TECHNICAL MEMORANDUM ◦ NOVEMBER 2021

Sediment Supply to the Upper Eel River

PREPARED FOR

Two-Basin Solution Partners
California Trout
Humboldt County
Mendocino County Inland Water and Power Commission
Round Valley Indian Tribes
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Cover photos: Sediment deposits in Lake Pillsbury

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1 BACKGROUND AND PURPOSE

1.1 Introduction

The Potter Valley Project (Project) is an inter-basin hydroelectric project located 15 miles northeast of Ukiah (Figure 1) that annually diverts approximately 60,000 acre-feet (ac-ft) of water from the upper Eel River to the upper Russian River. Project features include Scott Dam, a 130-foot-tall concrete gravity dam that impounds Lake Pillsbury, a 2,300-acre storage reservoir with an initial storage capacity in 1922 of 94,400 ac-ft; Cape Horn Dam that impounds the 106-acre Van Arsdale Reservoir; and a diversion system that diverts water from the Eel River at Van Arsdale Intake to the Project's powerhouse located in the headwaters of the Russian River watershed. The Project began diverting water in 1908 when Cape Horn Dam and the Van Arsdale Diversion were built. Scott Dam was built in 1922 approximately 12 miles upstream of Cape Horn Dam at river mile (RM) 168.5.

Pacific Gas and Electric Company's (PG&E's) Project license expires in 2022. PG&E filed a Pre-Application Document (PAD) and Notice of Intent (NOI) to formally initiate the relicensing process for the Project in April 2017. PG&E withdrew its NOI and PAD and discontinued its efforts to relicense the Project in January 2019, and in March 2019, the Federal Energy Regulatory Commission (FERC) issued a notice soliciting interested potential applicants other than PG&E to file an NOI and PAD. In May 2019, the Two-Basin Solution Partners (Partners) entered into a Planning Agreement to explore pathways to obtain a new license for the Project. In June 2019, the Partners filed a NOI with FERC stating the intent to undertake a Feasibility Study of a potential licensing proposal for the Project. The Feasibility Study examined the practicability of potential actions in meeting agreed upon common goals and to inform the Partners of cost and performance tradeoffs associated with those actions. Phase 1 of the Feasibility Study, completed and filed with FERC in May 2020, included the following key elements: (1) a Regional Entity that will apply for the new license and assume the new license if issued, (2) a Project Plan, (3) a Fisheries Restoration Plan, (4) an Application Study Plan, and (5) a Financial Plan. Phase 2 of the Feasibility Study was initiated in April 2020 with grant funding from the California Department of Fish and Wildlife to supplement technical analyses conducted during Phase 1, and to conduct new technical analyses.

This Technical Memorandum was prepared for the Partners by the Consultant Team to supplement technical analyses performed during Phase 1 of the Feasibility Study. The information provided in this document is a continuation of work along a path starting with preliminary analyses of feasibility, transitioning towards more refined analyses of a focused project plan, and hopefully ending with implementation of the best possible project that meets programmatic goals in a cost-effective manner. This Technical Memorandum is informational, is not binding of any of the Partners, and will not be filed with FERC as the basis for compliance under the Integrated License Process or other FERC regulations. While this Technical Memorandum contributes to the information available to the Partners, the Partners have not solely relied on this document for justification for any decision they have made or will make regarding FERC filings or cooperative agreements. More detailed environmental and engineering studies will be conducted during implementation of the FERC study and outside of the FERC process. Accordingly, this Technical Memorandum reflects a step that will be expanded and built upon in the coming years with additional studies, analysis, synthesis, and ultimately decisions by the Partners on proceeding with a Project Plan.

