3.3 Proposed Action and Action Alternatives

3.3.1 Geology and Soils

The discussion of geology and soils is divided into five 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, cumulative effects are described in Section 3.3.1.3, YCWA's proposed measures are discussed in Section 3.3.1.4, and unavoidable adverse effects are addressed in Section 3.3.1.5.

Where existing, relevant, and reasonably available information from YCWA's PAD was not sufficient to determine the potential effects of the Project on geology and soils, YCWA conducted two studies: 1) Study 1.1, *Channel Morphology Upstream of Englebright Reservoir*; and 2) Study 1.2, *Channel Morphology Downstream of Englebright Dam*. The studies are complete and technical memoranda providing the study results are included in Attachment E6 (Table 1.4.4-3.)

3.3.1.1 Affected Environment

This section describes existing geology and soils in the Yuba River and more specifically, within the Project Area. Geology and soil conditions relevant to the Project 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) channel processes.

3.3.1.1.1 Geologic Setting

The relevant geologic history of the Project Region can be summarized by describing its development for the period spanning the mid-Paleozoic (i.e., approximately 300-400 million years ago, or mya) to the present day. The basement rocks were in-placed as an oceanic plate in an ancient sea during a tectonically-quiet period through about 225 mya. The basement rock and overlaying sediments began to move westward due to the formation of a plate subduction boundary on what was then the western margin of the North American land mass (Schweickert et al. 1984), east of the present day Sierra Nevada. Metamorphic rocks derived from Paleozoic and Mesozoic terrains were accreted and subducted beneath the continent. The resulting magma within the subduction zone eventually rose as both surface volcanic rock and subsurface granitic plutons that form 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 creation of the famous Sierra Nevada gold deposits in the fractures (USFS 2002).

Uplift along the eastern Sierra Nevada margin resulted in the predominantly east-to-west incised drainages that are evident today. The incision occurred through the beginning of the Tertiary Period (65 mya), exposing the gold veins that had been created during the Mesozoic Period. These gold veins were eroded and deposited throughout the ancestral Yuba River, which ran approximately north to south across the peneplain that existed at the time. These "Tertiary River Gravels" are the source for much of the 19th Century mining in the Yuba River drainages (USFS 2002). The middle Tertiary Period was a time of volcanic eruptions that deposited lava, mudflows, pyroclastic flows, and ash throughout the Yuba River Basin. These deposits filled many pre-existing drainages, such as the ancestral Yuba River, as well as placing a cap of volcanic rock/volcanic debris on the existing granite and remnants of the early Mesozoic sedimentary rocks.

The bedrock geology in the Project Region is composed of Paleozoic metasediments and metavolcanics (i.e., undifferentiated), Paleozoic and Mesozoic granitics (i.e., Valley Pluton, Cascade Pluton, Yuba Rivers Pluton), and Mesozoic ophiolite (i.e., Smartsville Complex) (Figure 3.3.1.1-1). Eocene auriferous sediments, the Tertiary gold-bearing river gravels that were deposited by the ancestral Yuba River, also exist on eastern portions of the Project Region.

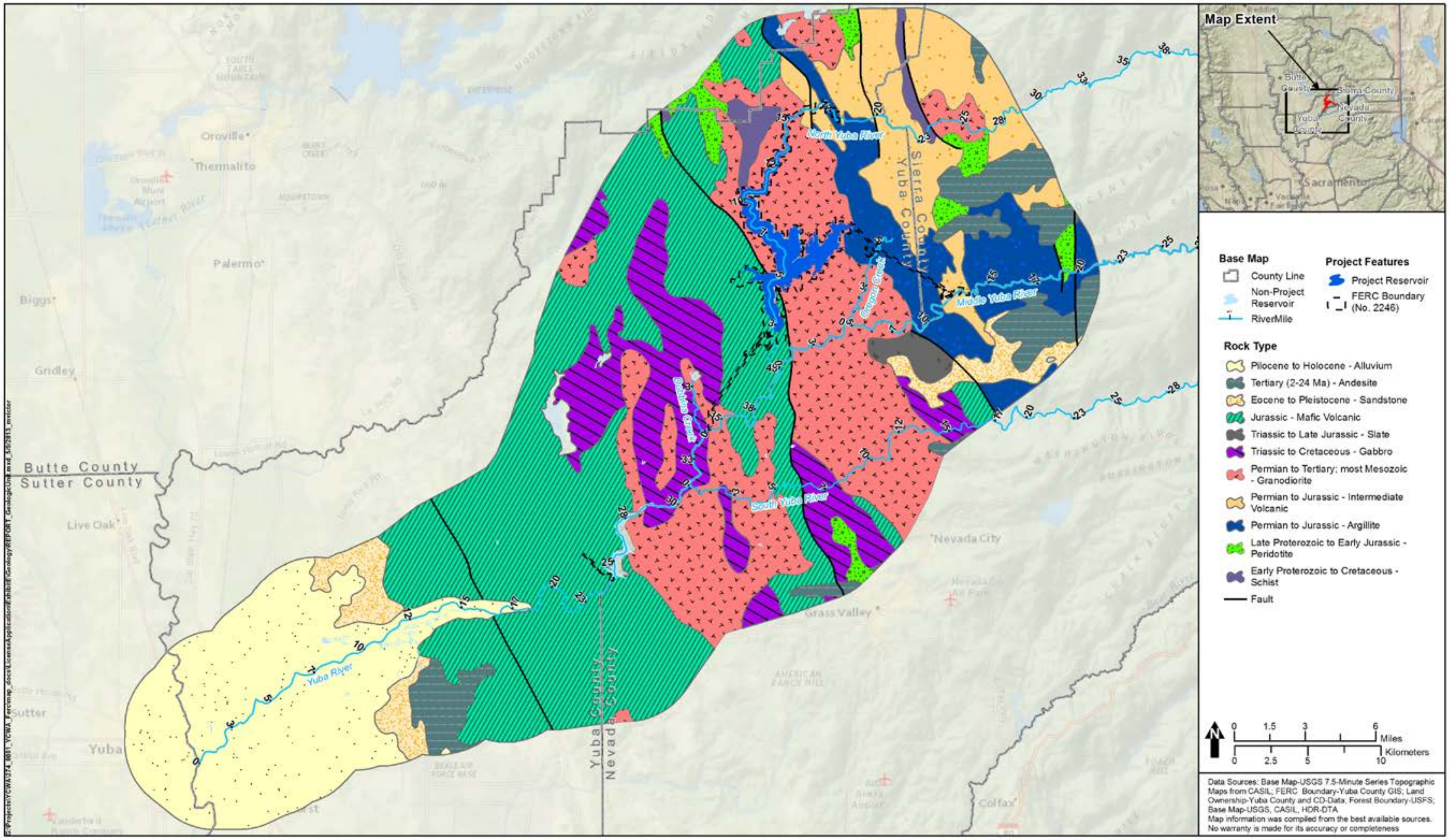

Figure 3.3.1-1. Generalized geologic map of the Project Vicinity. Project Vicinity was defined for the purposes of area computations as an area roughly 3 miles beyond the existing FERC Project Boundary.

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 consistent 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 down-warping of California's Central Valley.

Most faults resulted from late Paleozoic and Mesozoic tectonic collisions. Faults that were re-activated in the late-Cenozoic Period 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).

Big Bend Wolf Creek Fault Zone transects the Project's New Bullards Bar Reservoir on the western portion of the reservoir (Figure 3.3.1-1). This fault system marks the western margin of the Foothills fault system. The northern portion of this fault zone can be broken into three different segments. The southern segment, which is located south of Highway 49 and named the Wolf Creek Fault, extends from the City of Auburn to the City of Grass Valley. The central segment, which includes the Marys Ravine, Pine Grove, Jones Ravine, and Birchville faults, extends from the City of Grass Valley to New Bullards Bar Dam. New Bullards Bar Dam lies within the northern portion of the Foothills fault system, which is composed of a major Mesozoic fault system that extends from south of the City of Fresno to north of the City of Oroville, and marks the location of ancient subduction and accretion (AMEC Geomatrix 2004). The northern segment, composed of the Oroleve-Woodleaf, Sucker Run, and Maynards Ranch faults, extends from southwest of New Bullards Bar Dam northwest to Fields Ridge (AMEC Geomatrix 2004).

AMEC Geomatrix, Inc. completed a review of existing data in 2004 for the above faults. The majority of the faults was found to be inactive and is not considered a seismic source for the New Bullards Bar Dam. The two faults that were considered active were the Little Grass Valley fault and the Cleveland Hill fault, at 18 mi and 19 mi from the dam site, respectively. The Sanborn Mine (aka Camel Peak) fault is also considered active, due to the lack of consensus on the activity status. Of these potential seismic sources, the controlling fault is the Little Grass Valley fault with a Maximum Credible Earthquake magnitude of 6.75 at a distance of approximately 15 mi from the dam. The estimated median (50^{th} percentile) horizontal peak bedrock acceleration at the site due to a maximum magnitude earthquake on this source is 0.12 grams (g). In addition, AMEC Geomatrix, Inc. analyzed a random minimum earthquake. The "minimum earthquake" recommended by DSOD (Fraser and Howard 2002) has a magnitude of 6.25 with a duration of 14 seconds and a peak horizontal acceleration of 0.15 g at the median level, and 0.2 g at the 84^{th} percentile. AMEC Geomatrix, Inc. recommended in its report that the "minimum earthquake" of 6.25 should be used for analyses of the main New Bullards Bar Dam (AMEC Geomatrix 2004).

The Swain Ravine Fault Zone is located approximately 18 mi east of the confluence of the Feather and Yuba rivers, parallel to the Big Bend Wolf Creek Fault Zone (Figure 3.3.1-1). The Cleveland Hill Fault is the northern extension of this zone near Lake Orville. The 1975 Oroville earthquake, which occurred on the Cleveland Hill fault, also developed cracks over the northern portions of the Swain Ravine fault (AMEC Geomatrix 2004)

3.3.1.1.3 Mineral Resources

Gold mining is the dominant mineral resource activity, the dominant influence on how the Yuba River looks today, and the primary reason people settled in the area. Lode gold mining began in 1853 (DOC 2003) with exploitation of surface deposits of placer gold, followed by riverbed, quartz, and alluvial gravel mining. Deep mines and gigantic hydraulic operations followed as the more-easily accessed deposits were depleted (SNEP 1997). Because lumber and water resources were needed to support mining, camps and towns were needed as well. After 1900, quartz gold mining grew in importance.

Many abandoned and active mines are scattered throughout the Yuba River system, and damage from historic hydraulic mining for gold is visible throughout the river corridor (Figure 3.3.1-2). Erosion of exposed mining material and transport of it to local river channels are the most likely indirect effects of mining operations, with sediment transport potentially affecting stream channel morphology. Mercury was imported from the Coast Range and used for gold extraction. Mercury remains sequestered in sediments within the Project Region and continues to be a potential source of mercury as a pollutant to Yuba River surface water.

