution coincides with the underlying bedrock and geomorphic location. Table 3.3.1-4 provides a summary of the soil series characteristics including parent material, geomorphic position, slope, elevation range, average precipitation, mean annual temperature, and drainage. Soil descriptions have been summarized from the Natural Resources Conservation Service's "Official Soil Series Descriptions and Series Classifications" website (NRCS 2018) for each of the series.

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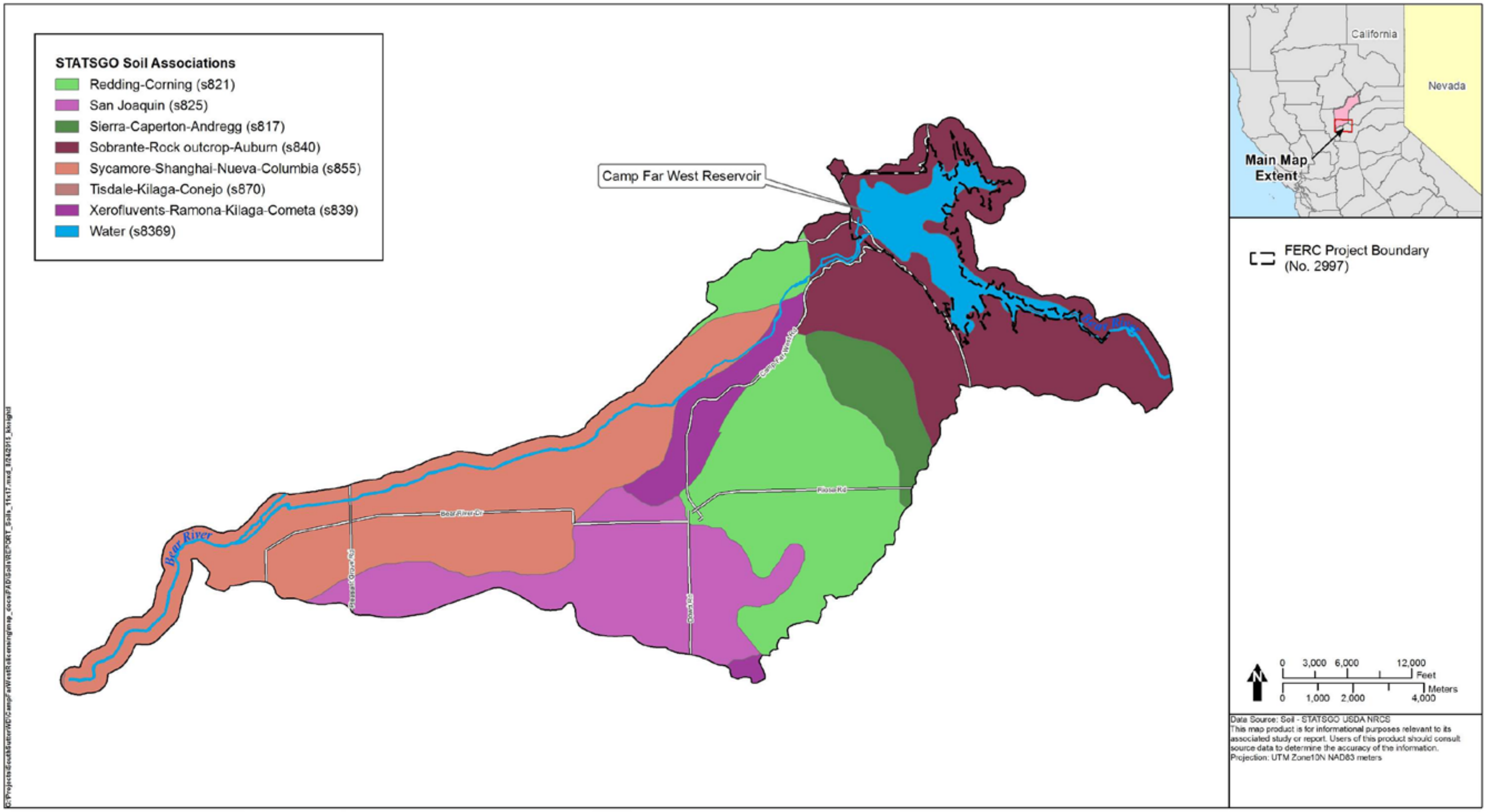

Figure 3.3.1-4. Soil associations in the Project Vicinity.

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Table 3.3.1-4. Soil series and order summary description in the Project Vicinity.

Series	Parent Material	Geomorphic Position	Slope (%)	Elevation (ft)	Avg. Annual Precipitation (in.)	Mean Annual Temperature (°F)	Drainage
Andregg	Weathered granitic	Undulating to steep slopes on foothills	2-75	200-1,500	27	60°	Well-drained
Auburn	Amphibolite schist	Foothills	2-75	125-3,000	24	60°	Shallow to moderately deep, well drained
Caperton	Weathered granitic	Uplands	2-50	200-1,500	27	60°	Shallow, somewhat excessively drained
Columbia	Alluvium	Flood plains and natural levees	0-8	10-155	12-25	61°	Very deep, mod well drained
Cometa	Granitic	Gently sloping, slightly dissected older stream terraces	0-15	200-600	16	62°	Moderately well or well-drained
Conejo	Alluvium from basic igneous or sedimentary rocks	Alluvial fans/stream terraces	0-9	30-2,000	20	62°	Very deep, well drained
Corning	Gravelly alluvium	High terraces with mound, intermound relief	0-30	75-1,300	23	62°	Very deep, well or moderately well drained
Kilaga	Alluvium from mixed sources	Terraces	0-9	50-200	20	62°	Deep and very deep, well drained
Nueva	Alluvium from mixed sources	Floodplains	0-2	20-80	16	62°	Very deep, somewhat poorly drained
Ramona	Alluvium from granitic rocks	Terraces and fans	Nearly level to mod steep	25-3,500	15	63°	Well-drained
Redding	Alluvium	High terraces	0-30	40-2,000	22	61°	Moderately deep to duripan, well or mod well drained
San Joaquin	Alluvium from predom. Granitic source	Undulating low terraces	0-9	20-500	15	61°	Mod deep to duripan, well and mod well drained
Shanghai	Alluvium from mixed sources	Floodplains	0-2	20-150	18	62°	Very deep, somewhat poorly drained
Sierra	Acid igneous	Foothills	Gently sloping to steep	200-3,500	20-38	59° - 62°	Deep, well drained
Sobrante	Basic igneous and metamorphic	Foothills	2-75	125-3,500	32	60°	Mod deep well drained
Sycamore	Mixed sedimentary alluvium	Floodplains	Nearly level	10-100	15-20	60° - 62°	Poorly drained
Tisdale	Alluvium from mixed sources	Low terraces	0-2	20-80	18	62°	Mod deep, well drained
Xerofluvents	Young soils not differentiated enough to separate from soil suborder. Shallow, developed in Mediterranean climate, slopes of less than 25% and mean annual soil temperature above freezing and Holocene-age carbon; associated with low-gradient alluvial material adjacent to the lower Bear River corridor.						
Total	**18 Soil Series**						

Erosion hazard within a soil series is often strongly dependent upon slope. In general, the steeper the slope, the more erosive the soil, although erosion potential on steeper slopes may be moderated by coarse, well drained soils, such as those derived from granitic parent material.

3.3.1.1.5 Physiography

The current Bear River basin drains the northwestern Sierra Nevada via a series of deep canyons cut by mountain channels, separated by high, steep sided ridges and a parallel drainage network.

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In the upper section of the Bear River above Lake Combie, downcutting, through the relatively soft Paleozoic metamorphic rock (Shoo Fly Complex) has created a deep, v-shaped canyon where short, steep-sided tributary drainages are typical (Geomatrix 1997). However, in the lower Bear River downstream of Camp Far West Dam, the river flows through alluvial material and constructed levees. According to Sacramento River Watershed Program's report on the Bear River, a high volume of mining sediment along with the levees restricting lateral movement that have caused the lower Bear River to become incised (SRWP 2010); Foothills Water Network (FWN) (2015) also cites this condition yet neither have provided data nor sources. During habitat mapping of the lower Bear River in 2015, SSWD found numerous locations where the channel is bounded by near vertical slopes between levees and vegetated, stable terraces. There are also inset floodplains, and low, semi-active terraces that are adjacent to the low flow (e.g., 25 cfs) channel.

3.3.1.1.6 Sedimentation

There are no known excessive sources of erosion that would lead to sedimentation within the Project Area. In 2008, a bathymetry study was done on Camp Far West Reservoir and compared against 1968 bathymetry. The 1968 reservoir storage volume was estimated at 104,000 ac-ft and in 2008 at 93,740 ac-ft, a reservoir capacity loss of 10,260 ac-ft[1] over 40 yrs (Mead and Hunt 2012). Based on an average specific weight of 70 pounds/cubic feet (cu ft), as estimated by Dendy and Champion (1978) for Lake Combie, this volume of sediment deposition in the reservoir indicates 16 million tons of sediment have been deposited, or 321,000 tons/yr, which translates to 2,188 tons/mi^2/yr. Accumulation rates for other reservoirs in the area are shown on Table 3.3.1-5.

Table 3.3.1-5. Accumulation rates in nearby reservoirs.

Stream	Reservoir (River Mile (RM) at Dam)	Rate of Deposition (ac-ft/mi/yr)
Bear River	Rollins Reservoir (RM 50.4)	2.1
	Lake Combie (RM 37.2)	0.75[1]
	Camp Far West (RM 18.2)	1.4
Yuba River	Englebright Reservoir (RM 24.3)	0.6

[1] Estimated by Dendy and Champion (1978).

Though sediment supply is high in the lower Bear River due to continued movement and availability of hydraulic mining debris, downstream of some dams, the channel can respond either with coarsening of the bed, or there may be no change if the downstream channel was originally transport-dominated (e.g., bedrock control with little storage of sediment). Construction of Camp Far West Dam and Lake Combie Dam (aka Van Geisen Dam) in 1928 halted downstream transport of most mining sediment (James 1988). Downstream channel responses to Van Geisen Dam were negligible in the middle Bear River because channels are dominated by bedrock. There was significant accumulation of sediment in the early 1900s at the Van Trent Gage, which was inundated by the Camp Far West Reservoir, which was attributed to historic mining sediment (James 1999).

[1] Calculated volume: 10,530 ac-ft*43,560 ft^2= 458,686,800 ft^3, multiplied by 70lbs/ft^3 = 3.2x10^{10} lbs = 16 million (m) tons/50 year = 321,000 tons/year. Camp Far West Dam drains an area of 146.7 mi^2.

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Hillslopes in the Project Vicinity, shown in Figure 3.3.1-5, are generally less than 25 percent. (Table 3.3.1-6). Within the Bear River arm (the arm that comes into the Reservoir from the southeast), slopes are often greater than 50 percent, especially where it narrows upstream of the main reservoir body. However, it appears that these steeper slopes are dominated by bedrock, judging from aerial photographs and the soil survey that identifies the soil association as Sobrante-Rock Outcrop Auburn (Figure 3.3.1-4 and Table 3.3.1-4), and are likely resistant to erosion. The spillway just below the dam is also in the 25-50 percent hillslope range. However, the spillway flows over bedrock.