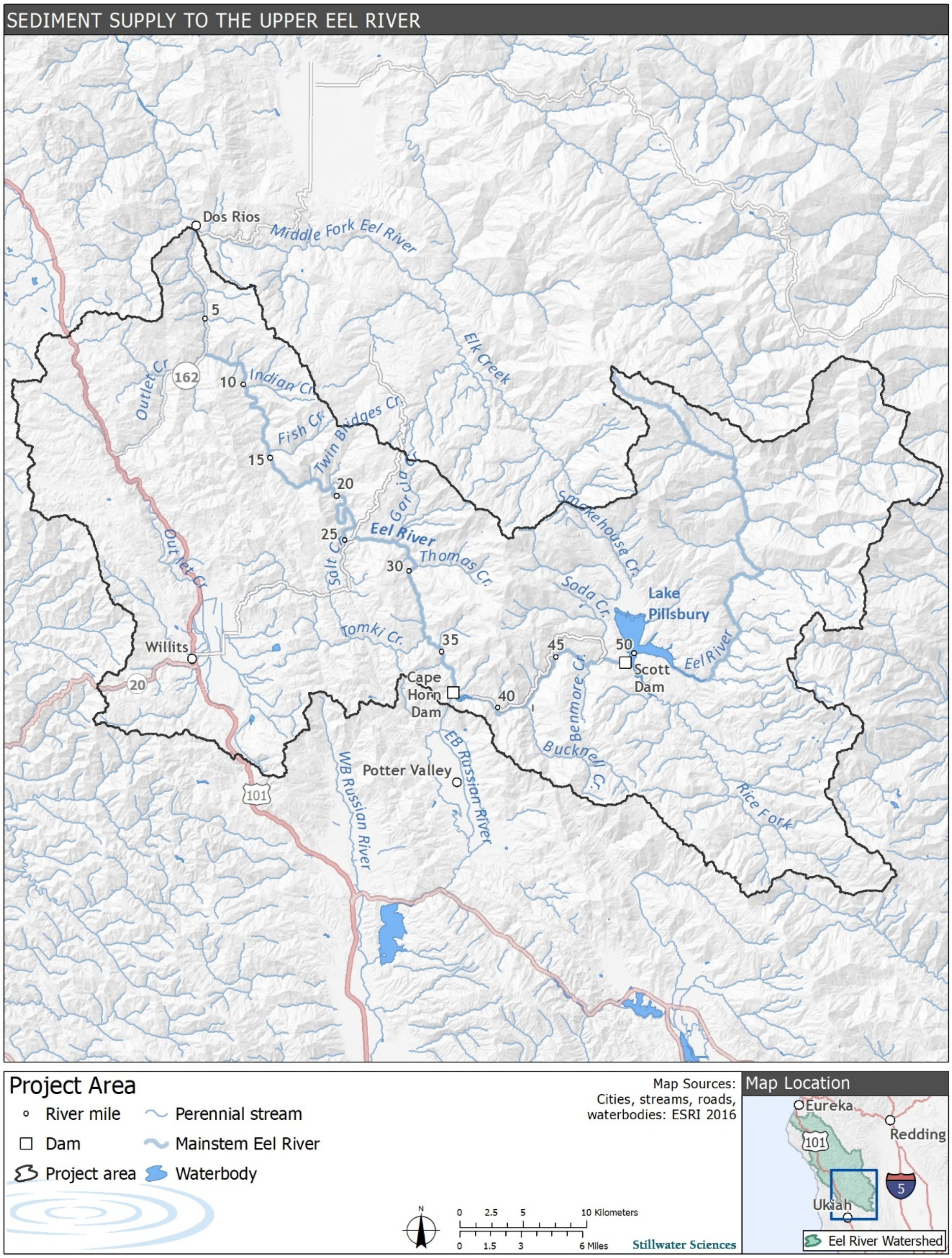


Figure 1. Project area. Analyses herein report river miles beginning at the Middle Fork Eel River confluence with mainstem Eel River (i.e., RM 0.0). The middle Fork Eel River is located 119.4 miles upstream from the mainstem Eel River confluence with the Pacific Ocean (i.e., mainstem RM 119.4).

1.2 Lake Pillsbury Sediment

The Project Plan proposes to remove Scott Dam in a phased process in coordination with infrastructure modifications to ensure continued power generation and water supply reliability for the Potter Valley Irrigation District and the Russian River. Preliminary analyses indicate that in the absence of sediment management during removal of Scott Dam, up to 12 million cubic yards (yd^3) of erodible sediment stored in Lake Pillsbury could be transported downstream by the Eel River (Stillwater Sciences et al. 2021). The Partners are conducting studies as part of the Phase 2 Feasibility Study (e.g., Stillwater Sciences 2021) to understand and address the uncertainties and potential effects of dam removal on the downstream Eel River and associated water supply reliability. The primary elements of these studies include assessing the quantity and potential mobility of sediment deposits accumulated in Lake Pillsbury; identifying the potential need for managing these sediment deposits under different dam removal options; and analyzing suspended load and bedload transport in downstream reaches. Additional sediment characterization, supply, and transport studies are included in the FERC Study Plan (Study AQ 4 – Fluvial Processes and Geomorphology and Study AQ 12 – Scott Dam Removal) that will build from the work of the Phase 2 Feasibility Study and refine assessments on the potential effects of the proposed project.