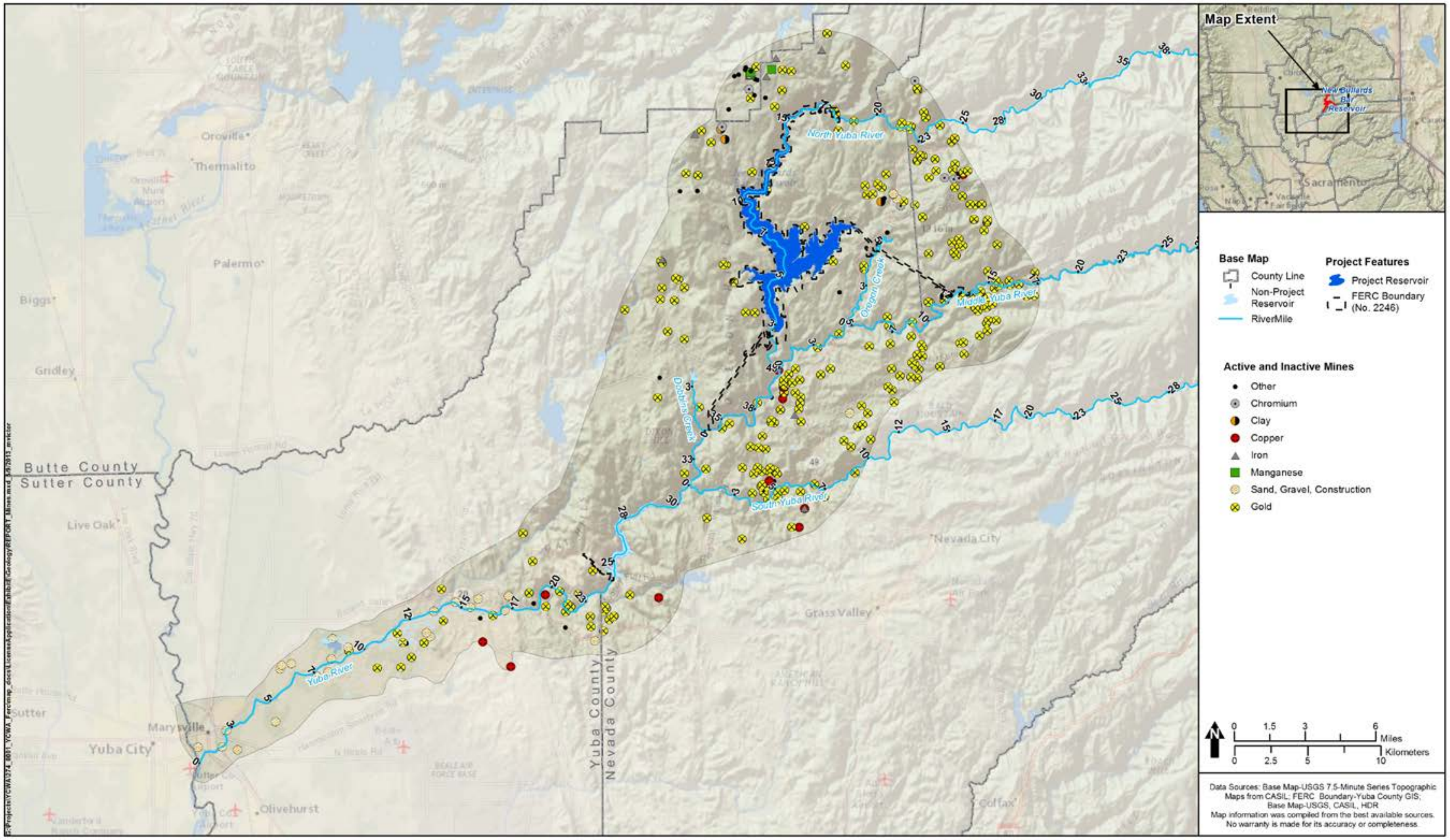

Figure 3.3.1-2. Active and inactive mines in the Project Vicinity. Project Vicinity was defined for the purposes of area computations as an area roughly 3 miles beyond the existing FERC Project Boundary.

The west edge of the north half of the Sierra Nevada range has many other important minerals (Diggles et al. 1996). While the Sawyer Decision of 1884 caused the end of placer gold mining, other gold mining techniques also declined after 1900. Nevertheless, more than 20 other minerals were mined between 1900 and 1960. Most of the entire western belt is geologically permissive for gold, chromium (i.e., chromite ore), copper, and manganese. "Geologically permissive" is defined by the environment of formation, including estimates of undiscovered resources to a depth of 0.6-mi, though not all deposits are known. About a third of the belt has one or more of these metals. Also occurring are barite, molybdenite and tungsten, which were important in the development of the communities near the Sierra Nevada range. Chrysotile (i.e., white asbestos) is found in veins in serpentinized ultramafic rocks near margins of serpentinite bodies. Serpentine and ultramafic rocks are generally found along fault zones, such as the Big Bend Wolf Creek Fault Zone in the Project Area.

Englebright Dam on the Yuba River was constructed in 1941 by the California Debris Commission, to trap sediment derived from mining operations in the Yuba River watershed. The California Debris Commission constructed Daguerre Point Dam in 1906 to relocate the river and prevent hydraulic mining debris from the Yuba River watershed from flowing into the Feather and Sacramento rivers.

As of 1994, sand and gravel mining exceeded gold mining in economic importance. California leads the nation in aggregate production, and virtually all aggregate is mined from alluvial deposits (Kondolf 1995). Deposits are abundant in the alluvium in the lower parts of the drainage basins. Sand and gravel are mined from channel deposits of the Bear, Feather, Yuba, and American rivers (WE&T 1991). Though demand for aggregate remains high in California, there is little likelihood of new aggregate mining operations in the Project Region due to access and location limitations (Aspen 2000). Aggregate extraction can have effects upon the river profile (e.g., knickpoint migration upstream), cause loss of spawning gravels, and undermine instream structures.

Potential hazards associated with historic or inactive mining operations include hidden or abandoned structures and linear features, such as tunnels and mine shafts (Aspen 2000). The mines with exposed and erosive material located adjacent to an active channel are the sites most likely to deliver sediment that could be indirectly affected by Project operations of streamflow management. The potential of delivery and mobility of instream sediment has not been assessed for every mine. Table 3.3.1-1 summarizes the number of active and inactive mineral extraction/exploration activities in the Project Region and current activity.

Table 3.3.1-1. Mines in the Yuba River Development Project Vicinity.

Mineral	Current Use[1]	Number of Mines
Unknown Mineral	Occurrence	15
	Prospect	2
	Unknown	3
Asbestos	Occurrence	1
Chromium	Occurrence	4
	Past Producer	4
	Producer	1
	Unknown	1

Table 3.3.1-1. (continued)

Mineral	Current Use[1]	Number of Mines
Clay	Occurrence	3
Copper	Occurrence	5
	Past Producer	1
	Prospect	4
	Unknown	1
Gold	Occurrence	83
	Past Producer	106
	Plant	2
	Producer	15
	Prospect	9
	Unknown	59
Gold, Copper	Past Producer	1
Gold, Silver	Producer	1
Iron	Occurrence	5
	Prospect	1
	Unknown	3
Limestone	Occurrence	1
Manganese	Occurrence	3
	Prospect	2
Molybdenum	Unknown	1
Molybdenum, Arsenic, Gold	Occurrence	1
Nickel	Unknown	1
Sand, Gravel, Construction	Occurrence	1
	Past Producer	1
	Producer	19
	Unknown	4
Silica	Producer	1
Stone – Crushed, Dimension, Stone	Producer	1
	Occurrence	2
Tungsten	Occurrence	1
Total	--	**369**

[1] Occurrence: Any locality where a mineral is found. Prospect: an occurrence that has been developed by underground or above-ground techniques, or by subsurface drilling to determine the extent of mineralization (McLemore 2012).

3.3.1.1.4 Soils

Soil Orders in the Project Vicinity include Alfisols, Andisols, Entisols, Inceptisols, Mollisols, and Ultisols in combination with mesic or frigid soil temperature regimes and zeric, udic, aridic, or aquic soil moisture regimes. The Project Area soil distribution coincides with the underlying bedrock. 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 (e.g., granitic). Table 3.3.1-2 provides a summary of the soils series' (in alphabetical order) characteristics, including parent material, geomorphic position, slope, elevation range, average precipitation, mean annual temperature, and drainage.

Table 3.3.1-2. Soil series and order summary description in the Project Vicinity.

Soil Series	Parent Material	Geomorphic Position	Slope (%)	Elevation (ft)	Avg. Annual Precipitation (in)	Mean Annual Temperature (°F)	Drainage
Ahwahnee	Granitic	Footslopes, mountains	2-75	200-2,800	30	60	Moderately (Mod) deep, well drained

Table 3.3.1-2. (continued)

Soil Series	Parent Material	Geomorphic Position	Slope (%)	Elevation (ft)	Avg. Annual Precipitation (in)	Mean Annual Temperature (°F)	Drainage
Aiken	Basic Volcanic	Gently sloping ridges, moderately steep to steep sideslopes	2-70	1,200-5,000	47	55	Very deep, well drained
Auberry	Intrusive, acid igneous	Foothills, mountainous uplands	5-75	400-3,500	22	62	Deep, well drained
Auburn	Amphibolite schist	Foothills	2-75	125-3,000	24	60	Shallow to moderately deep, well drained
Beaughton	Serpentinized peridotite	Mountains	5-60	1,500-5,000	45	55	Shallow, well drained
Boomer	Metavolcanic	Uplands	2-75	500-5,000	45	55	Deep and very deep, well drained
Chaix	Acid intrusive igneous	Mountains	5-75	1,200-6,500	40	54	Mod deep, somewhat excessively drained
Cohasset	Volcanic	Plateau-like uplands	2-50	800-5,500	53	51	Deep and very deep, well drained
Columbia	Alluvium	Flood plains and natural levees	0-8	10-155	12-25	61	Very deep, mod 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
Flanly	Acid intrusive igneous	Foothills	2-75	125-1,200	28	60	Mod deep, well drained
Grell	Serpentine/ ultramafic	Hills	7-50	3,000-5,000	15	47	Shallow, well drained
Hoda	Granodioirite/ acid igneous	Mountains	2-75	2,000-4,000	60	55	Very deep, well drained
Holland	Granitic	Mountains	2-75	1,200-5,600	55	55	Very deep, well drained
Ipish	Ultrabasic	Mountainous uplands	5-50	200-5,000	30	48	Deep, well drained
Ishi Pishi	Serpentinitic meta ultramafic	Mountains	15-75	400-5,000	75	55	Deep, well drained
Jocal	Meta-Sedimentary	Mountains	2-75	2,000-5,000	50	50	Deep and very deep, well drained
Josephine	Colluvium from altered sandstone and extrusive igneous	Broad ridgetops, toeslopes, footslopes, sideslopes	2-75	200-5,500	45	50	Deep, well drained
Kilaga	Alluvium from mixed sources	Terraces	0-9	50-200	20	62	Deep and very deep, well drained
Ledmount	Andesitic tuff breccia	Mountain side slopes and narrow ridge tops	2-75	2,000-6,000	53	52	Shallow, well to somewhat excessively drained
Mariposa	Tilted slates/schists	Ridges and sides of mountains	2-75	1,600-5,600	55	53	Moderately deep, well drained
McCarthy	Andesitic mudflows	Gently to very steep sloping dissected plateau	2-75	2,000-6,000	55	52	Mod deep, well drained
Mildred	Basic intrusive igneous rock	Mountains	3-50	1,500-2,500	45	57	Mod deep, well drained
Musick	Colluvium from granitic rocks	Mountains	2-75	2,000-5,000	50	54	Very deep, well drained
Nueva	Alluvium from mixed sources	Floodplains	0-2	20-80	16	62	Very deep, somewhat poorly drained
Orose	Basic intrusive igneous	Foothills	3-30	125-1,900	28	60	Shallow, well drained
Redding	Alluvium	High terraces	0-30	40-2,000	22	61	Moderately deep to duripan, well or mod well drained

Table 3.3.1-2. (continued)

Soil Series	Parent Material	Geomorphic Position	Slope (%)	Elevation (ft)	Avg. Annual Precipitation (in)	Mean Annual Temperature (°F)	Drainage
San Joaquin	Alluvium from predominately. granitic source	Undulating low terraces	0-9	20-500	15	61	Mod deep to duripan, well and mod well drained
Secca	Metabasic, basic, and ultrabasic volcanic	Gently sloping to steep mountainous	Gentle to steep	1,700-3,000	35-55	56	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
Surnuf	Gabbrodiorite	Mountains	8-50	1,400-2,800	45	57	Very 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
Wapi	Eolian sand and overlying basalt	Basalt plain	0-20	4,000-4,400	8	52	Shallow, excessively drained
Weitchpec	Serpentinitic	Mountains	30-75	850-5,500	50	53	Mod deep, well drained
Woodleaf	Ultramafic	Mountains	3-30	2,000-3,000	65	53	Mod deep, well drained
Xerorthent	Young soils not differentiated enough to separate from Soil Order. Shallow, developed in Mediterranean climate, not meeting the requirements of the other Entisols; associated with low-gradient alluvial material adjacent to the lower Yuba River corridor.						
Xerofluvents	Young soils not differentiated enough to separate from Soil Order. 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 Yuba River corridor.						