Table 3.3.1-6. Summary of slope classes within the Project Vicinity.

Slope Class (%)	Acres	Percent of Project Vicinity
0-25	661,664	93.6%
25-50	41,154	5.8%
50-75	3,723	0.5%
75+	389	0.1%
Total	**706,930**	**100.0%**

Excluding recreation-related roads, the Proposed Project includes one road: a short, paved road segment that accesses the Camp Far West Powerhouse. However, there are unsealed roads on the western side of the reservoir that may be contributing fine sediment. Slopes are steepest in the Bear River arm of the reservoir. However, there are few roads close to the water and the river appears to be bounded by resistant parent rock (i.e., there is no evidence of channel or hillslope instability that adds coarse or fine sediment) within the Project.

The inactive Dairy Farm Mine occupies a low terrace within the FERC Project Boundary that extends into the reservoir. Significant parts of the historic mine are within the drawdown zone and are currently being eroded. The Dairy Farm arm receives acidic, metal-rich drainage seasonally from the mined area (Alpers 2008). In the 1980s, several acres were reclaimed by removing pyrite-bearing waste rock and mill tailings to reduce the acidic runoff and pool soil quality (G. Vaughn, California Regional Water Quality Control Board-Central Valley Region, oral communication, 2001 as cited in Alpers 2008).

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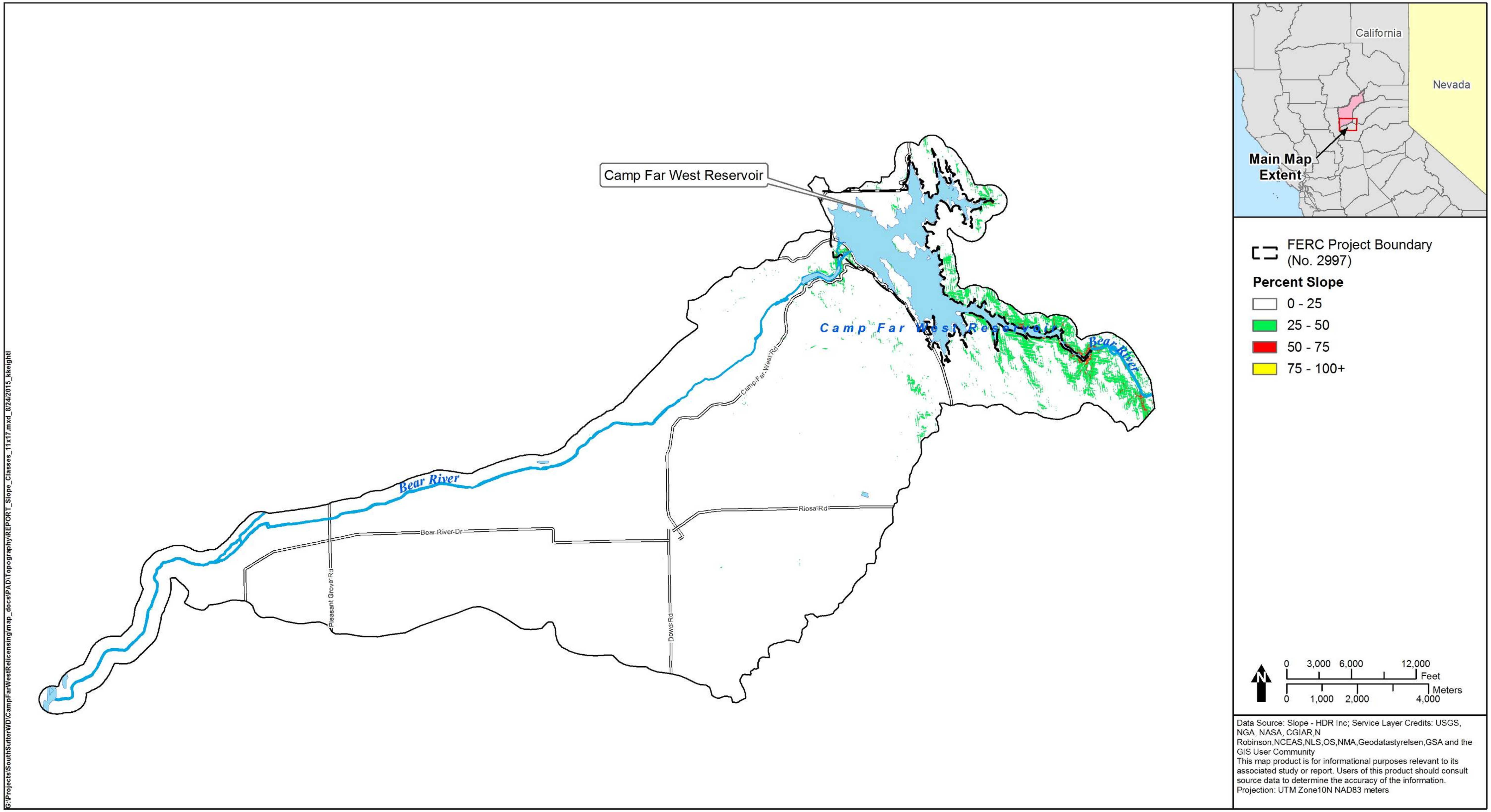

Figure 3.3.1-5. Slopes in the Project Vicinity.

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3.3.1.1.7 Existing Reach Information

This section presents existing information to describe channel setting and processes in the following reaches: 1) upstream of the Project; 2) within the Project; and 3) downstream of the Project.

Upstream of the Project

In reviewing aerial imagery (Google EarthPro 2015®), the Bear River flows through bedrock and boulder and there are substantial sections of bedrock gorge, which (James 1999) characterized as a “steep gorge”. (James 1999) reported that there has been little sediment production and storage between Lake Combie and Camp Far West Reservoir due to the steep gorge, and there are no major obstacles to sediment transport. A rough estimate of average gradient for this reach, based on change in elevation of 1,200 ft over 13.8 mi, is 1.6 percent.

NID owns and operates the Combie development. Lake Combie has little water storage capacity and the reservoir fills with each storm event. Dredging to maintain water storage capacity has occurred over the past 40 yrs, and was halted in 2002 due to high mercury levels. While monitoring and studying the effects on water quality and biota, a sediment and mercury removal project was approved to extract mercury from dredged sediments, initially estimated to be about 150,000 to 200,000 tons of accumulated sediment. The project is estimated to take 3-5 yrs to complete, with on-going maintenance to remove the annual sediment accumulation, estimated to be 50,000 tons/yr (NID 2012). Initially, 804 milligrams of elemental mercury was removed from 944 kilograms of material from Lake Combie (NID 2012). In June 2018, NID agreed to move forward with a pilot project to remove and clean approximately 80,000 cu yd of sediment from Combie Reservoir (NID 2018).

At the request of NID, reach assessments were conducted within an approximately 5.5 mi section of the Bear River from Lake Combie to Wolf Creek (ECORP 2014). One response reach within the Bear River was selected for an instream flow and sediment study. Three potential study sites were identified and an 844-ft section of the Bear River, known as the Laursen Reach, was selected by interested parties and found to be representative of habitat types and composition. Generally, the river is controlled by bedrock and large boulders with little vegetative cover. The complete results are found in the ECORP documentation. However, the general findings were:

- Average width was 35.5 ft for the Bear River location, and 34 ft within the study area, and widths within the study area ranged from 12 to 69 ft, and depth from 1 to 23 ft.
- Mid-channel pools composed over 50 percent of the habitat type, with riffles next (25 %) and then run/glide habitat (22 %).
- Cover provided by vegetation is less than 10 percent; cover from undercut banks is about 1 percent; large boulders provide 15 percent; surface turbulence and depth provided an average of 15 percent.
- Trout spawning habitat is less than 1 percent. Sediment typically ideal for trout spawning are scarce or armored below larger imbricated cobbles.

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- LWD is largely absent in the entire 5.5 mi section.
- Bear River is largely bedrock-controlled. Specifically within the Laursen Reach substrate ranged from coarse sand to bedrock, yet is dominated by 20-60 percent boulders and 10-65 percent bedrock.
- Very little sediment is present, most of which was located on point bars, behind boulders, and underneath or behind LWD. In the Laursen Reach, if sediments did exist, it was mostly gravels and to a lesser extent cobbles. Very little sediment was available for sampling.
- Bankfull discharge is estimated to be about 60-80 cfs.
- Roughly half of the available sediments between 20-43 millimeters (mm) in diameter would be entrained at flows up to 15 cfs within most of the habitat units.
- Minimum annual peak flow from 2001 to 2011 was 823 cfs.
- Flows capable of mobilizing and transporting large sediments likely occur every year. Bear River appears to be highly competent to transport 15 to 35 percent of the gravel materials at flows under 10 cfs, which makes this river unsuitable for gravel augmentation.

Channel reaches within the Bear River mining districts remain dominated by mining tailings after more than 100 yrs (James 1991). Much of the sediment produced by incision into mining tailing deposits was deposited near the aggrading confluences of Steephollow and Greenhorn creeks with the Bear River and currently forms deltas in Rollins Reservoir (James 2004). Detention of down-valley sediment deliveries by dams created a sediment-starved environment dominated by channel erosion in the lower Bear River valley below Rollins, Van Giesen, and Camp Far West dams. Channel incision below these dams reflects lowered sediment loads and effects of altered flow regime have exacerbated incision (James 1988). Anthropogenic changes due to mining changed the Bear River from a supply-limited system to a transport-limited system, and a change in geomorphic processes away from long-term drainage evolution dominated by ingrown meanders.

Within the Project

Camp Far West Reservoir may receive acidic, metal-rich drainage seasonally from the inactive Dairy Farm Mine. This mine, located within the FERC Project Boundary, is discussed in Section 3.3.1.1.3. Removal of pyrite-bearing waste rock and mill tailings in the 1980s reduced some of the acidic runoff and poor soil quality. However, the pit remains a likely source of trace metals, sulfate, and acidity to Camp Far West Reservoir and the lower Bear River. Elevated concentrations of total mercury in the water of Camp Far West Reservoir and in the biological taxa over a range of trophic levels were observed in fall and winter from October 2001 through August 2003 (Alpers et al. 2008). Alpers et al. (2008) reported mercury bioaccumulation factors are high compared to other reservoirs in northern California, which indicates relatively efficient biomagnification (Alpers et al. 2008). In contrast, SSWD's relicensing *Water Quality Study* found total mercury concentrations ranged between 2 nanograms per liter (ng/L) and 33.8 ng/L during three sampling events near Camp Far West Dam. Five of the six samples collected for

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mercury were less than 6 ng/L and the sixth sample (33.8 ng/L) was taken near the bottom of the reservoir in November 2017. All six samples SSWD collected and analyzed for total mercury were below the Basin Plan Water Quality Benchmark of 50 ng/L (EPA 2000). Regarding total and dissolved methyl mercury, five of the six samples were a "non-detection" and the sixth sample measured 0.1 ng/L (Table 3.3.3.2-9). These mercury concentrations were similar to those observed in the Bear River upstream of Camp Far West Reservoir where total mercury ranged between 2.4 ng/L and 11.3 ng/L over three sampling events and total and dissolved methyl mercury was a "non-detection" for two of the three samples and the third sample was 0.5 ng/L (Table 3.3.2.8). Additional discussion of mercury in Camp Far West Reservoir is in Section 3.3.2.1.2.4 of this Exhibit E.