1.3 Study Goals and Objectives

The goal of this component of the Phase 2 Feasibility Study is to develop an understanding of the background sediment supply (e.g., historical natural and management-related) to the Upper Eel River (Eel River from the headwaters to the confluence of Middle Fork Eel River). Specific objectives are to (1) summarize existing information about sediment supply rates (i.e., sediment delivery and yield) within the Project area, (2) apply the best available existing information to estimate cumulative sediment supply to key locations along the Upper Eel River from its headwaters to the Middle Fork Eel River confluence, and (3) relate these estimates of cumulative sediment supply to other relevant information (e.g., historical estimates of sediment load at U.S. Geological Survey [USGS] gaging stations). These objectives include refining estimates of the sedimentation rate in and yield to Lake Pillsbury. The results from this component will help inform how reservoir sediment release associated with different potential dam removal strategies may impact downstream channel conditions and riverine habitats relative to background sediment supply and transport conditions.

Preliminary estimates of cumulative sediment supply developed in this component of the Phase 2 Feasibility Study will be refined as part of the proposed Study AQ 4 - Fluvial Processes and Geomorphology to be implemented during FERC Project relicensing. Study AQ 4 will substantially refine these results by developing a sediment budget for key locations (i.e., sediment budget nodes) in the mainstem channel from Scott Dam to the Middle Fork Eel River and at select downstream sites (e.g., Dos Rios, Fort Seward, and Scotia) under existing conditions. Key objectives of Study AQ 4 will include (1) utilizing anticipated new information obtained from investigation of reservoir sediment deposits and bulk sampling of channel bed material to partition the sediment yield to Lake Pillsbury into relevant grain size fractions, (2) refining estimates of cumulative sediment supply by grain size fraction at sediment budget nodes, (3) estimating sediment transport capacity at sediment budget nodes (in coordination with hydrodynamic and sediment transport modeling conducted as part of Study AQ 12 – Scott Dam Removal), and (4) computing annual mass balance under existing conditions.

2 GEOLOGIC AND GEOMORPHIC SETTING

2.1 Geology

The Upper Eel River is in the northern part of the Coast Range Geomorphic Province. The northern coast ranges are predominantly composed of the Franciscan Complex; a deformed accretionary prism of sedimentary, metamorphic, and igneous rocks that were assembled in a subduction zone and accreted to the western continental margin between the Late Jurassic and Miocene (Figure 2) (Jayko et al. 1989; Ohlin et al. 2010, McLaughlin et al. 2018). The Franciscan Complex in the Project vicinity is overlain by the Jurassic Coast Range ophiolite. Sedimentary rocks of the Upper Jurassic Great Valley complex were deposited unconformably on the Coast Range ophiolite. Deformation subsequently incorporated the lower Great Valley complex into a regionally extensive mélange of ophiolite rocks (McLaughlin et al. 1990). Subduction in the Project area has been largely replaced by dextral strike-slip faulting associated with northward propagation of the San Andreas transform system. The northwest-trending structural grain strongly influences the modern topography, with major drainages and ridges trending northwest.

The major geologic terranes and structural relations, and their influence on erosion and sediment supply rates in the Project vicinity are described in more detail below. The descriptions below draw extensively from geologic mapping compilations and associated descriptions of geologic terranes by McLaughlin et al. (2018) and Mclaughlin et al. (2000).

2.1.1 Franciscan Complex

The Franciscan Complex consists of three structural belts that decrease in age from east to west: the Eastern, Central, and Coastal belts (Jayko et al. 1989).

2.1.1.1 Eastern Belt

The Eel River in the vicinity of Lake Pillsbury and the area draining to the reservoir occur predominantly within the Eastern belt. The Eastern belt is the earliest assembled and structurally the highest of the three Franciscan belts (McLaughlin et al. 2018). The Eastern belt is composed of rocks that are generally less disrupted but have undergone more uniform regional metamorphism than in the Central and Coastal belts to the west, including development of higher blueschist-grade metamorphic mineral assemblages and conversion of metasedimentary rocks to slate, phyllite, and schist (Blake et al. 1967). McLaughlin et al. (2018) divide the Eastern belt in the Project vicinity into the Yolla Bolly, Pickett Peak, and Mendocino Pass terranes.