The above soils series are grouped into soil associations. A soil association is a group of soils that are closely associated geographically and occur in a characteristic pattern, and are useful for a generalized soils map. Soil associations are presented in Table 3.3.1.1-3 and Figure 3.3.1.1-3. Just within the existing FERC Project Boundary, the most common series is the Musick-Holland-Hoda-Chaix series (40% of area), followed by the Woodleaf-Surnuf-Sites-Mariposa series (14.4% of area); water is 30 percent of the area within the existing FERC boundary.

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

Soil Association (Association Number)	Acres	Percent of Total
Josephine-Holland-Aiken (s525)	6,975	2.6
McCarthy-Cohasset-Aiken (s620)	34,010	12.9
McCarthy-Ledmount (s1109)	4,858	1.8
Musick-Holland-Hoda-Chaix (s844)	41,669	15.8
Orose-Mildred-Flanly (s873)	16,580	6.3
Redding-Corning (s821)	1,966	0.7
Rock outcrop-Mariposa-Jocal (s845)	32,869	12.5
San Joaquin (s825)	2,962	1.1
Secca-Rock outcrop-Boomer (s837)	134	0.1
Sierra-Rock outcrop-Auberry-Ahwahnee (s841)	13,419	5.1
Sites-Rock outcrop-Boomer (s848)	9,225	3.5
Sobrante-Rock outcrop-Auburn (s840)	38,755	14.7

Table 3.3.1-3. (continued)

Soil Association (Association Number)	Acres	Percent of Total
Sycamore-Shanghai-Nueva-Columbia (s855)	9,963	3.8
Tisdale-Kilaga-Conejo (s870)	16	<0.1
Wapi-Holland-Chaix-Arrastre (s528)	1,975	0.7
Water (s8369)	2,401	0.9
Weitchpec-Rock outcrop-Ishi Pishi-Ipish-Grell-Beaughton (s523)	302	0.1
Woodleaf-Surnuf-Sites-Mariposa (s874)	37,837	14.4
Xerorthents-Xerofluvents (s822)	7,546	2.9
Total	**263,462**	**100%**

James (in press) described soils adjacent to the lower Yuba River below Englebright Dam in the context of the alluvial history. Young soils, such as Entisols, composed of coarse-grained alluvium (e.g., Xerofluvents) were potential historical (i.e., EuroAmerican settlement) alluvium. Soils with some pedogenesis were considered pre-historic (e.g., Alfisols, Inceptisols). James (in print) classed modern river sediment as Riverwash, Xerofluvents, Xeropsamments (sandy soils corresponding to abandoned channels on the terrace below Daguerre Point Dam), and dredge spoils that are largely confined to the Yuba Gold Fields (between about RM 7.7 and 16). These alluvial soils are represented by soil associations Redding-Corning (s821), Xerorthents-Xerofluvents (s822), Sycamore-Shanghai-Nueva-Columbia (s855), and Tisdale-Kilaga-Conejo (s870) and generally below RM 17 (Figure 3.3.1-3) and encompass about 8 percent of the Project Area (within about 3 miles of the FERC Project Boundary)Area. . James (in press) also provides a database that includes a GIS shape file with soil polygons derived from USDA SURGO data.

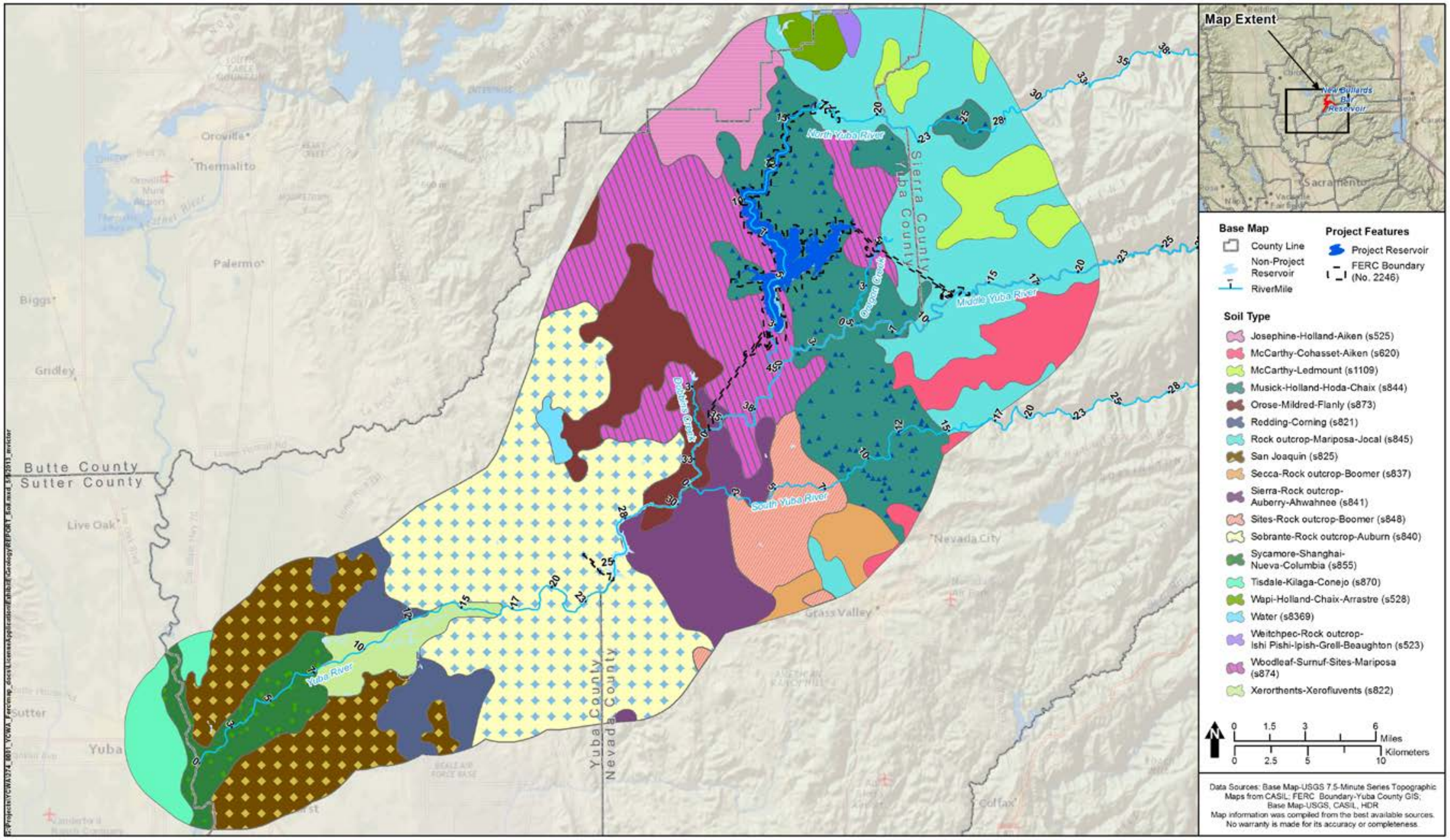

Figure 3.3.1-3. Soil associations within 3 miles of the Project Area.

3.3.1.1.5 Physiography

The Sierra Nevada crest forms the eastern limit of the Yuba Basin and trends north-northwest with steep, eastward-dipping escarpments to the Tahoe Basin. Downfaulting of the eastern Sierra face has affected drainage evolution by beheading and creating channels that now have their headwaters facing east (James and Davis 1994).

Uplifting and tilting of the Sierra Block reorganized drainage networks and initiated a period of sustained channel incision (Curtis et al. 2005a, b), and many of the modern channels have elevations below the Tertiary channels. The ancestral (Tertiary Period) Yuba River has cut about 985 feet (ft) below a surface defined by the San Juan, Washington, and Harmony ridges (James 2003). These ancestral deep channels drained north-northwest across the strike of the modern drainages (James 1991). The channels were filled first by very coarse, bouldery material rich in gold, followed by finer gravel and sand filling also rich in gold (James and Davis 1994). These Tertiary gravel deposits are the source of the gold heavily mined in the late 1800's.

Tertiary channels/gravels were buried by rhyolitic then by andesitic volcanics, then severely eroded and exposed by deep fluvial incision. The modern Yuba River began incising 5 Mya (Curtis et al. 2005a), and modern foothill channels strike perpendicular to the paleochannel and have downcut, leaving the deposits of the paleochannels as upland gravels (Merwin 1968). The basin was also affected by extensive Quaternary glacial erosion (James 2003).

The current Yuba River basin drains the northwestern Sierra Nevada through a series of deep canyons cut by mountain channels, separated by high, steep sided ridges and a parallel drainage network. The parallel drainage network results in narrow interfluves, small tributary contributing areas, and low tributary sediment loads under natural conditions; prehistoric debris fans at tributary junctions were not common (James and Davis 1994). Stratigraphic evidence indicates the presence of stepped, Quaternary terraces similar to piedmont channels flowing out of the Sierra (James 1988), but these terraces are generally now buried by mining sediment.

3.3.1.1.6 Sedimentation

Upstream of Englebright Reservoir

Our House and Log Cabin diversion dams create channel storage reservoirs of stored sediment. The areal extent of the Our House Diversion Dam deposit is approximately 11.4 ac; deposits were described by Stillwater Sciences (2013) as mostly coarse sediment (cobble, gravel, and sand) stored as topset beds in a prograding 1,500 ft delta, and as a terrace along the southern margin of the impoundment, and a small amount of finer sediment stored within the low water pool. The areal extent of the Log Cabin Diversion Dam deposit is approximately 3 ac. Slate Creek has a deposit at its confluence with the North Yuba River of about 0.6-ac, which was formed by backwater effects created by high flows in Slate Creek and the North Yuba River combined with a high water surface elevation in New Bullards Bar Reservoir.

Sediment has been removed from Our House Diversion Dam impoundment on several occasions, usually in response to large storm events that delivered the bulk of the sediments (EBASCO and

Envirosphere 1986). In 1986,[1] 1992,[2] 1997,[3] and again in 2006,[4] excavation operations by YCWA within the impoundment were conducted to clear sediment away from the valve structures on the dam and diversion intake. The volume removed is summarized in Table 3.3.1-4.

Table 3.3.1-4. Estimated volume of sediment removed from Our House Diversion Dam impoundment from 1986 to the present.

Year	Amount of Material Removed (yd^3)	Comments
1986[1]	Not quantified	Unknown amount removed; the 1986 flood event is assumed to be the primary source of impounded sediments. Some 7,333 to 15,000 yd^3 estimated passed downstream in 1986; 15,000 yd^3 estimated as remaining behind dam.
1992[2]	27,595	Disposed of off-site
1997[3]	67,894	Disposed of off-site
2006[4]	80,000	Disposed of off-site

1 EBASCO and Envirosphere 1986.
2 PG&E 1992.
3 PG&E 1997.
4 YCWA 2006.

There are no reliable estimates of sediment removed or passed below Log Cabin Diversion Dam. It is assumed that New Bullards Bar Dam traps all upstream sources of sediment. New Bullards Bar Reservoir has never been dredged.

Slate Creek Diversion Dam is located at RM 9.1 of Slate Creek, and owned and operated by South Feather Water and Power Association (SFWPA) to divert water from the Slate Creek watershed to Sly Creek Reservoir. The Slate Creek Diversion Dam impoundment is filled with cobble, gravel, sand, and silt mostly related to past hydraulic mining in the upstream source area (SFWPA 2007). Delivery of material from upstream hydraulic mine sites and aggraded channel

1 Sediments had been accumulating in the impoundment for 18 years since construction of the diversion dam in 1968 (EBASCO and Envirospere 1986). The floods of February 1986 were believed to have contributed the bulk of the sediments. Phase I dredging began sediment removal on August 1, 1986; an unquantified amount was removed and location of disposal was not specified. Necessary permits and approvals were obtained for sediment disposal. On August 20, 1986, between 7,333 and 15,000 $yd^3$was estimated to have been passed downstream through the release valve due to erosion of material in the reservoir, along with an additional unknown amount about a month later. YCWA discontinued removal in the fall of 1986, though an additional 15,000 yd^3 remained to be removed. Nine-thousand yd^3 were removed from downstream of Our House Diversion Dam in 1986 (EBASCO Environmental 1989).