The Bear River had a waterfall that barred upstream salmon movement in the vicinity of the Camp Far West Reservoir. The waterfall was submerged or built upon during construction of the dam (Wildland Resources Center 1996).

On the section of the Bear River, now inundated by the Camp Far West Reservoir, was the Van Trent stream flow gage that operated from 1905 to 1928. It was reported by Keyes (1878) that there was three meters (m) of aggradation that occurred in the 1870s. Channel instability and rating-curve changes were noted between 1907 and 1927. Large volumes of sediment were produced in the Bear River Basin from 1913-1914 and from 1918-1921; hydraulic mining provided sediment to the channel and high flows transported and redistributed the material downstream. These sediment volumes correspond to high flows recorded at the Van Trent gage (James 1991). Rating curve changes were noted in most years from 1914 to 1927, and in 1909, were specifically attributed to the movement of "mining debris" (James 1999).

The Camp Far West Dam existing spillway terminates in a chute excavated into solid rock. This unlined channel then joins the Bear River approximately 1,200 ft below the dam. Material eroded from the spillway channel has been deposited as an alluvial fan at the junction with the Bear River. The fan is approximately 450 ft long by 300 ft wide, and is composed of fairly coarse, stable material (Figure 3.3.1-6). The distal end of the alluvial fan, located about 700 ft downstream of the dam face, restricts the mainstem channel width from 70 ft to 23 ft, then the channel width increases downstream of the fan to over 200 ft. The alluvial fan material is stored within the backwater area of the diversion dam impoundment. There are no obvious additional failures or excessive sediment sources on the slopes or banks of the SSWD diversion dam impoundment below the reservoir.

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Figure 3.3.1-6. Camp Far West Dam and Spillway Channel on the Bear River at RM 16.9. The red circle indicates the alluvial fan.

In most years, SSWD collects no LWM from the surface of Camp Far West Reservoir. Very little LWM enters the reservoir from upstream and the reservoir shoreline has very little LWM.

SSWD is unaware of any reservoir shoreline stability issues. In general, the shoreline is gently sloping and stable. At the Dairy Mine site, the historic tailings pile is creating acid mine drainage (Alpers 2008). There is a two-track road that begins in the Project Area on the historic tailings pile and continues southeast onto private property. There is an eroded mound of dirt and gravel that is yellow and full of sulfur that was likely bulldozed into the location during mine destruction as trees are undisturbed; it is unclear if the material can be directly transported to the reservoir. Most of the Dairy Mine is on private property.

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Downstream of the Project

The lower Bear River is described below based on information developed by Allan James, the FWN, the Sacramento Watershed Program, and SSWD.

The lower Bear River was an anastomosing channel with a series of sloughs and with two terrace sets described by early settlers, the lowest terrace remains in-filled by deposition of mining sediments (James 1988). James estimated 164 million cu yd was stored in the lower Bear River during maximum aggradation. In the lower Bear River, incision processes dominated from 1905 to 1928. Between 1930 and 1955, the channel was relatively stable as pre-mining alluvial gravel armored the bed. The channel began to incise again in 1955 after a large flood penetrated the coarse gravel layer. Incision was unaffected by construction and enlargement of Camp Far West Dam, which suggests that changes in flow regime and sediment loads caused by the dam were much less important than penetration of the channel armor layer prior to dam construction (James 1988).

There is little urban development along the corridor. However, agricultural uses and levees influence floodplain development, water distribution, and riparian environments. In 2004, the Environmental Defense Fund, FWN and their partners reported in *Assessing Flow Improvement Needs and Opportunities in Northern California's Bear River Problemshed* various flow needs and flow-related challenges in the lower Bear River (FWN Bear River *Awakening* webpage 2015). Among the issues identified, due to past accumulation of mining sediments and presence of restricting levees, the channel has become narrow and incised, that downstream gravel recruitment had been limited for many yrs and would need to be supplemented to improve habitat, and that invasive Giant Arundo (i.e., giant cane, or *Arundo donax*) should be eradicated. They did not indicate there were data to support these identified issues. Figure 3.3.1-7 shows active and prolific sediment additions from near the CEMEX property above Highway 65 (~ RM 12) with giant cane in the active channel that had been stabilizing gravel bars. Much of the giant cane was removed by the very high flows in 2017.

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Figure 3.3.1-7. An example of bank erosion, gravel bar formation, and giant cane concentration in the lower Bear River (RM 13).

The USFWS was to develop competitive Request for Proposals for studies to evaluate baseline conditions as well as fishery restoration needs and opportunities on the lower Bear River below Camp Far West Reservoir (Yardas and Eberhart 2005). As of 2013, no projects have been conducted, nor is there information for the watershed (USFWS 2013).

Between 2005 and 2009, the Bear River Setback levee was designed and constructed by the Three Rivers Levee Improvement Authority to replace an existing levee. The improved levee was approximately 9,600 ft long and replaced levee portions at the junction of the Feather and Bear rivers. The setback levee was designed to provide a 200-year flood protection level. In addition, 1 million shrubs and trees were planted in the setback area to prevent erosion and to benefit threatened and endangered species in the expanded floodway (SRWP 2015).

There are significant quantities of gravel in the lower Bear River, much of which may be derived from hydraulically mined sediments. It was estimated previously that 160 million cu yd of mining sediment are stored in the lower Bear River (FWN 2015a). The high volume of mining sediment, in combination with restricting levees, has caused the lower Bear River to change from

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wide and shallow to deeply incised, according to the FWN. However, no data have been collected to support this claim. The Sheridan Pit gravel and aggregate mine (now part of the CEMEX sand and gravel mining and processing operation) is testament to the high volumes of sand and gravel present in and near the Bear River. Additional discussion of gravel availability as it relates to fisheries is provided in Section 3.3.3.1.3.

Further characterization of stream channel characteristics downstream of the Project is described below with respect to channel form, large woody material, and instream habitat.

Channel Form

To characterize sediment storage within the lower Bear River channel, a hillslope shading map was developed by SSWD (2010) using LiDAR to delineate floodplains and terraces adjacent to the lower Bear River (Attachment 3.3.1A). These maps were used to quantify channel sediment into sediment storage types (i.e., Active, Semi-Active, Inactive, and Stable), as defined in Table 3.3.1-7. The area used to quantify the aerial extent within each stability class was limited to between the constructed levees or stream-adjacent roads that would limit lateral channel movement. If no artificial limit to lateral movement was obvious but the channel was bounded by the Stable stability class (i.e., greater than 20 ft above the water surface during low-flow), approximately 100 ft on each side of the channel was used to quantify such areas. LiDAR data were not available for the area from the non-Project diversion dam to the Camp Far West Dam so this assessment was not performed for that area.

Sediment storage volume was assessed as part of the Study 3.3, *Instream Flow*, as shown in Table 3.3.1-7. Volume was estimated using average thalweg depth assessed during the *Instream Flow Study* at the upstream (between RM 14.2 to 15.1) and downstream (between RM 7.7 to 8.3) modeling sites, then converted to tons using Dendy and Champion (1978) formula. The greatest area of stored sediment is within the semi-active classification, while the lowest is within the active channel.

Table 3.3.1-7. Estimate of sediment stored within four stability classes within and adjacent to the lower Bear River.

Stability Class	Description[1]	Height above low-flow water surface elevation (ft)[2]	Area (million ft^2)	Volume (m ft^3)[3]	Quantity (m tons)[4]
Active	Moves at least once every few years	0-6	5.7	31	1.1
Semi-Active	Susceptible to revegetation and moved every 5-20 years	6-15	19.5	254	8.8
Inactive	Moves only during extreme events every 20-100 years and becomes well-vegetated in the interim	15-20	15.3	306	10.7
Stable	Deposits are not accumulating under present climate or channel regime, yet may be susceptible to cutbank erosion	20+	8.7	217	7.6

1 After Curtis et al. 2005 and Kelsey et al. 1987
2 Estimated from 2015 LiDAR; low flow discharge ~25 cfs
3 Using average/median thalweg depth and midpoint of stability class height times area
4 Based on an average specific weight of 70 pounds/cubic feet (cu ft), as estimated by Dendy and Champion (1978)

The stability classes were quantified within sub-reaches that were defined for habitat mapping and the quantification of LWM (Table 3.3.1-8, Figure 3.3.1-8).

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Table 3.3.1-8. Area within stability class by sub-reach of the lower Bear River between the Feather River and the non-Project diversion dam.

Sub-Reach Name	Location and Length	Stability Class (million ft^2)			
		Active	Semi-Active	Inactive	Stable
Feather River to Highway 70	RM 0 to 3.5 (3.5 mi)	0..6	1.1	2.2	1.1
Highway 70 to Pleasant Grove Rd	RM 3.5 to 6.8 (3.3 mi)	1.0	9.9	7.1	1.0
Pleasant Grove Rd to Highway 65	RM 6.8 to 11.5 (4.7 mi)	1.5	3.9	3.7	8.3
Highway 65 to SSWD Diversion	RM 11.5 to RM 16.9 (5.3 mi)	2.6	4.5	2.4	1.7
Highway 65 to CEMEX	RM 11.5 to 14.2 (2.7 mi)	1.0	1.8	1.3	1.1
CEMEX to non-Project diversion dam	RM 14.2 to RM 16.8 (2.6 mi)	1.6	2.7	1.1	0.6