2.1.1.2 Central Belt

The Eel River downstream of approximately Cape Horn Dam drains predominantly the Central belt. The Central belt consists of a Late Jurassic to Middle Cretaceous argillaceous mélange matrix enclosing large slab-like bodies of rock (McLaughlin et al. 2000, 2018). In the Project area, the large blocks or slabs are typically composed of sheared metasandstone and argillite, blueschist, pelagic chert or limestone, basaltic volcanic rocks, and other mafic to ultramafic parts of the Mesozoic ocean floor. The largest of these slabs, referred to as the Snow Mountain Volcanic Terrane (McLaughlin et a. 2018), occurs over a large area in the Upper Eel River basin east and upstream of Lake Pillsbury. The Snow Mountain volcanic terrane is a sequence of

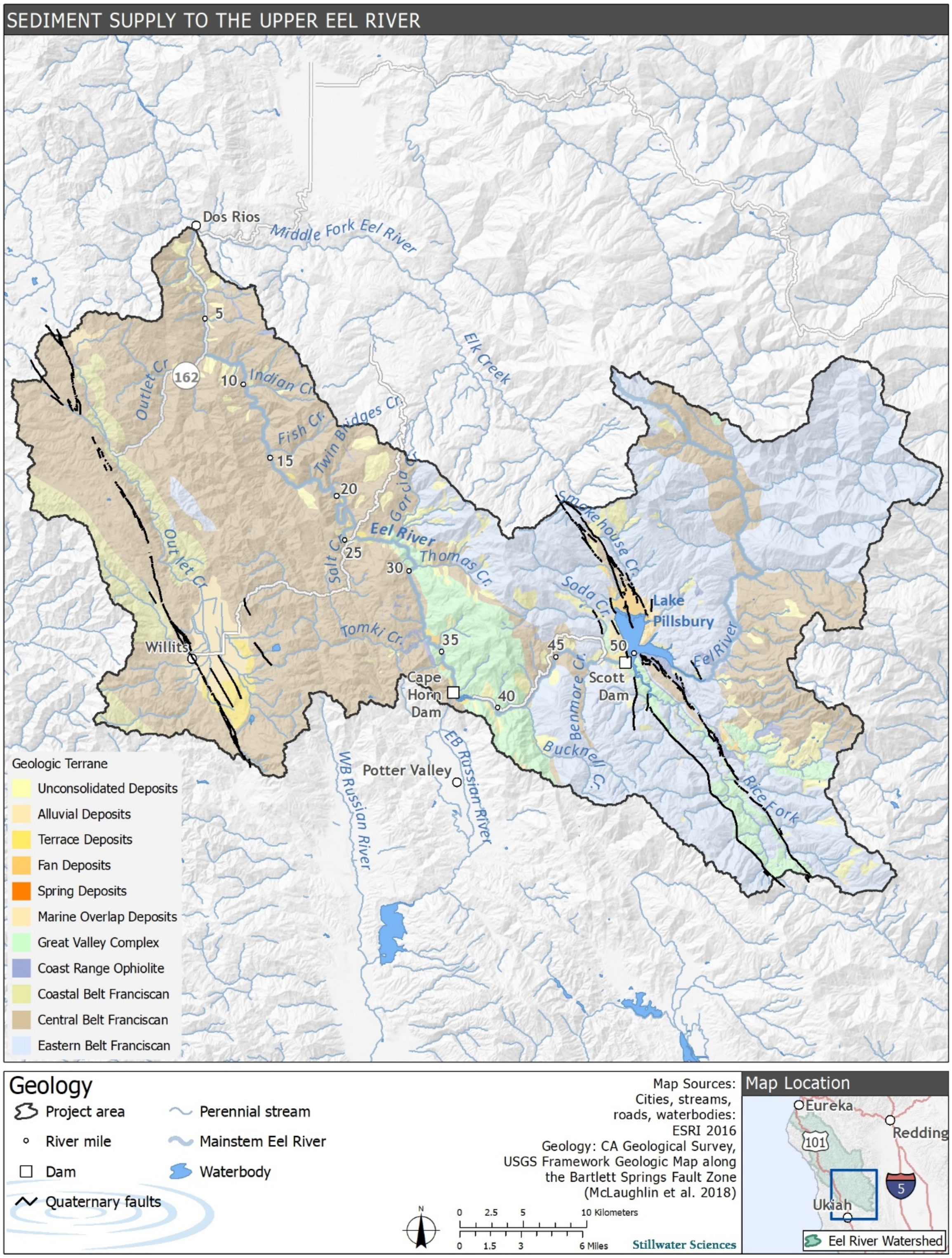


Figure 2. Geology of the Upper Eel River Basin.

metamorphosed rhyolitic to basaltic volcanic and volcaniclastic rocks interpreted to be a seamount (McLaughlin et al. 2018). These rocks structurally overlie or are enclosed by mélange extending up the mainstem Eel River to its headwaters between Bald Mountain and Round Mountain. The Central belt is underlain structurally by the Coastal belt beneath a regional low-angle fault referred to as the Coastal belt Thrust.