2 Dredging removed 27,595 $yd^3$of sediment between August 3 and September 5, 1992. Sediments were disposed of at a site at the Sierra Mountain Mills approximately 8 miles (mi) away from the dam (PG&E 1992). Necessary permits and approvals were obtained for sediment disposal.

3 Dredging removed 67,894 yd^3 of sediment between September 10 and October 30, 1997. Prior to removal, sediments were tested for mercury and found to be at natural background levels. Sediments were sent to a dredging disposal site on NFS land approximately 18 mi west of Our House Dam (PG&E 1997). Necessary permits and approvals were obtained for sediment disposal.

4 On December 31, 2005, an intense storm event carried sediments from the upstream reaches of the Middle Yuba River that partially blocked the low level outlet, tunnel intake structure, and fish release outlet. Dredging removed 80,000 yd^3 of sediment between August 10 and September 15, 2006. Sediments were disposed of in an old quarry site on Marysville Road on NFS land approximately 1 mi south of New Bullards Bar Dam (YCWA 2006). Necessary permits and approvals were obtained for sediment disposal. YCWA applied for and received a grant from the Federal Emergency Management Agency (FEMA) for $4,077,972 for sediment removal at Our House Diversion Dam and repairs at Our House and Log Cabin diversion dams due to the December 2005 storm.

reaches to the Slate Creek Diversion Dam impoundment was exacerbated in the 1950s by the breaching of St. Louis Debris Dam, located approximately 1mi upstream of the Slate Creek Diversion Dam on NFS land. Prior to 1986, SFWPA regularly passed bedload and suspended load sediment from upstream sources through a low-level outlet in the Slate Creek Diversion Dam during high flows, however, this practice was discontinued in 1986 due to concerns regarding fine sediment and potentially contaminated sediment delivered to downstream reaches. A sediment pass-through program (SPT) was approved in 2001, and SPT events were attempted in 2002, 2003, 2004, and 2005. Most SPT attempts were unsuccessful at moving any significant amount of sediment (SFWPA 2007).

There is a sediment deposit at the mouth of Slate Creek that has a maximum elevation of 1,967.7 ft, and this upper surface is composed of sandy material. The deposit is a fan that slopes steeply into the North Yuba River and more gently towards Slate Creek, with the lower slopes composed of cobbles. The sand could only be deposited during high water when either North Yuba River or Slate Creek were experiencing overbank flow and water was sufficiently slow to allow deposition of material in suspension (e.g., sand). "Perfect" conditions for creating a deposit in Slate Creek due to the base level control of the North Yuba River/New Bullards Bar water surface elevation would occur during a high flow event in the North Yuba River that is coincident with high flows in Slate Creek, and when New Bullards Bar Reservoir water surface is also high. The conditions that are conducive to this sort of deposit occurred twice in the period of record – once in February 1986 and once in January 1997. There were other times that the North Yuba River was flooding (e.g., 1980 and 2005), but the reservoir level was quite low so the backwater effect into Slate Creek would be reduced. The size of the cobble substrate, existence of a cobble bar, and age of the vegetation near the mouth of Slate Creek support the existence of a high flow event about 10-15 years ago, so it is likely the 1997 event that created the maximum backwater effect. The deposit at the mouth of Slate Creek also coincides with high water indicators in the North Yuba River adjacent to Slate Creek, and across the North Yuba River on a large cobble bar.

In the Project Area, there are few response reaches and most of the channels are transport-dominated. In the South and Middle Yuba rivers upstream of the Project, channels generally flow through resistant parent material with lateral and vertical control provided by bedrock. There is limited fine-grained storage due to generally low sediment supply and narrow gorge character (i.e., transport reaches). Numerous bedrock outcrops control plan and profile. There are local sources of sediment (e.g., Malakoff Diggins sediments transported to the South Yuba River [USFS 2002]) that provide cobble and finer material. Deposition is enhanced where downstream control is provided by a channel narrowed through a bedrock "pinch point" that leads to backwater deposition, i.e., there are short response sections upstream of bedrock pinch points. The low gradient above the pinch points allows deposition of gravel, but supplies are generally low due to the resistant nature of the bedrock. Exceptions are potential local sources from residual historic mining deposits and local placer mining that disturbs the bed and mobilizes previously stored gravel and finer material (e.g., observed on the Middle Yuba River upstream of Oregon Creek).

In 2011, YCWA conducted a channel morphology study in stream reaches upstream of Englebright Reservoir that are potentially affected by the Project. Sediment availability, channel sediment storage, and transport capability were evaluated.

Sediment availability is lower under With-Project conditions than under Without-Project conditions (Table 3.3.1-5). As part of the California Bay-Delta Authority Upper Yuba River Studies Program, sediment yields in the Yuba River basin were estimated to be between 160 and 340 tonnes/square kilometer/year (Snyder et al. 2004) based on an estimated accumulation rate behind Englebright Dam. The average of 250 tonnes/square kilometer/year (713 tons/square mile (mi^2)/year) was used to estimate a total sediment yield at seven sediment supply nodes (the current drainage area is assumed to be zero upstream of each node) (With-Project) compared to the drainage area above the dam (Without-Project). The greater the drainage area below the Project facility (e.g., Our House Diversion Dam), the greater the sediment availability below the facility.

Table 3.3.1-5. Estimates of sediment yield at sediment supply nodes based on regional estimate of yield and drainage area under the With-Project and Without-Project conditions.

Site Name	Drainage Area (mi^2)		Sediment Yield[1] ($tons/mi^2/year$)		Bedload Yield[2] ($tons/mi^2/year$)		S*[3]
	With-Project	Without-Project	With-Project	Without-Project	With-Project	Without-Project	
North Yuba at New Bullards Bar	0	488.8	0	346,070	0	51,911	0.00
Oregon Creek at Log Cabin Diversion Dam	0	29.1	0	20,603	0	3,090	0.00
Middle Yuba at Our House Diversion Dam	0	104.7	223[4]	74,128	0	11,119	0.00
Middle Yuba below Oregon Creek Confluence	23.0	156.8	16,284	111,014	2,443	16,652	0.15
Middle Yuba above Middle/North Yuba Confluence	36.5	170.3	25,842	120,572	3,876	18,086	0.21
Yuba River below Middle/North Yuba Confluence	38.4	661.0	27,187	467,988	4,078	70,198	0.06
Middle Yuba above Middle/North Yuba Confluence	69.1	716.1	48,887	506,999	7,333	76,050	0.10

1 Assuming 713 $tons/mi^2/year$ of sediment yield (250 $tonnes/km^2/year$).
2 Assuming 15% of sediment yield is bedload.
3 S*is the ratio of sediment supply With-Project to that of sediment supply Without-Project; dimensionless.
4 Though Our House Diversion Dam stores significant sediment from upstream, it was estimated that 7,333 to 15,000 cubic yards (cu yds) of material was passed during the 1986 flood (EBASCO and Envirosphere 1986). Assuming 62 lbs/ft^3 (0.837 tons/ yd^3, Dendy and Champion 1978), there was an addition of between about 6,100 to 12,600 tons in 1986. No estimates of sediment passed were made following other storms. An average of the lower and upper estimates is assumed and an annual input is estimated.

If tributaries add bedload, there is little evidence (e.g., alluvial fans) remaining near the junctions in the North, Middle and mainstem Yuba river channels. The likely exceptions for sediment additions are Dobbins Creek, Moonshine Creek, Studhorse Canyon, Nevada Creek, and sidecast material on the Marysville Road near New Bullards Bar Dam. Each of these is discussed below.

- Dobbins Creek. Dobbins Creek terminates on the upstream end of Condemned Bar on the mainstem Yuba River at about RM 33.9, which is located a few hundred ft downstream of New Colgate Powerhouse. Condemned Bar is mentioned as a gold mining site prior to the construction of Lake Francis Dam (Chamberlain 1879), indicating the longevity of the bar. The present size of Condemned Bar is about 800 ft long and 350 ft wide. The bar has a substrate of very coarse cobbles, and boulders up to 5 ft, larger than most substrate found on the Yuba River. There are recent sand deposits on the upper surface of the bar that indicate regular inundation from the Yuba River. In an aerial view, it appears as though Condemned Bar has locally confined the Yuba River to a narrow, deep channel along the canyon wall. Dobbins Creek is incised several feet upstream of Condemned Bar. The exposed banks of the incised Dobbins Creek are composed of large cobbles in a matrix of sand and gravel. A low-water crossing at the lower end of Dobbins Creek has been washed out in the past and appears to be regularly inundated. Days after the completion of Lake Francis Dam on Dobbins Creek in 1899, the dam was breached during an intense rainfall, sending over 16,000 yds^3 of material from the dam downstream (Schuyler 1907). The breach also sent a tremendous amount of water downstream and likely mobilized bank and channel sediment in Dobbins Creek. Lake Francis currently may limit the amount of sediment contribution from upstream of the dam, but Dobbins Creek has contributed coarse and fine sediment to the Yuba River in the past, and appears to be a chronic source. On the upstream side of the bar at the outflow of Dobbins Creek, the substrate is a veneer of fine material over cobbles. When gravel or finer material is added from Dobbins Creek during flood flow, some of it appears to be transported quickly as the North Yuba River becomes narrow, swift, and cobble- and boulder- dominated adjacent to the Bar (and downstream of the confluence). There are sand and gravel bars downstream of Condemned Bar, some of which may be contributed to by Dobbins Creek.

- <u>Moonshine Creek</u>. Moonshine Creek enters the Middle Yuba River at about RM 3.5, and has a drainage area of 4.1 sq mi. The creek terminates at an alluvial fan about 56 ft long, 31 ft wide and 3 ft deep at its distal end. The contributing alluvium is primarily sand with small cobbles and gravels. The Middle Yuba River channel bed and bars in this area are dominated by cobble-sized substrate, and the finer sediment coming from Moonshine Creek is quickly assimilated into the Middle Yuba River. Little evidence of deposition exists past the riffle crest downstream of the tributary, though there is some sand deposition in the deep pools downstream. It is not possible to separate the contribution from Moonshine Creek to this fine-grained deposit.

- <u>Studhorse Canyon/Nevada Creek</u>. Studhorse Canyon, with a drainage area of 1.7 sq mi, and Nevada Creek, with a drainage area of 1.1 sq mi, are adjacent watersheds with tributaries that enter the Middle Yuba River at RM 7.0 and 6.8, respectively. Emory Bar is located at the junction of these tributaries with the Middle Yuba River. Emory Bar is a very large, well-vegetated, cobble- and boulder-dominated bar that dissects the Middle Yuba River. The bar is vegetated with upland species of pine (*Pinus* sp.), indicating stability; it is a named, long-term feature on the Middle Yuba River. The course of the tributaries themselves, or any sediment contributed by these tributaries, are not apparent on the aerial video (YCWA 2009), though they may be somewhat responsible for the longevity of Emory Bar.

- <u>Marysville Road Sidecast</u>. There are exposed surficial deposits and material that were cast over the side during excavation from a quarry on the hillside on the Marysville Road above the North Yuba River (RM 0.8). Review of the aerial video shows what appears to be side-cast material just above the high water mark in the North Yuba River. There is a bar on the right bank (ascending) that may be contributed to by erosion of this side-cast material. This material appears to be an active source of gravel and smaller-sized material to the North Yuba River and is depositing locally.

The remaining tributaries investigated in 2012 showed no evidence of bedload at sufficient quantities to create an alluvial fan at the junction with the mainstem. However, it is possible that bedload material may have been added to the mainstems and rapidly moved downstream.