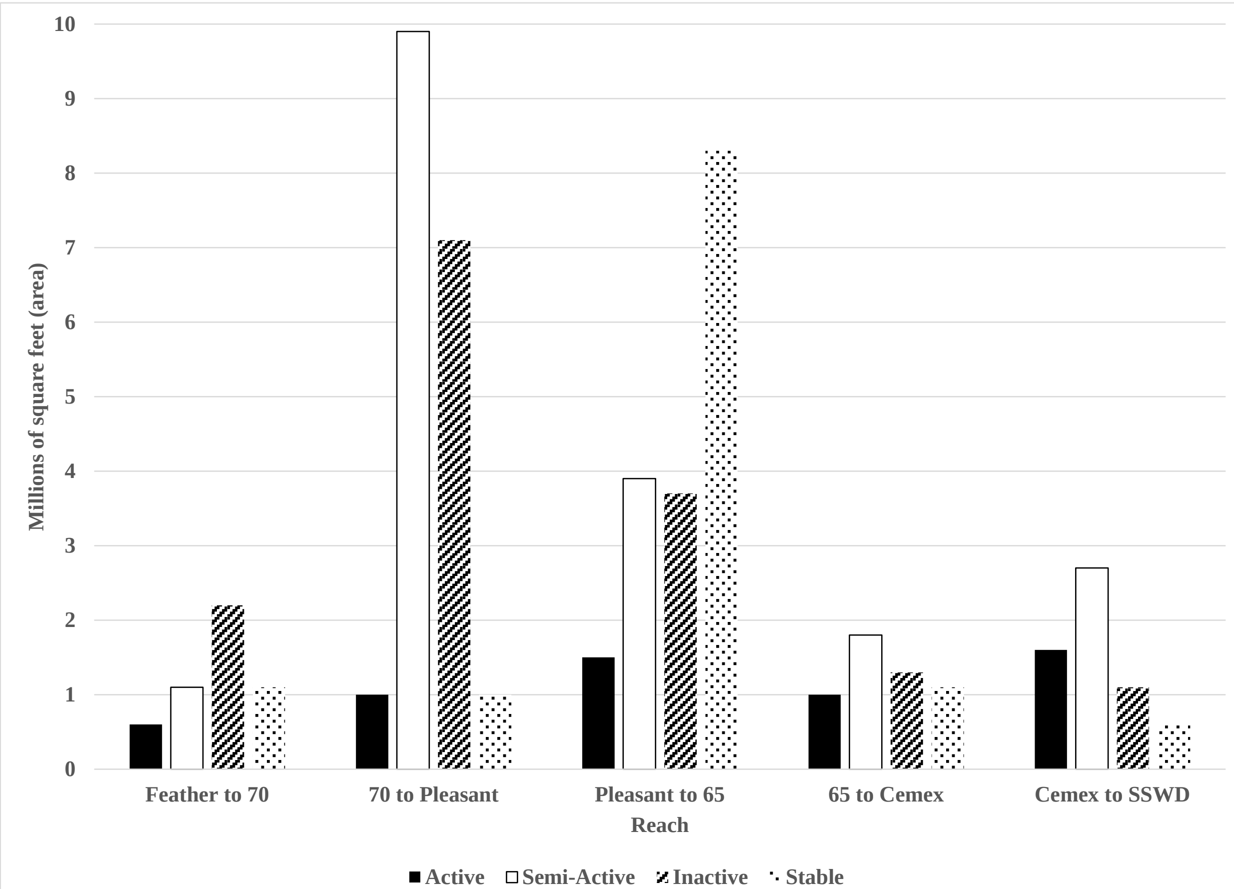

Figure 3.3.1-8. Area for each stability class within sub-reaches of the lower Bear River between the Feather River to the non-Project diversion dam.

The extent of channel confinement types was also quantified in terms of extent and location in the lower Bear River (Table 3.3.1-9). Seventy percent of the channel is defined as confined and 30 percent unconfined in the lower Bear River.

As defined above, the Active Stability class is considered the channel area within 6 ft of the low flow (~25 cfs) water surface elevation and is generally consistent with the 1.5 yr return

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frequency. The 1.5 yr return frequency stage height was estimated using instantaneous peak flows recorded at USGS Gage Station 11424000 on the Bear River near Wheatland at RM 11.5 along with the gage height/discharge relationship (Figures 3.3.1-9 and 3.3.1-10). Generally the river channel within a 1.5 yr return frequency is a floodplain under construction and flooded frequently at a relatively consistent recurrence interval and is important in geomorphic analysis (Dunne and Leopold 1978).

Table 3.3.1-9. Channel confinement types, extent and location in the lower Bear River between the Feather River (RM 0) and non-Project Diversion (RM 16.9).

Channel Type	River Mile		Distance (miles)	
	Start	End	Confined	Unconfined
Confined	0	3.1	3.1	--
Unconfined	3.1	3.5	--	0.4
Confined	3.5	3.9	0.4	--
Unconfined	3.9	4	--	0.1
Confined	4	4.35	0.35	--
Unconfined	4.35	4.6	--	0.25
Confined	4.6	5.6	1	--
Unconfined	5.6	6.5	--	0.9
Confined	6.5	6.7	0.2	--
Unconfined	6.7	7.4	--	0.7
Confined	7.4	9.1	1.7	--
Unconfined	9.1	10.2	--	1.1
Confined	10.2	10.9	0.7	--
Unconfined	10.9	11.3	--	0.4
Confined	11.3	11.6	0.3	--
Unconfined	11.6	11.7	--	0.1
Confined	11.7	14	2.3	--
Unconfined	14	14.4	--	0.4
Confined	14.4	15	0.6	--
Unconfined	15	15.8	--	0.8
Confined	15.8	16.9	1.1	--
		Total Miles	**11.75**	**5.15**
		Percent Total Reach	**70%**	**30%**

The Inactive Stability class is composed of the stable, vegetated terraces and levees located approximately 15-20 ft above the low flow 25 cfs water surface elevation. Sediment stored within the Semi-Active Stability class, typically accessed during high flow events, was often found to be composed of cohesive material that enhances lateral stability of the mainstem, in some cases including vertical slopes that resist lateral channel movement.

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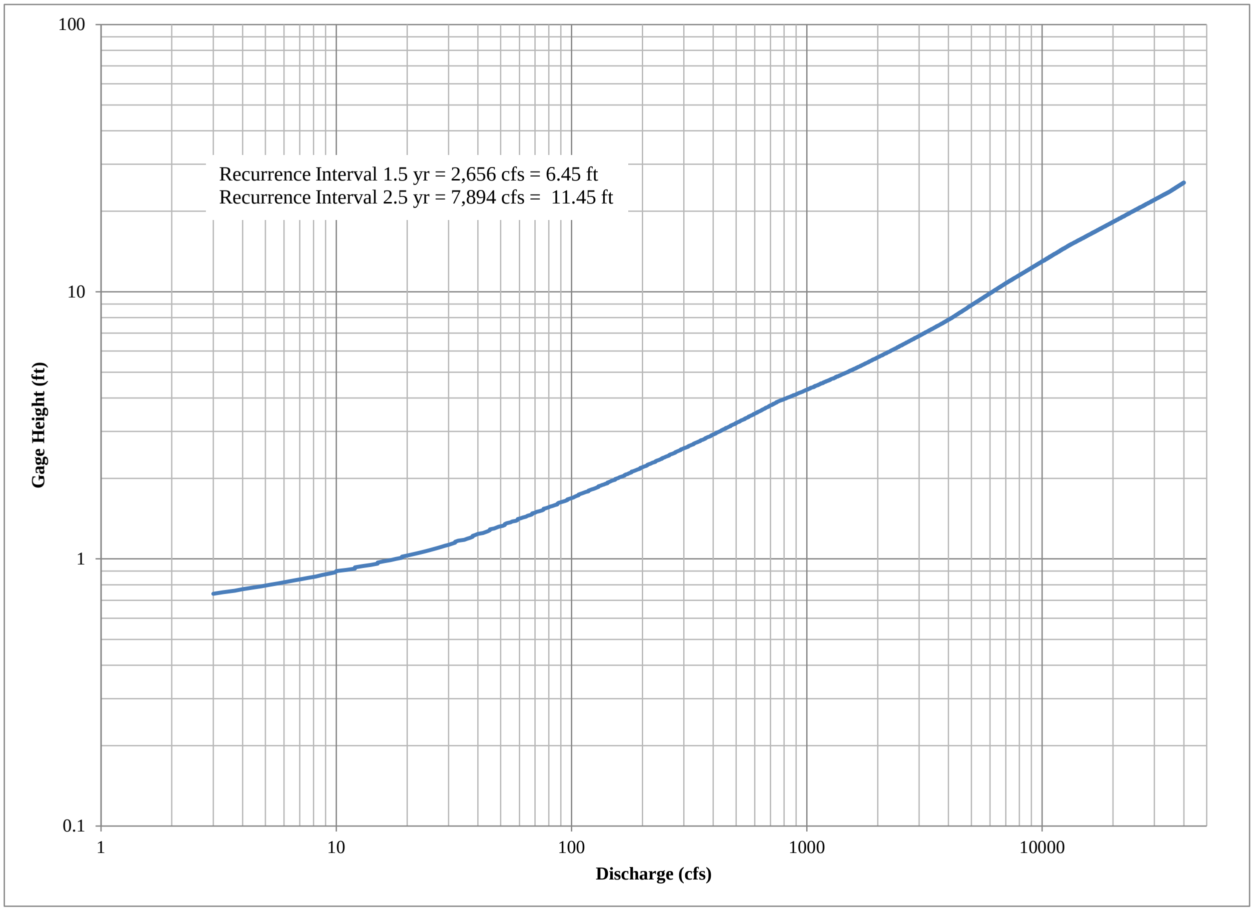

Figure 3.3.1-9. Rating curve for the Bear River at Wheatland USGS Gage 11424000 at Hwy 65 (RM 11.5) based on Instantaneous Peaks 1964 to 2015.

Figure 3.3.1-10. Determining the elevation of 1.5 yr frequency flow (2,656 cfs) for the Bear River at Hwy 65 (RM 11.5) based on instantaneous peaks 1964 to 2015 at USGS Gage station 11424000.

Channel confinement in the lower Bear River occurs between reinforced, vegetated levees or stable vegetated terraces, and also where the banks are vertical and eroding. About 50 percent of the mapped meso-habitat units were experiencing active bank erosion. Some of this erosion may be due to incision into the deposited historical mining sediments, and because levees restrict lateral channel movement. To further understand the bank types and mechanisms of erosion, the *Instream Flow Study* quantified the area (height and length) of bank types (Figure 3.3.1-11) within ten randomly selected sections of the lower Bear River, five within confined channels and five within unconfined channels (Table 3.3.1-10). Stability, for the purposes of the bank analysis exercise, refers specifically to bank erosion, and is a different type of stability than that defined for the broader sediment “Stability Classes” as above in Table 3.3.1-7.

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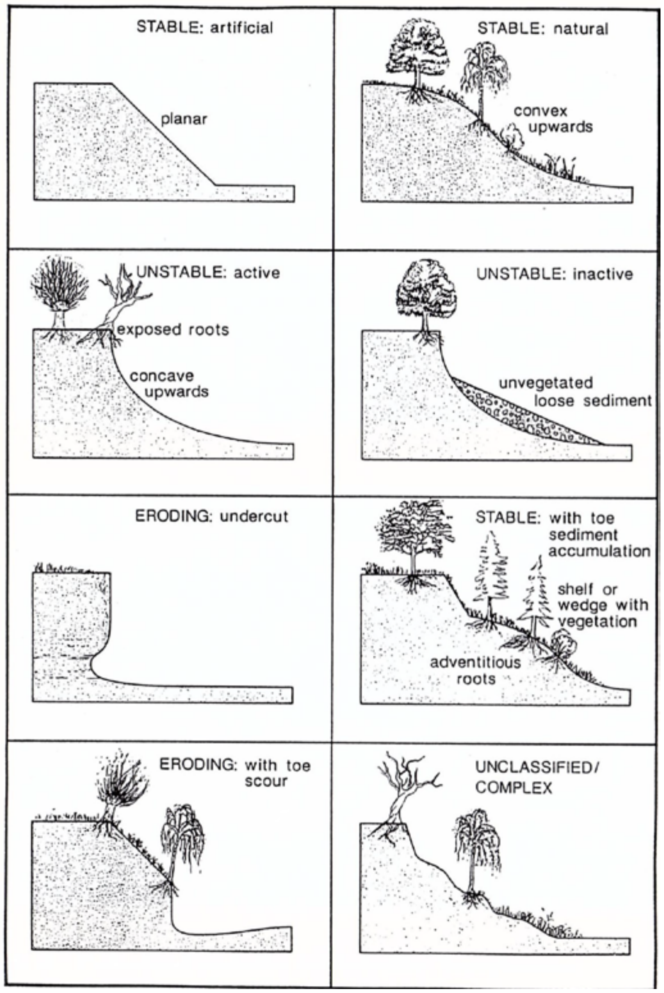

Additional Stable Bank Types:

STABLE: Top unstable, base stable

STABLE: Toe undercut

Figure 3.3.1-11. Bank types classified in the lower Bear River at 10 random sites between the SSWD Diversion and the Feather River. From: *Figure 19. Classification and morphological interpretation of typical bank profiles* (Thorne 1998).