2.1.1.3 Coastal Belt

The western-most portion of the Project area west of Little Lake Valley in the vicinity of Outlet Creek is underlain by rocks of the Coastal belt. These rocks are predominantly marine sandstone, argillite, minor conglomerate, and mélange with lenses of carbonate. Coastal belt terrane is Pliocene to Late Cretaceous in age (McLaughlin et al. 1994).

2.1.2 Coast Range Ophiolite

The Coast Range ophiolite consists of ultramafic and gabbroic rocks, mafic sills and dikes, pillow basalt and flow breccias, and pelagic chert that are broadly interpreted as oceanic basement (McLaughlin et al. 2018). Much of the original section of the Coast Range ophiolite is missing in the map area and the ophiolite is modified by Cretaceous and younger tectonism, uplift, and erosion that gave rise to sedimentary serpentinite and ophiolitic mélange (Jayko et al. 1987). These ophiolitic rocks locally underlie the Elder Creek terrane of the Great Valley complex.

2.1.3 Great Valley Complex

The Great Valley complex in the Project area is predominantly composed of the Elder Creek terrane (McLaughlin et al. 2018). The Elder Creek Terrane consists of the Middle to Upper Jurassic oceanic basement of the Great Valley complex (the Coast Range ophiolite plus serpentinite matrix mélange), overlain unconformably by Upper Jurassic to Lower Cretaceous strata of the Great Valley complex (Blake et al. 2000). These rocks are folded, sheared, and faulted. Overlapping younger Cretaceous strata of the Great Valley complex are less severely deformed. Upper Jurassic to Lower Cretaceous sedimentary serpentinite locally makes up a significant component of the Elder Creek terrane (McLaughlin et al. 2018).

2.1.4 Surficial Deposits

Numerous Quaternary and more recent Holocene alluvial deposits occur in terraces, fans, and valley fills throughout the Project vicinity (Ohlin et al. 2010). The largest Quaternary terrace deposits include the thick sequence of weakly consolidated and highly erosive sands and gravels on the east side of Lake Pillsbury, as well as deposits along the Eel River downstream of Cape Horn Dam and in the southern portion of Little Lake Valley. Unconsolidated Holocene sediments occur in numerous river valleys and landslide deposits throughout the Project area.