A source of sediment to the Middle Yuba River is sediment transported over Our House Diversion Dam as there is a large coarse sediment deposit below the streamflow gage downstream of the dam. Up to 15,000 yd^3 (11,470 cubic meters) may have been contributed from a 1986 flood event.

There is a small landslide on a steep slope between County Road 169 and the parking lot at Cottage Creek Recreation Area near New Bullards Bar Dam that occurred the weekend of January 12-13, 2013 (Christensen 2013). Material was deposited into the parking area, but none entered New Bullards Bar Reservoir or the North Yuba River. This area has been subjected to at least two other landslides - a larger landslide occurred during construction of the dam further downslope within the present reservoir and a rockslide on the right abutment of the dam in early 2006. Photographs, causation, and a complete description of the landslide are contained in Christensen (2013). Additionally, there is a large rotational landslide just north of the Cottage Creek parking lot rock-fall; landslide has not failed but has potential to and details of maintenance and mitigation are contained in YCWA's proposed Condition LU2, Transportation System Management Plan. Also on New Bullards Bar Reservoir, a slope near Dark Day Boat Launch is unstable (YCWA 2013c). The slope has been failing for some time and despite YCWA stabilization measures, contributions of sediment to the boat launch area continues.

Channel storage of alluvially-derived sediment is located in active, semi-active, and inactive elements and ranges from about 14 to 84 m^3/m (Table 3.3.1-6). In the Middle Yuba River, the amount of coarse sediment is about four times higher below Oregon Creek than above. Oregon Creek has the greatest amount of channel storage, but half of this amount is stable and composes the long-term terrace that forms Celestial Valley.

Table 3.3.1-6. Summary of channel storage of coarse sediment in Middle Yuba River and Oregon Creek downstream of Project diversion dams.

Reach	Surveyed Length (m)	Number of Measured Elements	Active[1] (m^3/m)	Semi-Active (m^3/m)	Inactive (m^3/m)	Stable (m^3/m)	Total (m^3/m)
Middle Yuba River above Oregon Creek	1,152	124	6.6	6.2	1.0	--	13.8
Middle Yuba River below Oregon Creek	1,173	108	12.2	20.3	21.4	--	53.9
Total	**2,325**	**232**	--	--	--	--	--
Average	--	--	**9.4**	**13.3**	**11.3**	--	**34.0**
Oregon Creek	1,031	109	6.0	13.7	29.7	34.5	83.9

[1] Activity levels are: Active - Moves at least once every few years; Semi-Active- Susceptible to re-vegetation and moved every 5-20 years; Inactive - Moves only during extreme events every 20-100 years and becomes well-vegetated in the interim; Stable - Deposits are not accumulating under present climate or channel regime but may be susceptible to cutbank erosion (Source: Curtis et. al. 2005b)

There are adjustments to sediment supply and transport capacity comparing With- and Without-Project conditions. The presence of bedrock or other resistant channel boundaries or intrinsically low sediment transport rates can affect responses to dam construction. The capacity for channel adjustment is a function of the how transportable the bed sediment is, how erodible the bed and banks are, and whether there is opportunity for lateral mobility. Hypothetical morphological changes may be expected first in grain size of the stream bed, followed by construction or removal of in-channel bars, incision, and bank erosion; changes in stream planform and channel slope would be observed over a longer time frame. The existing condition of the Project-affected channels are that bed scour and grain size has likely increased; there is likely incision in certain depositional sections of the channel and a possible decrease in frequency of mid-channel bars, but there is insufficient evidence as to what the conditions were prior to the Project, and there are no measureable or distinct changes in planform when considering Without-Project conditions. Regardless of the pre-Project conditions, assessment of the existing condition of the channels is that they are fairly resistant to further change.

The Middle Yuba River has a coarse and resistant bed and banks in most of its length, with few possibilities of lateral or vertical shifting. Locations on the upstream side of bends and within and downstream of long-term depositional areas are more alluvially dominated, but sediment transport is still very high and particles move with fairly high frequency. Sediment is available to the channel and being transported at a higher rate than it is replaced; however, the estimates show that even under Without-Project conditions, the river would still have a sediment deficiency. The sediment deficit estimates highlight the fact that bedload transport equations rely on the availability of sediment for transport, which it is not in this system.

Stillwater Sciences (2013) found evidence that shear stresses are likely too high below Our House Diversion Dam ("Our House") to retain material that is stored upstream by Our House. The surface grain size distribution in pool tails (a depositional area) below Our House is generally coarser than delta deposits upstream of Our House. However, the more mobile sediment that is stored in pool margins and in velocity shadows of obstructions downstream of Our House has a size distribution very similar to deposits upstream of Our House. This suggests that mobile material, such as is currently stored upstream of, and available downstream, of Our House, will be stored in deep pools or on pool margins, deposited in small patches associated with boulder and bedrock obstructions, or deposited in the interstices of coarse bed materials. However, there is insufficient material and too high shear stress for substantive aggradation at least in the steeper reaches (e.g., greater than 2 percent) of the Middle Yuba, such as exists below Our House. Geomorphic monitoring following the 1986 event showed that a peak flow (1,930 cfs[5]) and mean daily flows (1,000 to 2,000 cfs for one day) moved material that was stored in a 0.75-mi long deposit, 3-6 ft deep, that had been transmitted over and through the dam during and after the storm, downstream two miles (EBASCO Environmental 1989). In 1989, a peak flow of 5,033 cfs with mean daily flows greater than 2,000 cfs for 6 days dispersed sediment further downstream, but did not remove all of the sand and gravel from pools within that same two-mile reach downstream of Our House.

[5] Flows measured at USGS Gage #11408850 near Camptonville.

The same overall condition applies to the North Yuba River and the Yuba River upstream of the New Colgate Powerhouse (i.e., coarse bed and banks resistant to movement, with storage of sediment in small areas in deep pools, in velocity shadows, and on lateral bars). Mid-channel bars are uncommon, but they exist in every one of the reaches, though whether or not they have been reduced in size or frequency since dam construction is unknown.

Oregon Creek is much smaller than the other reaches, but also has an estimated greater transport capacity than there is sediment available. Again, though, there are storage reservoirs of sediment and there sediment forming and reforming bed forms, bars, and floodplains. There is little likelihood of further change, as the bed and banks appear to be stable under the current regime.

The Yuba River downstream of the New Colgate Powerhouse is a reach that appears to be accumulating sediment, though at a slower rate than it would under Without-Project conditions. The long-term bars (e.g., Rice's, French and Condemned) that existed before the Project will continue to exist, though there are some indications that the channel could shift to occupy French and Rice's bars. Because there are numerous floods within this most downstream section of the Yuba River, shifting is not only possible, but likely.

Englebright Reservoir, when first constructed, had a gross storage capacity of 70,000 ac-ft; however, due to sediment capture, the gross storage capacity today is approximately 50,000 ac-ft (USGS 2003).

While no specific sites were identified, Yuba County (2008) identified eastern Yuba County soils on steep topography as being prone to erosion when disturbed. An erosion hazard maps shows that most of the slopes adjacent to New Bullards Bar Reservoir have a "Very Severe" erosion hazard. In general, the highest erosion hazards are located along the Yuba River between Smartsville and the northeast boundary of Yuba County.

YCWA also conducted an assessment of Primary Project Roads and Trails (Technical Memorandum 9-1). About half of the roads inventoried had some type of measurable erosion and sediment delivery potential, with a total of 15 high-risk active erosion features. Of the two Primary Project Trails, a portion of one trail segment is rated in poor condition due to landslide features in a localized area.

Plugged culverts and flow diversion work in concert to trigger road failure: for example, during a storm, if an upslope road crossing plugs and diverts flow onto the road, the receiving road crossing located downslope must then convey both the natural flow and the additional flow from the upslope road crossing; this can result in road prism failure at the downslope crossing. In large flood events, a cascade of crossing failures can occur with multiple points of failure. None of the water-crossing features (i.e., culverts) intersected fish-bearing stream channels, based on field survey data and professional judgment (e.g., stream flow regime, location in the watershed, known fish distribution and habitat, distance from perennial streams, stream channel slope upstream and downstream of the stream road crossing). Sixteen individual road segments had culverts with diversion potential. New Bullards Bar Dam Road and Our House Road had the largest number of culverts with diversion potential followed by Log Cabin, Colgate Haul, and Narrows No. 2 Access Roads. During the field inventory in April 2012, the Colgate Tunnel

Muck Road had a plugged culvert that was actively diverting stream flow down the road. The diverted stream flow had triggered a fill slope landslide 250 ft downstream of the water crossing.

Fifty percent of the culverts inventoried had "shotgun" outlets that extended beyond the fill slope that could result in additional erosion; if the road prism is not armored, then the water flow will cause scour that can lead to gully formation and potentially road failure, especially on fill slopes. Most of the shotgun outlets assessed has active gully erosion below the culvert. None of these sources was identified as adding substantial sediment to a stream that resulted in excessive deposition and aggradation but effects were localized and generally directly associated with the road.

Downstream of Englebright Dam

Between 1852 and 1906, an estimated 366,500,000 yd^3 of hydraulic mining debris moved downstream from the upland mining areas of the greater Yuba River watershed and was deposited in the Yuba River downstream of Englebright Dam causing aggradation on the order of 26-85 ft (Adler 1980). This massive sedimentation in the channel and floodplains transformed the river into a braided, unstable stream system, though Mendell (1881) stated that most of the sediment was not exported from near-mine locations until the floods of 1861. Even prior to mining, the river had already been highly altered by sedimentation, agriculture, and engineering projects (James 2013). Pre-European, the riparian zone near Marysville had been described as covered by tall tress, brush and vines, with a low floodplain in places with a dark soil developing; an older terrace rose above the floodplain further from the channel that was capped with a soil that supported fewer trees. Adler (1980) states that by 1906, the supply of hydraulic mining debris from upland areas was mostly depleted and degradation became the dominant process along the Yuba River. Based upon historical channel cross-section data collected along the Yuba River during the late 1800s and early 1900s and updated in 1979, Adler concluded that the river channel had attained equilibrium by 1940 to a channel morphology similar to its pre-1849 channel configuration (i.e., single stable channel, similar channel elevation), except the stream channel is now bordered by large cobble training walls that constrain the channel width in many sections (Adler 1980). The study further concluded that since 1940, almost 90 percent of the hydraulic mining debris deposited in the Yuba River below Englebright Dam remains today as quasi-permanent deposits in the floodplains. The cobble training walls, along with the massive deposit of hydraulic mining debris behind the training walls, are now a stable, generally immobile part of the lower Yuba River system.

The effects of hydraulic mining are particularly significant where the Feather and Yuba rivers converge near Marysville (EDAW 2006). At the mouth of the Yuba River at the south edge of Marysville, 70 ft or more of sediment eventually filled the river channel. Upstream of Marysville, entire communities were buried under more than 40 ft of silt and gravel (Hoover et al. 1990). Sacramento River Flood Control Project levees were constructed along the Feather and Yuba rivers and their tributaries to prevent flooding of valley communities. The levees prevented communities from becoming buried under the sediments that were washed down from the mountains. The levees were built even higher and designed to confine the floodwaters to a relatively narrow channel that would maintain sufficiently high velocities to efficiently convey sediment through the system, reducing the amount of dredging necessary to maintain navigation.

As a result of the levees, Marysville, Olivehurst, and Linda are now many feet below the floodwater levels of the Feather and Yuba rivers. James (2013) has constructed a more detailed history of the Yuba River below Englebright Dam.

More recently, studies by the Three Rivers Levee Improvement Authority broadly state that as hydraulic mining sediment supplies decline, the rivers again will adjust to a new equilibrium. Ultimately, hundreds to thousands of years in the future, it is likely that the river channels will cut down to their pre-mining elevations and begin migrating laterally (TRLIA 2006).

While no specific sites were identified, Yuba County (2008) identified eastern Yuba County soils on steep topography as being prone to erosion when disturbed. In general, the highest erosion hazards are located along the Yuba River between Smartsville and the northeast boundary of the county. Additionally, the erosion hazard rating of "Very Severe" also applied to soils downstream of the Merle Collins Reservoir for about four miles along Dry Creek.