Table 3.3.1-10. Summary of bank erosion quantified by channel type at 10 random sites in the lower Bear River between the non-Project Diversion and the Feather River.

Site (RM)	Channel Type	Extent of Bank Erosion Area (sq ft)	
		Stable	Unstable
2.57	Confined	-0-	33,944
3.33	Unconfined	6,953	19,336
5.83	Unconfined	9,444	8,278
6.11	Unconfined	1,348	21,336
6.35	Unconfined	5,919	17,563
8.56	Confined	21,753	8,612
9.64	Unconfined	3,046	11,678
10.56	Confined	203	12,262
11.80	Confined	5,506	18,904
14.77	Confined	2,352	30,692

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In general, confinement was not particularly relevant to extent or type of bank erosion. Most of the banks are exposed and actively eroding. The base of the banks are often undermined and undercut (i.e., Eroding – with toe scour [36%], Eroding – undercut [12%]), as described in Table 3.3.1-11. LWM is periodically added to the channel from these vertical banks wherein the entire tree, including the root mass is added to the channel often creating areas of bed scour and bank protection. The banks maintain a vertical profile due to fine-grained and cohesive bank material. The dominant material is composed of sand and finer, as shown in Table 3.3.1-12. The less cohesive cobble and gravel banks are associated with the extensive gravel and floodplain deposits; (refer to the hillslope shading map [Attachment 3.3.1A] where the 0-6 ft stability class occupies a larger fraction of the area between the levees, e.g., above RM 14.1). Near the toe of these coarse-grained deposits (e.g., stream-adjacent within the low flow active channel), the gravel bars have fairly resilient and resistant bank protection provided by sedges, rushes and hydrophytic vegetation within the low flow active channel. Boulders were not found except where artificially placed to stabilize the bank from lateral erosion.

Table 3.3.1-11. Area (height and length) of bank types quantified within 10 sites (20 channel widths in length) in the lower Bear River between the Feather River and the non-Project Diversion Dam.

Bank Type	Area (sq ft)	Percent Area	Stable
Eroding - with toe scour	84,943	36%	
Unstable - active	40,613	17%	
Eroding - undercut	28,185	12%	
Stable - with toe sediment accumulation	26,671	11%	x
Unclassified - complex	18,752	8%	
Stable - toe undercut	13,526	6%	x
Unstable -inactive	12,437	5%	
Stable - natural	7,250	3%	x
Stable - artificial	4,834	2%	x
Top unstable, base stable	1,917	1%	x

Table 3.3.1-12. Area (square feet) of dominant substrate of bank types quantified within 10 sites (20 channel widths in length) in the lower Bear River between the Feather River and the non-Project Diversion Dam.

Bank	Dominant Substrate (square feet)				
Type	Boulder	Cobble	Gravel	Sand	Silt and Finer
Unstable - active	0	260	1,303	26,967	12,083
Unstable -inactive	0	1,221	6,103	5,113	0
Eroding - undercut	0	1,087	1,737	10,043	15,319
Eroding - with toe scour	0	4,400	7,817	31,982	40,744
Stable - with toe sediment accumulation	0	0	4,623	7,753	14,295
Unclassified - complex	0	2,033	1,718	5,434	9,568
Top unstable, base stable	0	0	1,917	0	0
Stable - artificial	4,834	0	0	0	0
Stable - natural	0	1,356	286	0	5,608
Stable - toe undercut	0	5,964	0	720	6,843
Total	**4,834**	**16,321**	**25,504**	**88,012**	**104,460**

Large Woody Material

LWM was quantified during the habitat mapping effort. All pieces within the active channel (1.5 yr frequency elevation) that were larger than 4-in diameter at the large end, and longer than 3 ft were tallied (Table 3.3.1-13). LWM concentration ranged between 18 and 65 pieces per mile (1.1 to 4.0 pieces/100 m), and most of the pieces were within the wetted channel. The

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highest concentration of LWM was located between Highway 70 and Pleasant Grove bridges, and the lowest concentration was between Highway 65 (RM 11.5) and the CEMEX gravel operation (RM 14.2). The riparian area of the lower Bear River is heavily modified by levees and agricultural modifications so the recruitment potential is very low and outside of the control of Project operations. Key pieces of LWM were defined as pieces either longer than 0.5 times the low flow active channel (LFAC), or are deposited in a manner that alters channel morphology and aquatic habitat (e.g., trapping sediment or altering flow patterns). Table 3.3.1-14 summarizes the key pieces found during the habitat mapping effort in 2016. Based on incidental observations by SSWD during other field efforts, some of these pieces moved during the 2016/2017 high flows. However, new pieces were added due to bank failures.

Table 3.3.1-13. Summary of LWM count by diameter and length class within the lower Bear River between the Feather River and the non-Project diversion dam.

Reach	Diameter (in)	Length (ft)				Total Number of Pieces	Number of Pieces Within Wetted Channel	Pieces / Mile	Pieces / 100 m
		3-25	26-50	51-75	>75				
Feather River to Hwy 70	4-12	67	11	--	--	--	--	--	--
	13-24	29	12	--	1	--	--	--	--
	25-36	4	7	2	--	--	--	--	--
	>36	1	--	--	--	--	--	--	--
	SUM	**101**	**30**	**2**	**1**	**134**	**92**	**38**	**2.4**
Hwy 70 to Pleasant Grove	4-12	118	18	1	--	--	--	--	--
	13-24	25	19	5	--	--	--	--	--
	25-36	10	8	7	1	--	--	--	--
	>36	--	--	1	--	--	--	--	--
	SUM	**153**	**45**	**14**	**1**	**213**	**161**	**65**	**4**
Pleasant Grove to Hwy 65	4-12	100	16	--	--	--	--	--	--
	13-24	26	17	3	--	--	--	--	--
	25-36	4	7	3	1	--	--	--	--
	>36	--	--	2	1	--	--	--	--
	SUM	**130**	**40**	**8**	**2**	**180**	**90**	**38**	**2.4**
Hwy 65 to Cemex	4-12	26	3	--	--	--	--	--	--
	13-24	7	8	--	--	--	--	--	--
	25-36	1	4	--	--	--	--	--	--
	>36	--	--	--	--	--	--	--	--
	SUM	**34**	**15**	**0**	**0**	**49**	**43**	**18**	**1.1**
Cemex to non-Project Diversion Dam	4-12	41	2	--	--	--	--	--	--
	13-24	12	1	--	--	--	--	--	--
	25-36	5	1	--	--	--	--	--	--
	>36	--	--	--	--	--	--	--	--
	SUM	**58**	**4**	**0**	**0**	**62**	**55**	**23**	**1.4**

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Table 3.3.1-14. Summary of key pieces of LWM within the lower Bear River between SSWD's non-Project Diversion Dam and Feather River.

Reach	Diameter (in)	Length (ft)				Function Provided	
		3-25	25-50	50-75	>75	Type	Percent of Function[1]
Feather River to Hwy 70	4-12	--	3	--	--	Cover Bank Protection Scour Sediment Storage No geomorphic function Vegetation trapping	40 10 15 5 25 5
	13-24	--	7	1	--		
	25-36	--	5	1	1		
	>36	--	--	--	--		
	SUM	--	15	2	1		
Hwy 70 to Pleasant Grove	4-12	6	5	--	--	Cover Bank Protection Scour Sediment Storage No geomorphic function Vegetation trapping Dam	30 20 26 8 13 2 1
	13-24	1	14	9	1		
	25-36	2	10	7	--		
	>36	1	2	1	--		
	SUM	10	31	17	1		
Pleasant Grove to Hwy 65	4-12	2	1	--	--	Cover Bank Protection Scour No geomorphic function	47 23 12 18
	13-24	--	--	1	--		
	25-36	4	2	--	--		
	>36	2	5	--	--		
	SUM	8	8	1	--		
Hwy 65 to Cemex	4-12	2	1	--	--	Cover Bank Protection Scour Sediment Storage No geomorphic function	28 28 34 7 3
	13-24	2	7	--	--		
	25-36	--	2	--	--		
	>36	--		--	--		
	SUM	4	10	--	--		
Cemex to non-Project Diversion Dam	4-12	1	--	--	--	Cover Bank Protection Scour	50 25 25
	13-24	1	--	--	--		
	25-36	--	--	1	--		
	>36	--	--	--	--		
	SUM	2	--	1	--		

[1] Some pieces have more than one function.

There was no real difference in the amount, size, species, or function of the LWM (including key pieces) found within the downstream instream flow modeling site (Tables 3.3.1-15 and 3.3.1-16) from that quantified in the lower Bear River as a whole (Table 3.3.1-14). There was no LWM in the upstream modeling site that met the minimum size criteria.

Table 3.3.1-15. LWM found in Bear River downstream instream flow study site (RM 7.7 to 8.3).

Location	Diameter (in)	Length (ft)				Total Number of Pieces	Number of Pieces Within Wetted Channel
		3-25	25-50	50-75	>75		
Downstream Instream Flow Study Site	4-12	16	2	1	--	--	--
	13-24	5	6	5	--	--	--
	25-36	--	--	1	--	--	--
	>36	--	--	--	--	--	--
	SUM	**21**	**8**	**7**	**0**	**36**	**19**

Table 3.3.1-16. Key piece characteristics within the downstream instream flow study site (RM 7.7 to 8.3).

Piece ID Number	Total Length (ft)	Diameter (in)	Orientation	Function	Root Wad Attached?
1	28	8	downstream	Bank protection	Yes
2	50	12	downstream	Bank protection	Yes
3	65	12	downstream	Bank protection	Yes
4	50	18	downstream	Bank protection	Yes
5	60	12	downstream	Bank protection	Yes
6	40	12	downstream	Scour	Yes
7	70	15	downstream	Bank protection	Yes
8	38	20	downstream	Bank protection, scour	Yes
9	64	36	downstream	None	No

Instream Habitats

In June 2015, October 2016 and August 2017 (following high flows during the winter of 2016/2017), SSWD evaluated the Bear River between Camp Far West Dam and the Feather River for habitat features and channel characteristics. The mapping consisted of assessing length of meso-habitat types and other channel features such as bank erosion and floodplain/terrace development. As part of these measurements, the LFAC was measured as a surrogate for bankfull width. The LFAC was defined as the area where vegetation was still hydrologically connected when flow was at a minimum instream flow (~10 – 25 cfs) and was identifiable in the field. Each meso-habitat had the length, LFAC width, and substrate recorded, along with a photograph. Maximum and average pool depth were also recorded for pools. In some units (a sub-set of the reach), more details were collected such as bank erosion and cover.

Meso-habitat types were dominated by pools, short riffles, runs, and long glides. The average gradient of the Bear River is generally less than 0.5 percent, with few falls, cascades, chutes, rapids, step runs, pocket water, or sheet flow habitat types. Habitat types in the Bear River are summarized in Figure 3.3.1-12. There is one exception near Highway 70 where the Bear River flows over a bedrock control and falls, rapids, and a plunge pool occur. The substrate of the mapped units in the majority of the channel is dominated by gravel with mostly cobble sub-dominant (Table 3.3.1-17). Sand is a minor component though is often the subdominant substrate present. Increasing amounts of exposed bedrock and cobble substrates occur closer to the non-Project diversion dam. The coarsening of material in the upstream direction is likely due to both a change in parent material (i.e., alluvium to volcanics) and a decrease in available sediment due to storage in Camp Far West Reservoir. Additional mudstone bedrock is exposed in the channel above HWY 65 at about RM 12.4 and upstream of Pleasant Grove Road at RM 6.7. Very little silt occurs in the active channel, though the banks are often composed of finer, sandy/silty material. There was not much in-channel cover observed and most of it was from giant cane concentrations that lined and often extended across the channel (Figure 3.3.1-13). The giant cane is fairly resistant to removal from higher flows, and served to scour pools and develop some areas of spawning gravel. While the giant cane populations were reduced during the winter 2016/2017 high flows, resistant roots were observed indicating that the cane will re-sprout and re-inhabit the channel.

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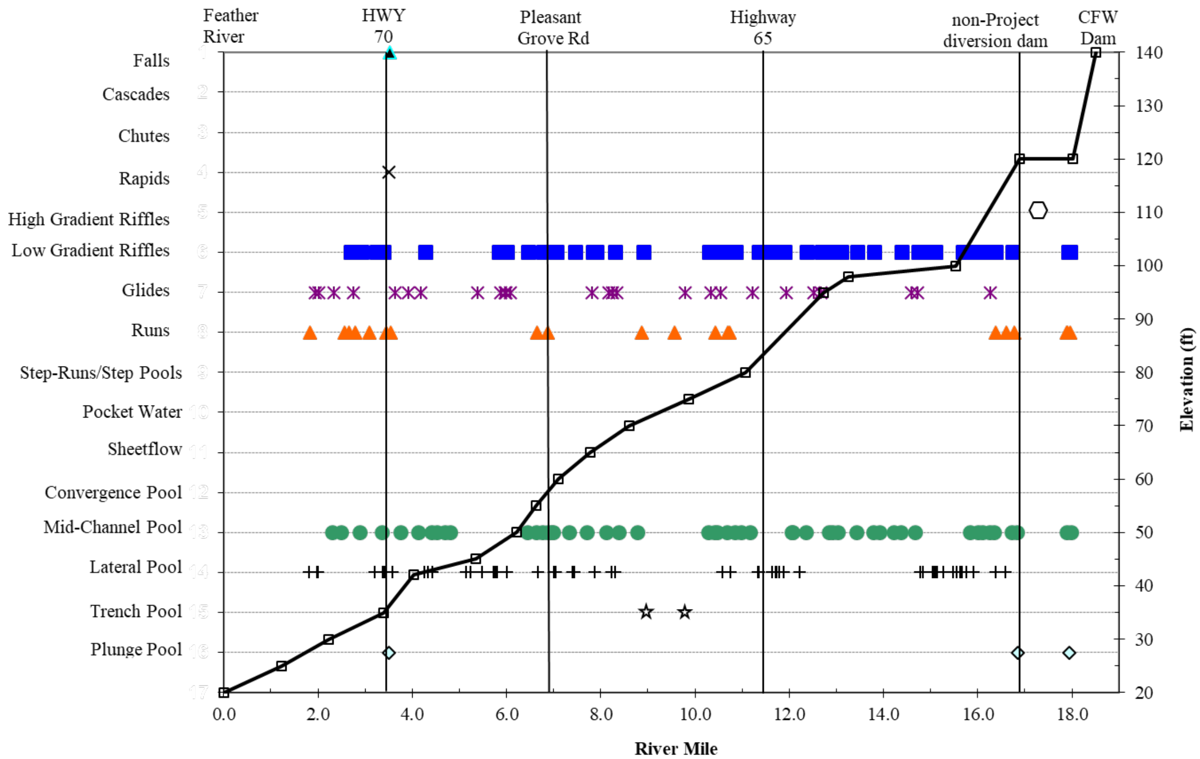

Figure 3.3.1-12. Longitudinal profile and habitat types mapped in the lower Bear River.

Table 3.3.1-17. Dominant, subdominant and bank substrate total length and frequency in the Bear River.

Substrate Type	Dominant Substrate		Subdominant Substrate		Bank Substrate	
	Total Length (ft)	Frequency (%)	Total Length (ft)	Frequency (%)	Total Length (ft)	Frequency (%)
Bedrock	696	4	603	4	872	7
Boulder	538	3	0	0	538	4
Cobble	4,893	27	4,577	29	1,257	10
Gravel	10,179	56	5,496	35	3,269	27
Sand	1,753	10	3,849	24	2,996	24
Silt	0	0	1,282	8	3,478	28
Total	**18,059**	**100**	**15,807**	**100**	**12,410**	**100**

Figure 3.3.1-13. Effects of introduced giant cane in providing cover, pool formation, gravel bar deposition and scour, and sorting of spawning-size gravels (pre-2016-17 high flows).

High flows during the winter of 2016/2017 (Figure 3.3.1-14) caused some changes to instream habitats due to scour and deposition based on observations made by SSWD before and after the high flows. SSWD observed that low gradient riffles increased in frequency and length in 2017 due to increased deposition and in areas where patches of giant cane were removed. Glides also increased in length and frequency due to deposition of gravel into areas that were previously runs or shallow pools. Some pools had enhanced scour if there were elements such as bedrock, boulder or large woody material forcing three-dimensional flow patterns (Table 3.3.1-18).

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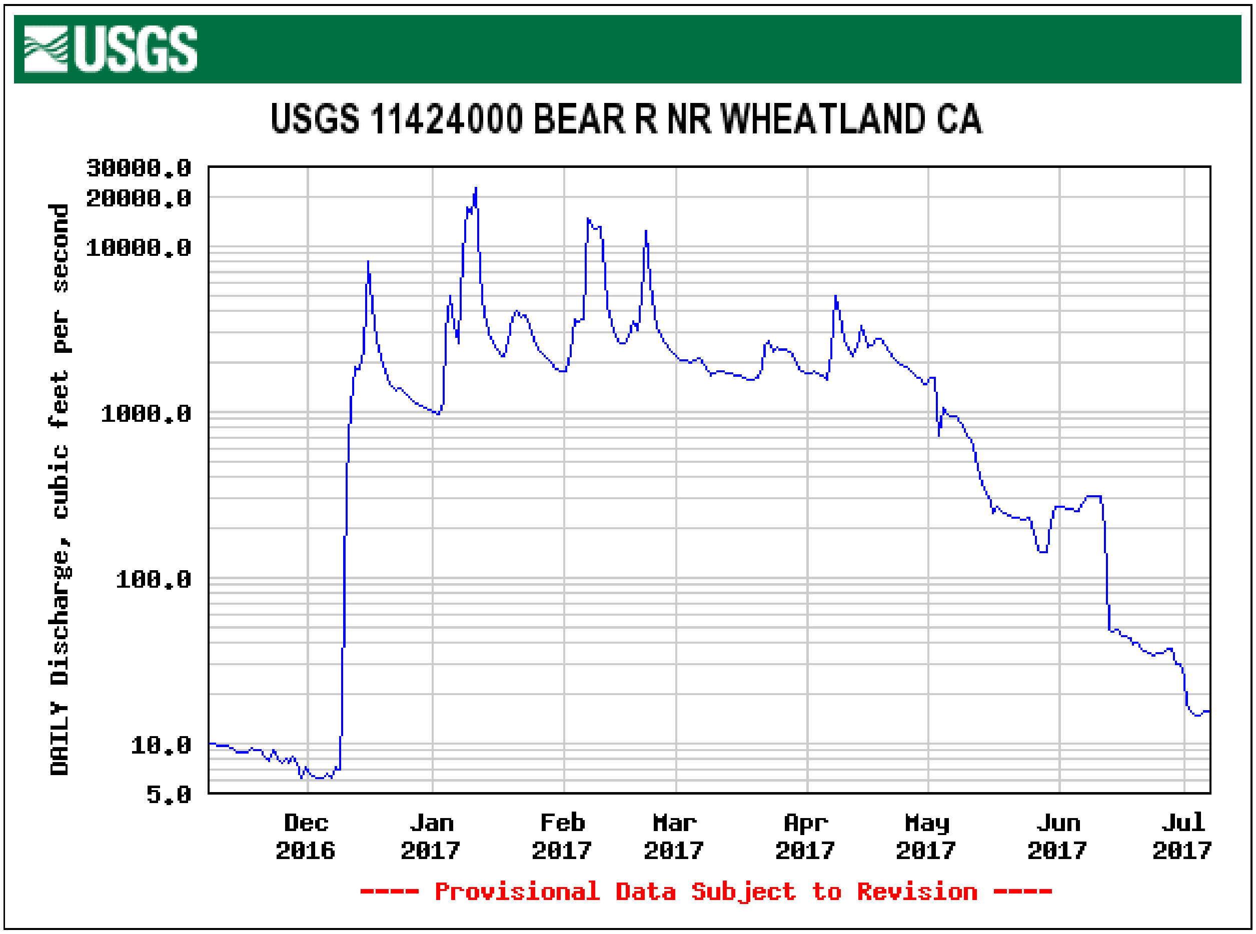

Figure 3.3.1-14. Data from USGS Gage 11324000 of Bear River near Wheatland California showing the high flows of late 2016 and early 2017. (Source: waterdata.usgs.gov. Accessed 2/8/18).

Table 3.3.1-18. 2017 Habitat type, length and frequency, and 2016 pre-flood relative frequency of habitats in the lower Bear River.

Unit Type	2016 Percent of Total Length (%)	2017 Percent of Total Length (%)	Change (%)
Mid-Channel Pool	35.9	35.1	-0.8
Lateral Scour Pool	19.5	18.7	-0.8
Glide	11.2	12.1	0.9
Backwater	10.2	10.1	-0.1
Trench Pool	6.1	5.1	-1.0
Reservoir[1]	5.3	5.3	0.0
Low Gradient Riffle	5.1	6.6	1.5
Run	4.3	4.3	0.0
Split	1.8	2.1	0.3
Rapid	0.2	0.2	0.0
Plunge Pool	0.2	0.2	0.0
Fall	0.1	0.1	0.0
High Gradient Riffle	0.1	0.1	0.0

1 Reservoir habitat is created by the non-Project diversion dam and extends approximately 5,000 ft upstream towards Camp Far West Dam.