A continuing source of sediment to the Yuba River is artificial gravel injection below Englebright Dam to enhance Chinook spawning habitat. UC Davis, USFWS and USACE collaborated on a pilot gravel injection project below Englebright Dam in November of 2007 (Pasternack 2009). The estimate is approximately 361 cu yds of material were added to the Yuba River in 2007 (5,000 short tons). To date, a total of 15,500 short tons of gravel have been placed into the Yuba River below Englebright Dam.

3.3.1.1.7 Channel Processes

Upstream of Englebright Reservoir

Project-affected reaches in the North and Middle Yuba rivers are mostly transport reaches, with few response reaches where depositional processes dominate within or adjacent to the channel. Within the North and Middle Yuba rivers, there is significant bedrock control and the mainstems channels often travel through bedrock gorges. There are short depositional sections where conifers grow to the channel margin, and with mid-channel and lateral bar development, which could be considered short and localized response reaches. The rivers are mostly laterally and vertically stable, e.g., there is little likelihood of large-scale plan-form change or incision. High energy flow events, such as the 1986 and 1997 floods, are important as "reset" mechanisms in most every project-affected reach because they disturb and rework floodplain deposits and mid-channel bars, where they exist, and work in combination with legacy mining material (e.g., tailings that confine the channel) and effects (e.g., sediment availability). For example, in the Middle Yuba River, the 1997 event exceeded 20,000 cfs, which is a 22-year recurrence interval based on mean daily annual peaks.

Channels are characterized by large substrate, steep gradients, vertical confinement, low bank erodibility, and low fine sediment accumulation. Modeled sediment mobility indicated that flow regulation (i.e., by NID and PG&E, who manage upstream facilities) does not often change the frequency with which the median bed particle size would be mobilized under unimpaired flow conditions. Adequate sources of sediment occur to create gravel bars, floodplains, and enhance riparian growth, as indicated by sand and gravel deposits on some lateral gravel/sand bars, floodplains, and low terraces. The sediment sources include bank erosion, surface erosion, debris flows, side channel development, historic spill channel erosion, and current and historic mining debris.

In 2011 and 2012, YCWA conducted a channel morphology study in stream reaches upstream of Englebright Reservoir that are potentially affected by the Project. The study focused on channel morphology, riparian vegetation and sediment mobility (YCWA 2013a). Data were collected at each of seven intensive study sites and included measurement of longitudinal profiles and cross sections, site sketches, facies mapping and quantification, and channel and bank stability evaluation. Each site encompassed a minimum length of 20 bankfull-widths and ranged from about 850 to 4,460 ft long. In addition to the seven intensive study sites, YCWA assessed three sites for bedload deposition within the backwater effects above Log Cabin and Our House diversion dams and within the influence of the NMWSE of New Bullards Bar Reservoir within Slate Creek. Sediment mobility was estimated, along with the frequency of bed and particle-mobilizing flows and the changes in bedload transport capacity due to regulation. Additionally, tracer particles were placed in the Middle Yuba River and Oregon Creek and bed armoring (i.e., surface-to-sub-surface ratio of D_{50} of exposed bars) was measured at four sites in the Middle Yuba River and one site in Oregon Creek. Table 3.3.1-7 lists the 24 cross sections that YCWA measured and analyzed in the 10 sites.

Table 3.3.1-7. Location of reaches where channel morphology study sites were located, and transects selected for channel morphology evaluation from among Study 3.10, *Instream Flow Upstream of Englebright Reservoir*, transects.

Stream	Reach Name	Location	Study Site Name	Study Site No.	Cross Section Numbers
INTENSIVE SITES					
Middle Yuba River	Oregon Creek Reach	Downstream of Oregon Creek: upstream and downstream of Moonshine Creek	Middle Yuba River downstream of Oregon Creek	1	9, 12, 13
	Our House Diversion Dam Reach	Upstream of Oregon Creek	Middle Yuba River upstream of Oregon Creek	2	2, 9, 12
	Our House Diversion Dam Reach	Downstream of Our House Diversion Dam	Middle Yuba River downstream of Our House Diversion Dam	3	2, 4, 7
Oregon Creek	Log Cabin Diversion Dam Reach	Celestial Valley upstream of Ridge Road	Oregon Creek Celestial Valley Sub-Reach	5	8, 10, 12
North Yuba River	North Yuba River Reach	Upstream of Middle Yuba River/North Yuba River Confluence	North Yuba River	7	7, 8, 10
Yuba River	New Colgate Powerhouse Reach	Downstream of New Colgate Powerhouse	Yuba River downstream of New Colgate Powerhouse	9	1, 2, 3
	Middle Yuba/North Yuba River Confluence Reach	Upstream of New Colgate Powerhouse	Yuba River upstream of New Colgate Powerhouse	10	8, 11, 15
NON-INTENSIVE SITES[1]					
Middle Yuba River	No reach name – above Project facilities	Upstream of Our House Diversion Dam: within influence of base level control affected by Our House Diversion Dam	Middle Yuba River upstream of Our House Diversion Dam	4	1
Oregon Creek	No reach name – above Project facilities	Upstream of Log Cabin Diversion Dam: within influence of base level control affected by Log Cabin Diversion Dam	Oregon Creek upstream of Log Cabin Diversion Dam	6	1

Table 3.3.1-7. (continued)

Stream	Reach Name	Location	Study Site Name	Study Site No.	Cross Section Numbers
NON-INTENSIVE SITES[1] (continued)					
Slate Creek	Slate Creek Reach	Within NMWSE of New Bullards Bar Reservoir	Slate Creek	8	1

[1] Sites were located to evaluate the effects of base-level control of the Project on bedload deposition. The level of analysis was limited to physical extent of bedload deposition and a "snapshot" of the channel just upstream of the influence that included one cross section, a pebble count and a gradient. Sites were not associated with Study 3.10, *Instream Flow Study Upstream of Englebright Reservoir* (YCWA 2013b).

Figure 3.3.1.1-4 shows the seven intensive sites and three non-intensive sites marked by a number that corresponds to the study site number in Table 3.3.1.1-7.

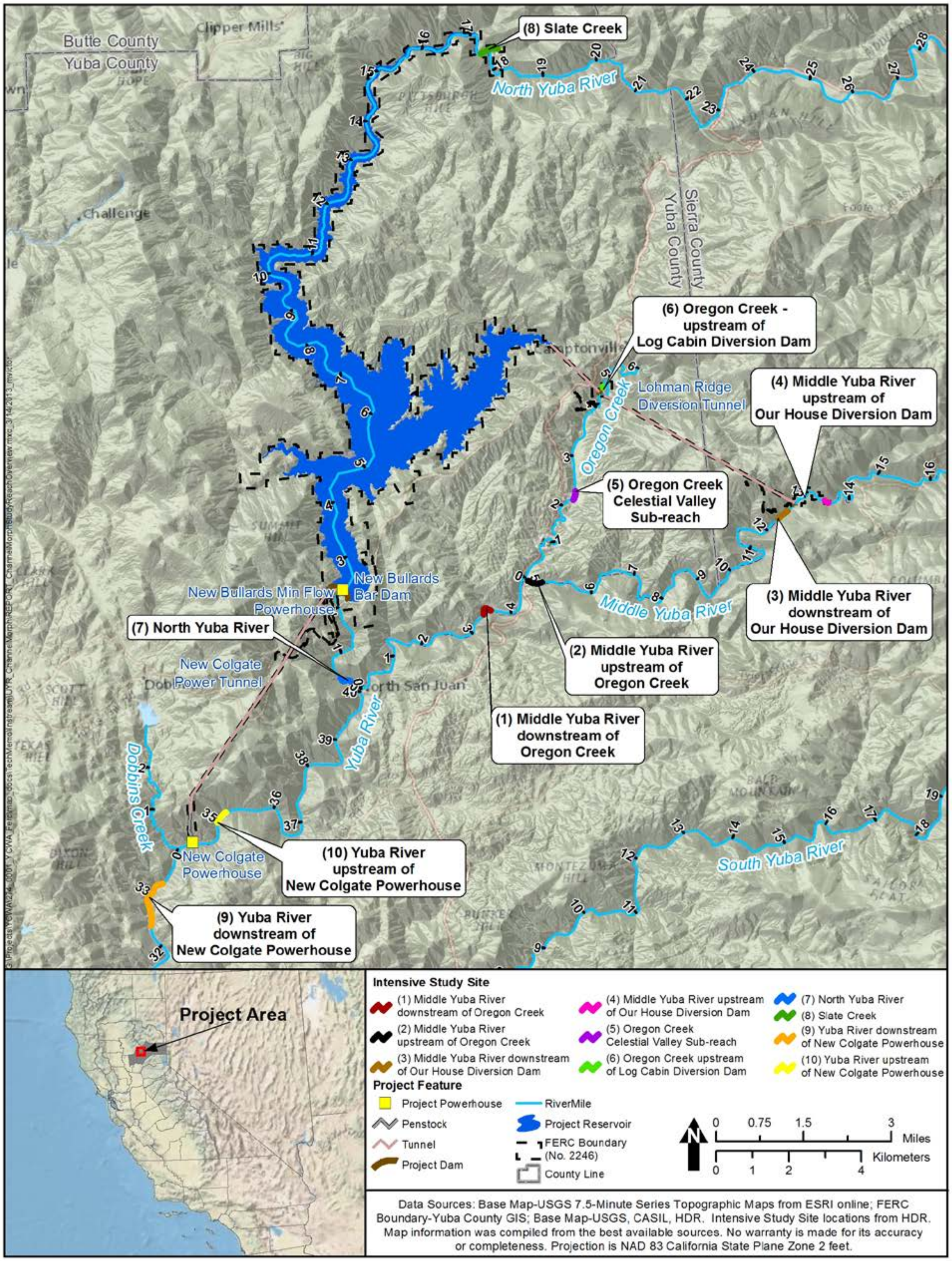

Figure 3.3.1-4. Study area and sites for YCWA's Study 1.1, *Channel Morphology Upstream of Englebright Reservoir*.

Six of the seven intensive study sites had gradients greater than 1 percent and are composed of coarse and generally resistant bed and bank material. Gradients were between 1 and 2.9 percent, except for the site on the mainstem Yuba River below the New Colgate Powerhouse. The mainstem Yuba River below the New Colgate Powerhouse had a gradient of 0.2 percent, which decreases as flows increase to floodprone depth, indicating a likely influence of backwater effects from Englebright Reservoir that extends into the site. The North Yuba River site was the steepest at almost 3 percent.

Reach-averaged D_{50} values range from 75 millimeters (mm) downstream of New Colgate Powerhouse to a maximum of 193 mm in the North Yuba River.

Bedrock/boulder controls figure prominently in most of the intensive sites and range from 1 percent in Oregon Creek to a maximum of 66 percent at the North Yuba River site.

Because of the amount of bedrock and boulder control, channel stability is good and bank erosion hazard is low to very low.

Quantity of mobile material (i.e., $D_{84,}$ which is generally less than 128 mm) ranges from a low of 1.6 cubic meters (m^3)/meter (m) of stream at the Yuba River upstream of New Colgate Powerhouse to a high of 29.2 m^3/m at the Yuba River downstream of New Colgate Powerhouse. The next highest value is the Middle Yuba River downstream of Oregon Creek at 6.9 m^3/m. The quantity of mobile material at the rest of the sites ranged from 2.1 to 3.0 m^3/m.

Armoring ratio is strongest below Oregon Creek at 5.4 and considered strongly armored**,** but is moderate (between 1.4 and 2.7) at all other Middle Yuba River sites. The weakest armoring ratio is just above the Middle Yuba River/North Yuba River confluence, though it is still considered moderate. In Oregon Creek within Celestial Valley, the armoring ratio is moderate at 1.7.

The spillway at New Bullards Bar Dam has been eroded to bedrock, but there is no remaining evidence in the North Yuba River of material that was potentially removed. The Log Cabin and Our House diversion dams are passive-spillway dams that spill regularly; these spills do not cause erosion of a spillway. There is pass-through of coarse and fine sediment downstream during large flood events below Our House Diversion Dam, and there may be pass-through over Log Cabin Diversion Dam of fine-grained material (e.g., washload). The banks downstream of New Colgate Powerhouse are generally stable, mostly bedrock and boulder, with only a minor amount of bank erosion that could be due to peaking flows from the New Colgate Powerhouse.

Tracer particles were placed in the Middle Yuba downstream of Oregon Creek (Site 1) and Oregon Creek Celestial Valley Sub-Reach (Site 5) prior to a flood event in December 2012. Estimates of peak discharge at each of the sites for this event were 8,500 cfs at Site 1 and 637 cfs at Site 5. The events had recurrence intervals of about 4.7 years and 2.3 years, respectively (With-Project hydrologic conditions). All but two of the particles placed at Site 1 were moved or buried. A cobble/gravel bar expanded near the lowermost transect during the flood event, so all the particles were shifted or buried and only one 180 mm particle was found. While there was no sediment added to the uppermost transect, only one 256 mm particle remained within 1 m, and there was one painted cobble perched on the gravel bar well downstream of the transect. At Site 5, 30 percent of the particles were moved more than 1 m off the transects. Ninety percent of the particles that moved were 90 mm and smaller.

There are adjustments to sediment supply and transport capacity comparing With- and Without-Project conditions. The presence of bedrock or other resistant channel boundaries or intrinsically low sediment transport rates can affect responses to dam construction. The capacity for channel adjustment is a function of how transportable the bed sediment is, how erodible the bed and banks are, and whether there is opportunity for lateral mobility. Hypotheses as to the adjustments to the channel due to dam construction include changes expected first in grain size of the stream bed, followed by construction or removal of in-channel bars, incision, and bank erosion; changes in stream planform and channel slope would be observed over a longer time frame (Grant et al. 2003, Wilcock et al. 2009). The existing condition of the Project-affected channels are that bed scour and grain size has likely increased. There is likely incision in certain depositional sections of the channel and a possible decrease in frequency of mid-channel bars, but insufficient evidence as to what the condition was prior to the Project. There are no measureable or distinct changes in planform when considering Without-Project conditions. Regardless of the Without-Project conditions, assessment of the existing condition of the channels is that it is fairly resistant to further change.

The Middle Yuba River has a coarse and resistant bed and banks in most of its length, with few possibilities of lateral or vertical shifting. Locations on the upstream side of bends and within and downstream of long-term depositional areas are more alluvially dominated, but sediment transport is still very high and particles move with fairly high frequency. Sediment is available to the channel and being transported at a higher rate than it is replaced; however, the estimates show that even under Without-Project conditions, the river would still have a sediment deficiency. The sediment deficit estimates highlight the fact that bedload transport equations rely on the availability of sediment for transport, which it is not in this system. Stillwater Sciences (2013) found that mobile material stored in pool tails-outs is coarser than that stored in the deposit upstream of Our House Diversion Dam, though is similar in size class to that stored in deep pools, along pool margins, and in the velocity shadows of obstructions, suggesting that shear stresses are typically too high in these locations to retain sediment that would pass over and through the dam during storm events.

The same overall condition applies to the North Yuba River and the Yuba River upstream of the New Colgate Powerhouse (i.e., coarse bed and banks resistant to movement, with storage of sediment in small areas in deep pools, in velocity shadows, and on lateral bars). Mid-channel bars are uncommon, but exist in every one of the reaches, though whether or not they have been reduced in size or frequency since dam construction is unknown.

The Yuba River downstream of the New Colgate Powerhouse is a reach that appears to be accumulating sediment, though at a slower rate than it would under Without-Project conditions. The long-term bars (e.g., Rice’s, French and Condemned) that existed before the Project will continue to exist, though there are some indications that the channel could shift to occupy French and Rice’s bars. Because there are numerous floods within this most downstream section of the Yuba River, shifting is not only possible, but likely.

Oregon Creek is much smaller than the other reaches, but also has an estimated greater transport capacity than there is sediment available. Again, though, there are storage reservoirs of sediment and mobile sediment forming and reforming bed forms, bars, and floodplains. There is little likelihood of further change, as the bed and banks appear to be stable under the current regime.

Downstream of Englebright Dam

The Yuba River downstream of Englebright Dam to the Feather River confluence is a single-thread channel of which the morphology and functional processes are in accordance with similar alluvial channels (i.e., C3 Rosgen channel types). The total length is about 24.2 mi along the baseflow thalweg. The river corridor is confined in a bedrock canyon in the uppermost 2 mi, then transitions to a wider bedrock valley and finally, to a wide alluvial valley for 19 mi. The river has an average channel gradient of 0.16 percent and a mean substrate size of 97 mm (i.e., cobble-size material). Historical hydraulic mining is the source for the vast majority of the modern alluvium, and the tailings were used to create training berms for much of the lower river corridor. The channel and floodplain are highly connected - floods spill regularly onto the floodplain. The valley corridor is wide enough to allow for potential meandering and, in fact, meandering is cutting into artificial training berms presenting the potential of eventual re-incorporation of the Yuba Goldfields. Avulsion is a key geomorphic mechanism that keeps distal floodplain regions geomorphically active even in the absence of high sinuosity. Bars and floodplains are hydraulically connected, and the floodplain up to the level of the floodway/valley is inundated about every 2.5 years. Overall, there is a slight deficit of sediment; namely, scour processes (i.e., mostly within-channel scour processes) exceed depositional fill processes from all other processes, including in-channel bar processes. Sediment is both eroded and deposited throughout the river valley in a complex spatial pattern, with a relatively small net outflux, though the outflux is still quite large compared to other rivers in the region. The river continues to adjust back to the pre-mining base level through dynamic processes.

3.3.1.2 Environmental Effects

This section includes a description of the anticipated effects of YCWA's proposed Project. The section below is divided into the following areas: 1) effects due to new ground-disturbing activities; 2) effects on upland erosion and sources of sediment; 3) effects of shoreline erosion and sediment deposition in Project reservoirs; 4) effects of the Project on channel stability; and 5) effects on sediment transport.

3.3.1.2.1 Effects due to New Ground-Disturbing Activities

New Project Facilities

YCWA proposes to add to the Project a flood control outlet at New Bullards Bar Dam, a TDS at New Colgate Powerhouse, and expansion of some recreation facilities. These new facilities, and anticipated construction, are described in Section 2.2.1. Anticipated effects to geology and soils resources due to these new facilities are described below.

New Bullards Bar Dam Flood Control Outlet

Construction of the New Bullards Bar Reservoir flood control outlet would require excavation in the upper left abutment area of the New Bullards Bar Dam site. To serve tunnel construction, a construction access road would be built from the left abutment area down to the outlet area. A natural cofferdam (i.e., *in-situ* soil and rock) would be left in place in the inlet approach channel to protect the construction work and prevent uncontrolled release of reservoir water through the excavation area and tunnel. The natural cofferdam would likely need stabilization and buttressing measures to ensure the site is adequately protected from the reservoir. The lope from the concrete outlet to the channel would be cleared of vegetation and soil down to rock. After the concrete intake structure is completed, the over-excavated areas would be backfilled with structural fill, and riprap would be placed on the slopes that may be exposed to wave erosion. Disposal areas will be required for the permanent placement of excess excavated materials obtained during construction activities. Material placed in the disposal areas would consist of soil and rock from required excavation, including tunnel muck. The estimated total quantity of excavated material, including an appropriate bulking factor, is approximately 300,000 cu yds. The materials obtained from required excavations would primarily consist of soil and metavolcanic rock. While there is an increase in disturbed and exposed soils, erosion control measures are in place to minimize any potential delivery to aquatic resources and effects are expected to be minimal. In addition YCWA will implement its Erosion and Sediment Control Plan (YCWA proposed Condition GS1), which will minimize disturbance and potential transport of sediment to an active channel. YCWA will also obtain all necessary permits and approvals for the work, including FERC's approval. The effects of construction of the TDS is expected to be insignificant, local (the area is in a remote location) and short term.

Effects on geology and soils of operation and maintenance of the new flood control outlet will be insignificant. While it is possible that some turbidity will occur during initial use of the outlet, this effect will be short-term and minor since it will occur when flow are high in the stream.

New Colgate Powerhouse TDS

Construction of the TDS will not require borrow areas because the work does not entail significant earthwork. It is expected that the available space within the New Colgate Powerhouse fenced area will be sufficient for laydown and staging of materials and equipment. All work will be confined to the powerhouse, yard and immediate vicinity. No undisturbed areas are anticipated to be disturbed as a result of the work, so effects on sediment availability and erosion are expected to be minimal. In addition YCWA will implement its Erosion and Sediment Control Plan (YCWA proposed Condition GS1), which will minimize disturbance and potential transport of sediment to an active channel. YCWA will also obtain all necessary permits and approvals for the work, including FERC's approval. The effects of construction of the TDS is expected to be insignificant, local (the area is in a remote location) and short term.

Effects on geology and soils of operation and maintenance of the TDS will be insignificant because the TDS will be enclosed in New Colgate Powerhouse.

Expanded Recreation Facilities

Reconstruction and rehabilitation of existing facilities have the potential to affect sediment availability and, if sediment is delivered to active channel, sediment deposition and/or transport and water quality. Rehabilitation of the existing recreation facilities or construction of new facilities has short-term geology and soils impacts. Implementation to YCWA's proposed Condition GS1, Erosion and Sediment Control Plan, and the terms and conditions to all appropriate permits and approvals will protect geology and soils resources and mitigate any impacts.

Other Ground Disturbing Activities

If YCWA were to propose additional ground-disturbing activities not currently addressed in this Exhibit E that could affect erosion and sediment in surface waters, which in turn could affect water quality and aquatic resources, YCWA's proposed Project includes four conditions to address such instances.

The first measure, YCWA's proposed Condition GEN1 would: 1) assure that YCWA's planned activities are efficiently coordinated to the extent possible with Forest Service activities; 2) make Forest Service and other applicable agencies aware of YCWA's planned O&M activities on federal land; and 3) make YCWA aware of all pertinent Forest Service orders, rules and policies that might affect YCWA's planned activities. YCWA would meet in the first quarter of each year with Forest Service and other agencies to discuss YCWA's planned Project O&M activities for that calendar year to the extent they are known. An annual meeting early in the year is appropriate, since YCWA normally develops an annual maintenance plan early in each calendar year. YCWA would file documentation of the meeting with FERC, including recommendations by Forest Service, if requested by FERC. The measure does not imply that YCWA may not proceed with planned Project O&M activities until YCWA has reviewed the planned O&M activity with Forest Service, or relieve YCWA from obtaining all necessary approvals and permits for the planned maintenance work. Implementation of the measure would provide early notice to agencies regarding any planned ground disturbing activities.

The next YCWA proposed Condition (GEN2) pertains to new ground disturbing activities on federal land. If during the term of the new license, YCWA proposes ground disturbing activities not addressed by the relicensing NEPA process; such activities have the potential to adversely affect special-status species and other resources. This measure would assure that reasonable PM&E measures are developed to address the potential effects of the new ground disturbing activities. Specifically, prior to performing the new ground disturbing activity, YCWA would consult with Forest Service, as appropriate, and other appropriate agencies to: 1) discuss potential effects; 2) determine if additional information is needed to assess effects; 3) gather additional information, if needed; and 4) upon Forest Service request, as appropriate, enter into an agreement to fund a reasonable portion of Forest Service staff, as appropriate, to perform staff activities related to the proposed ground disturbing activity. This measure provides for the timely review of new ground disturbing activities.

The third YCWA proposed Condition (GEN3) also pertains to activities not addressed in FERC's NEPA review. If, during the term of the new license, YCWA proposes new Project facilities that were not addressed in FERC's NEPA process, prior to construction

The fourth YCWA proposed Condition (GS1) would implement an Erosion and Sediment Control Plan that would minimize disturbance and potential transport of sediment to an active channel.