3.3.1.2 Environmental Effects

This section discusses the potential environmental effects of SSWD's Proposed Project, as described in Section 2.2 of this Exhibit E. As part of the Project relicensing, SSWD proposes a Pool Raise of 5 ft, modifications of existing recreation facilities, and modification of the existing Project boundary.

3.3.1.2.1 Effects of Construction-Related Activities

To mitigate effects to geology and soils resources from the Pool Raise construction, SSWD will obtain and implement all permits required for construction, which may include mitigation measures related to erosion. Construction related to the Pool Raise would have short-term and local effects on geology and soils, and with implementation of all permits and approvals required for construction the effects would be less-than-significant.

3.3.1.2.2 Effects of the Pool Raise

The current effects of shoreline erosion along Camp Far West Reservoir are minor due to the lack of erodible strata. The amount of deposition in Camp Far West Reservoir since the Project was developed is fairly low as a percentage of the total volume (approximately 10% of original volume, or about 0.2% per yr). SSWD does not propose to remove sediment from Camp Far West Reservoir as part of its Proposed Project, and SSWD does not propose any activities that may increase shoreline erosion or deposition of sediment besides the Pool Raise.

Lower gradient slopes will likely experience wave action and sediment suspension initially that will diminish as the water interface develops more of an armor layer as fines are removed, leaving a surface of coarser and more resistant material. In the steeper slopes, which are largely stable bedrock, there may be increased rock fall and small local failures due to wave action and saturation of toe slopes. These failures are not expected to be extensive, given the stability of the igneous and metamorphic bedrock associated with the steeper shorelines. Table 3.3.1-19 shows the amount of area based on slope that will be inundated by the Pool Raise, most of which are less than 25 percent. The steepest slopes that will be inundated occur within the approximately 3,000 ft of additional backwatering up the Bear River that the Pool Raise will cause.

Table 3.3.1-19. Slopes inundated by the Pool Raise.

Slope Class (%)	Number of Acres Inundated by Pool Raise
0-25%	148
25-50%	9.2
50-75%	1
>75%	0.1

The inactive Dairy Mine in the Bear River Arm of the Reservoir may experience more surface erosion and sediment suspension due to the Pool Raise since approximately 1.3 ac will become newly inundated seasonally (Figure 3.3.1-15). Erosion from the Dairy Mine deposits may be rejuvenated due to wave action within the newly inundated shoreline at full pool elevation. Effects of the Pool Raise on geology and soils would be short-term and less-than-significant due

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to a lack of erodible strata within the additional 5-ft inundation zone, and the removal of available fines would temporary and decreasing over time as the additionally inundated shoreline would subsequently become more resistant to wave action. Potential water quality effects are discussed in Section 3.3.2.2.2.

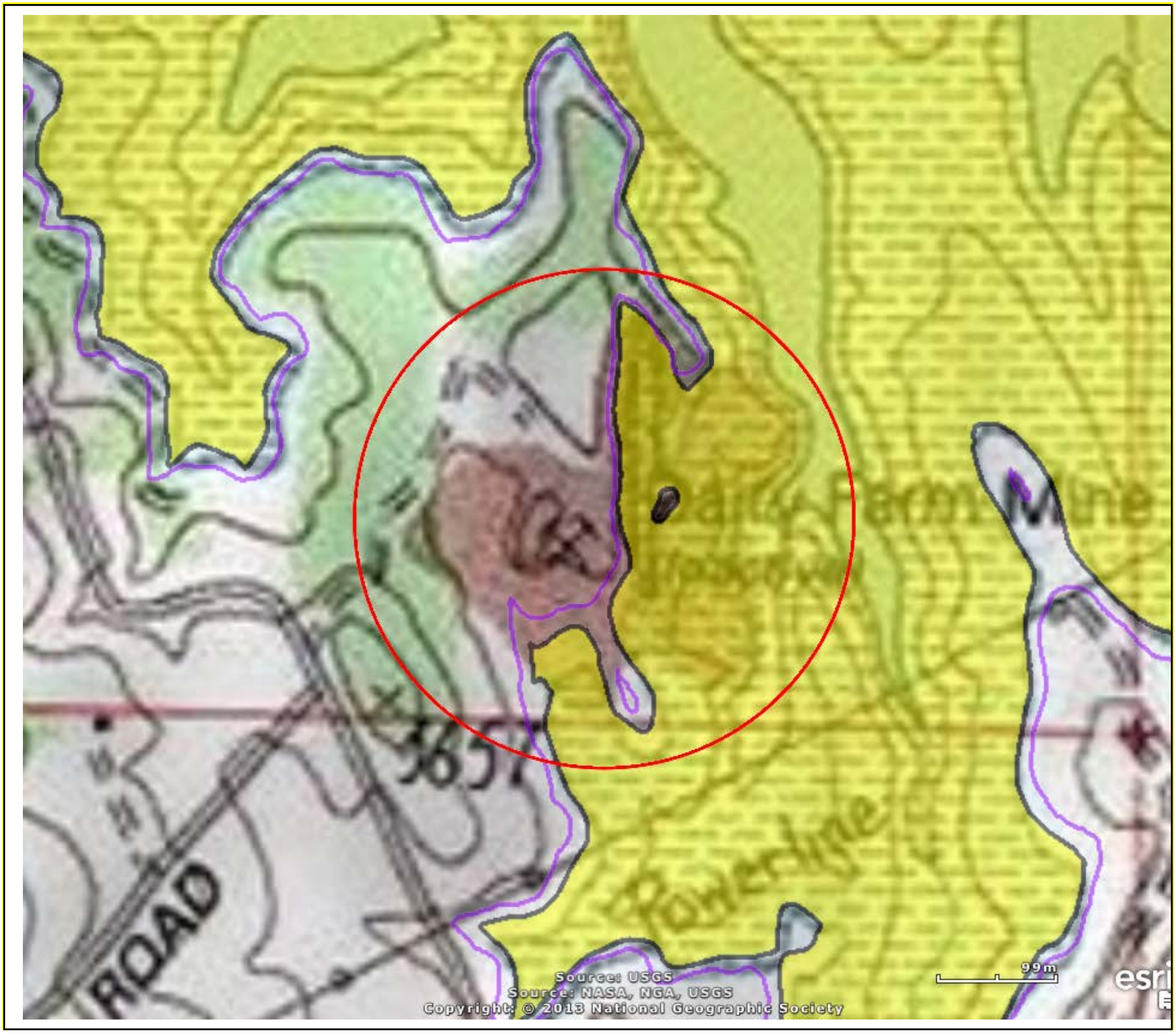

Figure 3.3.1-15. Dairy Farm Mine location adjacent to Camp Far West Reservoir. Yellow shading represents current NMWSE (300 ft) and purple line represents the estimated Pool Raise NMWSE (305 ft).

3.3.1.2.3 Effects of Proposed Project Operations and Maintenance

SSWD's Proposed Project does not include any significant changes in operations other than management of the Pool Raise which has been addressed in Section 3.3.1.2.2 regarding Camp Far West Reservoir. The Pool Raise will also slightly alter the timing and magnitude of spill events downstream of Camp Far West Dam, which could affect sediment and LWM transport in the lower Bear River. However, as discussed below, these effects are should be minimal. Flows in the Bear River downstream of the non-Project diversion dam are anticipated to decrease by approximately 4 cfs, on average, resulting from changes in the timing and magnitude of spill from Camp Far West Reservoir. Additional details regarding Project flows and reservoir storage under the Proposed Project is provided in Section 3.3.2.2.2 of this Exhibit E. Overall effects on geology and soils resources by the continued O&M of the Project will be less than significant.

SSWD considered proposing a condition to enhance sediment, especially for anadromous salmonid spawning, in the lower Bear River. However, the condition is not needed because, under existing conditions, there are adequate quantities of sediment in the lower Bear River, with estimates as high as 160 million cu yd, mostly from mining tailings (FWN 2015a). The Sheridan Pit gravel and aggregate mine, now part of the CEMEX sand and gravel mining and processing operation, is testament to the high volumes of gravel present in and near the lower Bear River. Furthermore, SSWD found suitable quantity and quality of gravel for anadromous salmonid spawning during its recent investigation. Additional discussion of gravel availability as it relates to fisheries is provided in Section 3.3.3.1. 3 of this Exhibit E.

In addition, SSWD considered proposing a condition to enhance LWM in the lower Bear River. However, the condition is not needed because there are adequate quantities of LWM in the lower Bear River. Existing conditions show that LWM concentration range between 18 and 65 pieces per mile (1.1 to 4.0 pieces/100 m), and most of the pieces were within the low-flow, wetted channel. Furthermore, based on incidental observations by SSWD during other field efforts, some LWM moved during the 2016/2017 high flows. However, new pieces were also added due to bank failures. The lower Bear River is also not dependent exclusively on LWM to provide habitat for fish or to assist in channel forming because of beaver dams and the presence of giant cane patches that also provide these channel morphology functions.

SSWD also considered proposing a condition related to spring flows to mobilize sediment and LWM in the lower Bear River. However, the condition was not needed. Considering the amount of gravel and LWM present in the lower Bear River and SSWD's observations of how gravel and LWM were moved during 2016/2017 high flows, no additional measures are necessary to provide flows to mobilize gravel or LWM. Spill events at Camp Far West Reservoir are also largely out of the control of SSWD because of upstream water projects that capture most of the run-off in the Bear River watershed. The Pool Raise will only slightly affect the timing and magnitude of spills.

Lastly, SSWD has not proposed a measure related to erosion control because during construction of the Pool Raise, including the relocation of recreation facilities, SSWD will implement all required permit measures which will include specific mitigation for erosion. Any other O&M activities that SSWD conducts that could cause erosion (e.g., future construction and) would likely have similar measures included in applicable permits. The Pool Raise will have some short-term effects on erosion locally around Camp Far West Reservoir, as described above, yet does not warrant a specific measure. Finally, erosion in the lower Bear River is caused during high flow events that are not under the control of SSWD because they occur through the ungated spillway. Erosion in the lower Bear River is also heavily influenced by the levees that exist from

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the non-Project diversion dam to the Feather River confluence, which confines high flows and promotes erosions between them.

3.3.1.3 Unavoidable Adverse Effects

The Project is expected to continue to store water in the spring and as it is released from upstream water projects, and capture sediment and LWM that would otherwise be available in the lower Bear River. However, the presence of several upstream dams on the Bear River already limits the amount water, sediment and LWM transported into Camp Far West Reservoir. During spill events, sediment and LWM may be passed below Camp Far West Dam and SSWD's studies have shown that sediment (especially gravel appropriate for anadromus salmonid spawning) and LWM are present in the lower Bear River. Therefore, these effects are expected to be minor.

Project and recreation roads will continue to erode during runoff events, which is a long-term, minor effect. Under existing conditions, there appear to be no significant effects due to sedimentation from Project and recreation roads. SSWD's proposed recreation measure would maintain recreation roads in good condition. The one, short Primary Project road is paved and regularly maintained, so erosion should be minor, if at all.

Replacement of Project recreation facilities could result in site-specific erosion problems. However, the effects would be short-term and minor with implementation of required permits and mitigation measures.