3.3.1.2.2 Effects of Upland Erosion and Sources of Sediment

The only way that the Proposed Project can affect upland erosion and sources of sediment that may be delivered to an active channel is through Project roads or construction, which are discussed above. There are numerous road sediment sources and culverts that have a potential to deliver fine and coarse sediment to an active channel. YCWA's proposed Condition LU1 would implement a Transportation System Management Plan, which specifies how YCWA would maintain Primary Project Roads and Trails and recreation roads in proper functioning condition to minimize erosion and sedimentation.

Rehabilitation of the existing recreation facilities or construction of new facilities has short-term adverse impacts (noise, ground disturbance including vegetation and erosion, and water quality); however, YCWA has proposed appropriate resource protection measures and plans to minimize the potential sediment additions or erosion from construction activities.

Construction projects proposed and potentially proposed by YCWA may have short-term adverse effects due to ground-disturbance including vegetation and erosion, and perhaps to water quality. However, implementation of the Erosion and Sediment Control Plan (YCWA's proposed Condition GS1), and elements in place during construction, would control and minimize any adverse effects to active channels.

There are existing sources of sediment from the tributaries Dobbins Creek, Moonshine Creek, Studhorse Canyon, Nevada Creek, and sidecast material on the Marysville Road near New Bullards Bar Dam. None of these sources will be affected by the Proposed Project.

There are no known upland sources of sediment (i.e., from Proposed Project roads or construction activities) in the Yuba River downstream of Englebright Reservoir. As described above, the USACE has implemented a gravel injection program below Englebright Dam, and the effects of this injection are being monitored by USACE.

3.3.1.2.3 Effects of Shoreline Erosion and Sediment Deposition in New Bullards Bar Reservoir, and Sediment Deposition Upstream of Our House and Log Cabin Diversion Dams.

The effects of shoreline erosion along New Bullards Bar Reservoir are minor due to the lack of erodibility along the shoreline. Though the erosion hazard on the slopes around the reservoir is considered "Very Severe" based on slope and soil type (Yuba County 2008), few landslides or problem areas have been identified. The amount of deposition in New Bullards Bar since the Project began is low, and reservoir shoreline erosion is minor.

YCWA does not propose to remove sediment from New Bullards Bar Reservoir as part of its Proposed Project, or propose any activities that are likely to increase shoreline erosion or deposition of sediment.

Minor shoreline erosion, which is typical for reservoirs in the Sierra Nevada, and some deposition of sediment in New Bullards Bar Reservoir are expected to continue with the proposed Project, but these effects are considered less than significant. Effects are less than significant because impacts are of minor magnitude and limited to localized areas. Site-specific, localized landslides have been identified at Cottage Creek Recreation Area and Dark Day Boat Launch, as discussed above. These problem-areas have been on-going. The slide near Dark Day Boat Launch may have added a slight amount of sediment to the reservoir, but amounts are minor as compared to the size of the reservoir.

Upstream of the Project's diversion dams, there is storage of sediment that, if the Project were not in place, would enter the downstream reaches. YCWA's proposed Conditions GS2 and GS3 would facilitate the movement of sediment. Condition GS3 provides for the periodic transport of sediment past both Our House and Log Cabin diversion Dams. Under this condition, the low level outlets in each dam would be opened in winter for 48 consecutive hours when the dam is at full pool (i.e., not spilling) and flows are expected to increase to over 1,000 cfs soon after the 48-hour period. The event is proposed to occur at full pool so that the maximum velocity occurs through the low-level outlet (e.g., no flow over the dam). A period of 48 hours is appropriate because this will allow sediment movement and a reasonable expectation of higher flows following the event (i.e., difficult to accurately forecast higher flows much longer than 48 hours into the future). The 1,000 cfs and winter period are appropriate because the 1,000 cfs flows will initially distribute the sediment passed through the low level outlet to downstream areas, and the higher flows in the spring will continue this process of mobilizing and distributing the material downstream. Based on historic hydrology, YCWA expects that this condition would be implemented on average every other year at Our House Diversion Dam and once every 3 to 4 years at Log Cabin Diversion Dam. YCWA's proposed Condition GS4 would provide for periodic monitoring of the channels below the diversion dams.

YCWA's proposed Condition GS2 acknowledges that extremely intense storms, which periodically occur in the Middle Yuba River and Oregon Creek, can move large amounts of material into the diversion impoundments that cannot be controlled through the low level outlets. In these cases, active sediment removal from the impoundments may be required to assure dam safety. Condition GS2 implements a sediment removal plan when these extreme storm events occur. The plan describes how the sediment would be removed, transported and disposed, including protection and mitigation measures. The plan provides that, on a case-by-case basis and in consultation with agencies, some of the material may be placed in the channel downstream of the diversion dam.

3.3.1.2.4 Effects on Channel Stability

There are no Proposed Project effects on channel stability because most of the reaches are transport-dominated (i.e., few response reaches), and channels are resistant to further change. The majority of stream reaches affected by the Project are stable transport reaches where the capacity of the channel to move sediment is greater than the amount of sediment entering the channel. Bedrock and boulder control on much of the bed and banks limit the lateral or vertical movement of the stream channels.

YCWA does not propose any changes to the Project or its operations that would have a significant effect on overall channel stability or the nature of the transport reaches. YCWA's proposed Conditions GS2 and GS3 would reduce the storage and character of the sediments impounded in the diversion pools and would result in an increase in mobile sediment downstream. This added sediment could create localized deposits, which the channel could then adjust to by possibly moving into, through, and around the deposits. These site-specific channel-shifts in response to added sediment supply would be considered beneficial, though whether they are long-term would be assessed with monitoring (YCWA's proposed Condition GS4).

3.3.1.2.5 Effects on Sediment Transport

YCWA does not propose any changes to the Project or operations that would have a significant adverse effect on the nature of the transport reaches that are prevalent in Project-affected streams. The effects of the Proposed Project on sediment transport are long-term though minor and site-specific. The Proposed Project captures sediment, which is no longer available for transport through Project-affected stream reaches. However, there are no proposed changes to the Project that will change this condition, other than sediment additions as discussed above.

The Proposed Project also affects flood flows capable of transporting large amounts and larger sediment; New Bullards Bar is designed for flood control and spills will be controlled so sediment-moving flows are reduced. However, the large size of the substrate in the bed and banks of the North Yuba below New Bullards Bar and the Yuba River below the North/Middle Yuba River confluence and lack of deformable substrate are such that sediment transport is likely unchanged and minor. Large floods in the Middle Yuba River and Oregon Creek capable of transporting sediment will continue to occur every 5 to 10 years because the Proposed Project cannot control large floods, i.e., passive spill occurs during floods over Our House and Log Cabin Diversion Dams. These floods will transport cobble and finer material, move onto and shift cobble/gravel bars and local floodplains, and deposit sand into vegetated riparian zones, and are capable of shifting riparian zones. Additionally, deformable and moveable substrate should increase with YCWA's proposed condition to pass sediment trapped upstream of Log Cabin and Our House Diversion dams (YCWA's proposed Condition GS3). This pass-through would increase sediment downstream; monitoring is proposed to assess the transport and fate of the added sediment (YCWA's proposed Condition GS4).

In the Yuba River below Englebright Dam, no changes on sediment transport due to the Proposed Project are expected. Below Englebright Lake, finer material, such as sand and fine gravel, are mobile at flows less than the representative bankfull condition, with coarser particles becoming mobile as flows increase. Overall, the combination of in-channel fill and overbank scour has resulted in a floodplain that is not isolated or being left on high, but is instead a dynamic, interactive component of self-organized river corridor system. This is not expected to change with the proposed Project.

LWM added as a result of the Proposed Project may enhance local deposits of sediment and affect sediment transport around the roughness created by the LWM. YCWA is proposing a LWM pass-through condition (YCWA's proposed Condition TR5). Increases in LWM in the reaches downstream of these diversion dams may result in increased sediment storage, bank protection, and channel heterogeneity. Monitoring below the dams (YCWA's proposed Condition GS4) would assess if the effects of LWM additions are significant in affecting sediment transport.

3.3.1.3 Cumulative Effects

Historical elements of the past and present have contributed to the existing, baseline condition in the Yuba basin. The Proposed Project will contribute little to the future condition of the channels already affected by these historical elements. Our House and Log Cabin Diversion Dams pass flood events so there is little incremental effect from these diversions. New Bullards Bar Dam does control flood events by design, and high flows are returned to the Yuba River at the New Colgate Powerhouse, so there will be a net change in peak flows delivered to Englebright Reservoir.

There is little on-going effect on the North and mainstem Yuba channels because changes have already occurred and further change is unlikely due to ongoing Project operations. There is net sediment export out of the Project-affected reaches, which sediment is transported to Englebright Reservoir, in addition to sediment continued to be trapped by the Project and non-Project diversions, and therefore the cumulative effect is a decrease in sediment availability to the Yuba River downstream of Englebright Dam.

3.3.1.4 Proposed Environmental Conditions

3.3.1.4.1 Conditions Proposed by YCWA

As described above, YCWA's proposed Project includes nine conditions specifically related to geology and soils:

- Proposed Condition GEN1: Consult with the Forest Service Annually Regarding Project Effects on NFS Land
- Proposed Condition GEN2: Consult with the Forest Service Regarding New Ground Disturbing Activities on NFS Land
- Proposed Condition GEN3: Consult with the Forest Service Regarding New Facilities on NFS Land
- Proposed Condition GS1: Implement Erosion and Sediment Control Plan
- Proposed Condition GS2: Implement Our House and Log Cabin Diversion Dams Sediment Removal Plan[6]

[6] Plan included in Appendix E3 of Exhibit E of Application for New License.

- Proposed Condition GS3: Pass Sediment at Our House and Log Cabin Diversion Dams
- Proposed Condition GS4: Monitor Channel Morphology Downstream of Our House and Log Cabin Diversion Dams
- Proposed Condition GS5: Pass Large Woody Material at Our House and Log Cabin Diversion Dams
- Proposed Condition LU1: Transportation System Management Plan

Each of these conditions is provided in full in Appendix E2. Management plans are included in Appendix E3.

3.3.1.4.2 Proposed Measures and Studies Recommended by Agencies or Other Relicensing Participants That Were Not Adopted by YCWA

[Relicensing Participants – This is a placeholder in the Draft License Application. This section will be completed in the Final License Application. YCWA]

3.3.1.5 Unavoidable Adverse Effects

Operating and maintaining the Project would continue to capture sediment above Project dams and alter flow in reaches downstream of the dams.

There is a long-term, major, cumulative and unavoidable effect of sediment storage and flood control due to Project dams. Over the course of the Proposed Project (e.g., a long-term effect), flood events will continue to occur that add sediment to the reservoirs upstream of New Bullards Bar, Our House Diversion Dam and Log Cabin Diversion Dam. These floods are unavoidable and are why YCWA is proposing sediment removal and low-level outflow sediment pass-through on Our House and Log Cabin Diversion Dam when these catastrophic events occur.

There is a long-term, unavoidable and cumulative effect on the channels downstream of Project dams due sediment storage above dams in that there is less sediment available that might deposit and create deformable substrate and subsequent “response reaches.” However, Project-affected reaches are transport reaches and there are few locations that could respond by enhanced sediment deposition from a higher supply, so the on-going effect is considered minor.

Short-term, site specific and minor effects due to proposed and potential construction activities and recreational facilities reconstruction or rehabilitation could occur by exposing and disturbing slopes and soils. However, by implementing YCWA’s proposed Erosion and Sediment Control Plan (GS1) and adhering the terms and conditions in permits and approvals for the specific work, the effects will be short-term, local and minor.

Long-term, site-specific, and minor effects could occur due to landslides, blocked culverts, road surface erosion, and road drainage issues associated with Project roads. Project roads could continue to erode during runoff events, which is a long-term, minor effect. There are expected to be few or minor effects due to sedimentation from Project roads. YCWA’s proposed

Transportation System Management Plan (LU1) would maintain Project roads in good condition and address issues such as shotgun culverts and landslides within the road prism that have the potential to deliver sediment to live channels and New Bullards Bar Reservoir.