3.3.1.4 Measures or Studies Recommended by Agencies and Not Adopted by SSWD

As described in Appendix E4 in this Exhibit E, USFWS, NMFS, CDFW, SWRCB and FWN each submitted written comments on SSWD's December 29, 2018, DLA. Only NMFS's comment letter recommended a measure related to geology and soils, and none of the comment letters recommended a study related to geology and soils.

In NMFS' April 15, 2019 letter commenting on the DLA, it stated:

> The Project effects on the recruitment of large woody material and spawning gravel should be mitigated for based on the length of the license. Even though these resources are available now, the Project will continue to inhibit the addition of new materials; future sediment/LWM surveys and new substrate augmentation are likely to be needed. This Project effect should be acknowledged and long-term mitigation measures should be developed.

This items was on the agenda for the PM&E Resolution Meeting (see summary in Appendix E2 in this Exhibit E), but NMFS said it was not ready to discuss the item in detail. SSWD has not included NMFS's recommendation in its FLA a PM&E measure for three reasons. First, NMFS does not provide an adequate description of the rationale, scope, or estimated cost for the suggested monitoring and augmentation so that SSWD can respond in detail to NMFS's request.

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Without these details, SSWD can only evaluate and reply to NMFS's suggestion in general terms. Second, and in general terms, the need for monitoring is unclear, because the best available science shows that adequate quantities of these resources currently exist and continue to persist in the lower Bear River, and because NMFS does not provide adequate description of a mechanism by which these resources would become depleted in the future. Third, and also in general terms, the use of monitoring data and utility of LWM and gravel augmentation is unclear. Specifically, NMFS does not describe a mechanism to isolate in monitoring data Project-related effects from non-Project-related effects on these resources, and does not describe how monitoring data would be used to inform and guide augmentation activities.

3.3.1.5 List of Attachments

Attachment 3.3.1A Channel Form and Large Woody Material Maps

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Attachment 3.3.1A

Channel Form and Large Woody Material Maps

LEGEND

- Bank Erosion Site
- Key LWM Piece
- Major River Mile
- River Mile Tenth

Stability Class: Elevation Above Water Surface

- 0 - 6
- 6 - 15
- 15 - 20
- 20 - 25
- >25

DATA SOURCES: Key Piece, Bank Erosion Site, Giant Cane - HDR Inc. Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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ATTACHMENT E3.3.1A
CHANNEL FORM AND LARGE WOODY MATERIAL KEY PIECES

CAMP FAR WEST HYDROELECTRIC PROJECT FERC NO. 2997

N

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FEET

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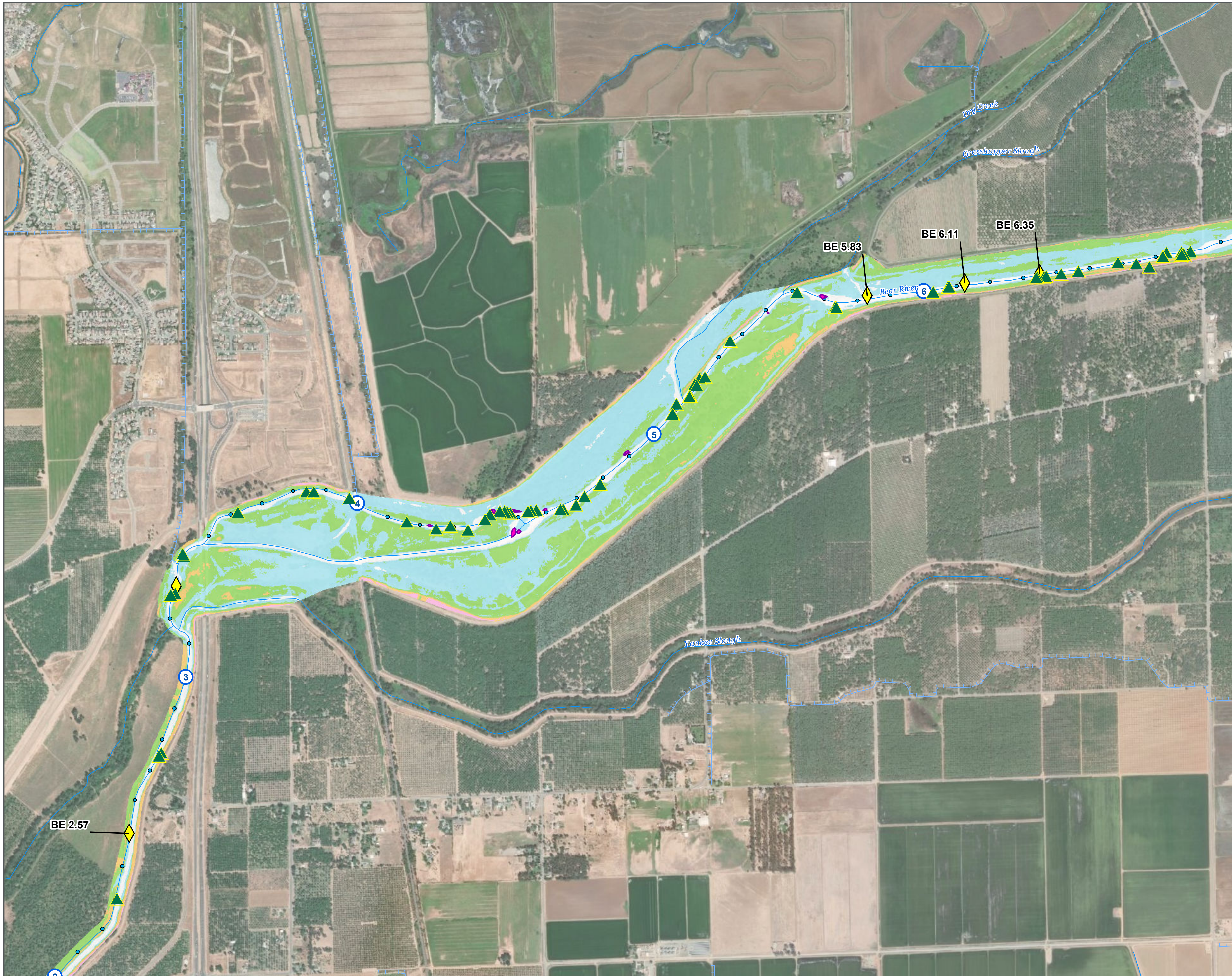

LEGEND

- Bank Erosion Site
- Key LWM Piece
- Major River Mile
- River Mile Tenth
- Giant Cane *(Arundo donax)*

Stability Class: Elevation Above Water Surface

- 0 - 6
- 6 - 15
- 15 - 20
- 20 - 25
- >25

DATA SOURCES: Key Piece, Bank Erosion Site, Giant Cane - HDR Inc.
Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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ATTACHMENT E3.3.1A CHANNEL FORM AND LARGE WOODY MATERIAL KEY PIECES

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- River Mile Tenth
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DATA SOURCES: Key Piece, Bank Erosion Site, Giant Cane - HDR Inc. Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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ATTACHMENT E3.3.1A CHANNEL FORM AND LARGE WOODY MATERIAL KEY PIECES

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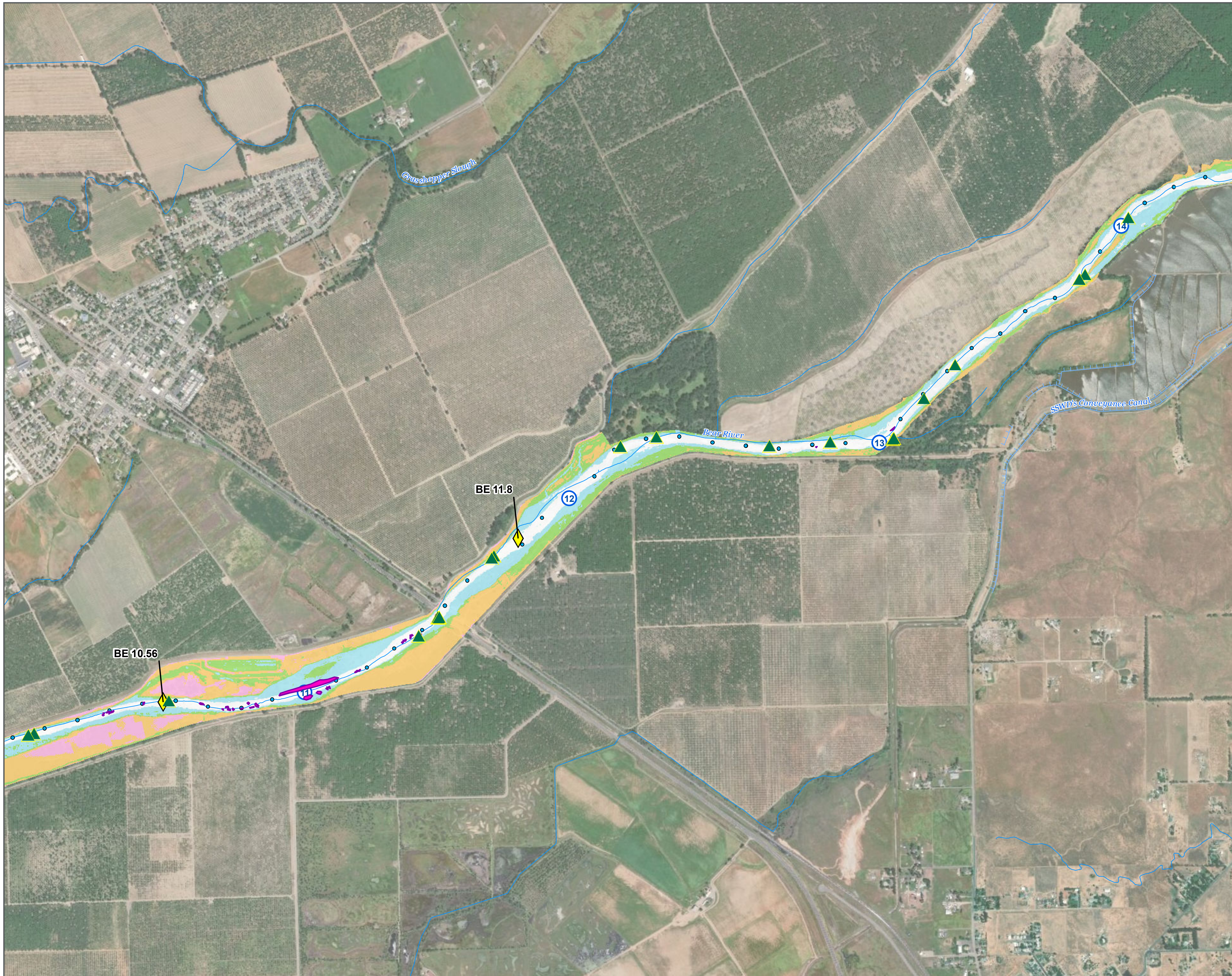

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ATTACHMENT E3.3.1A CHANNEL FORM AND LARGE WOODY MATERIAL KEY PIECES

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ATTACHMENT E3.3.1A CHANNEL FORM AND LARGE WOODY MATERIAL KEY PIECES

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