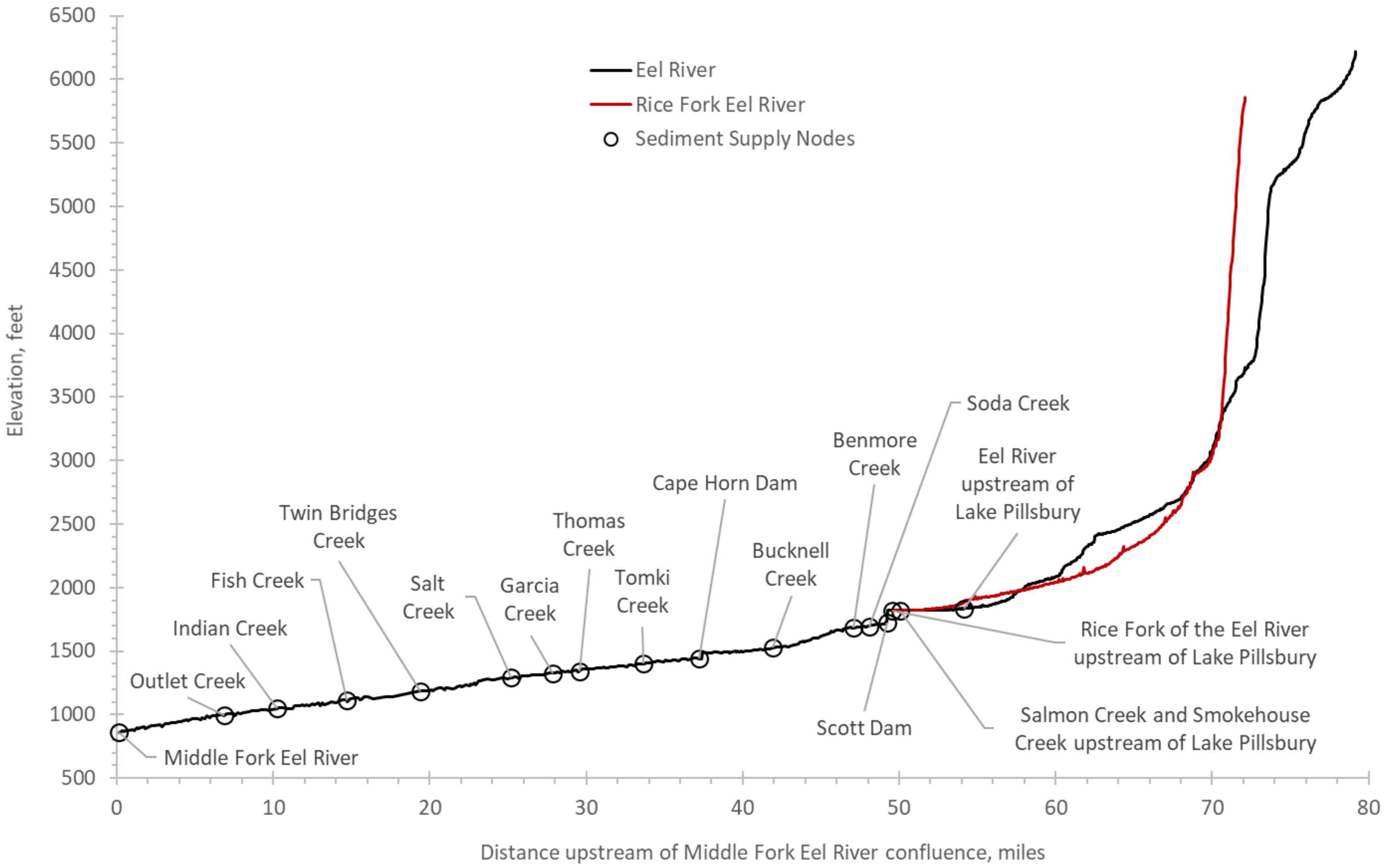
2.2 Structure

The northern Coast Ranges in the Project vicinity are dominated by structures associated with northerly migration of the Mendocino triple junction and evolution of the San Andreas transform boundary. In the Northern Coast Ranges, strike-slip faulting along the San Andreas fault system splays into several separate major faults across a 50-mile-wide zone (McLaughlin et al. 2018). The major structures in this system are the San Andreas fault, the Rodgers Creek-Maacama fault system, and the Green Valley-Bartlett Springs fault system. All three of these structures have been active in the Quaternary and are associated with ongoing seismic activity (McLaughlin et al. 2018). The most significant active structural features in the Project vicinity are the Bartlett Springs fault, located east of Scott Dam, and the Maacama fault, located along the western edge of the Project area near Little Lake Valley and Outlet Creek. The Bartlett Springs fault zone has a general strike of N35W and extends approximately 50 miles from the Middle Fork of the Eel River southeast of Round Valley, past Lake Pillsbury and Bartlett Springs to just north of Cache Creek (Lienkaemper 2010, McLaughlin et al. 2018)). The surface expression of the fault zone follows a series of small structural basins, narrow valleys, and low drainage divides that coincide with a 0.9-mile-wide zone of Franciscan mélange and ultramafic rocks (McLaughlin et al. 2018).

2.3 Geomorphology

The Eel River drains 3,684 mi^2 and has a mean annual discharge of 6.5 million ac-ft. Major subbasins include the Main Eel River (1,477 mi^2), the Van Duzen River (428 mi^2), the South Fork Eel River (690 mi^2), the North Fork Eel River (283 mi^2), and the Middle Fork Eel River (753 mi^2). The Upper Eel River, defined as the 78-mile-long segment of the Eel River from its headwaters to the confluence of the Middle Fork Eel River, originates at elevations above 6,700 feet and drains 688 mi^2. From its headwaters, the Upper Eel River flows in a southerly direction for 23 miles before turning westward and flowing into Lake Pillsbury. The river descends an average of 200 feet per mile in this reach. Below Lake Pillsbury, the river flows 12 miles westward to Van Arsdale Reservoir, with an average slope of approximately 29 feet per mile. Downstream from Van Arsdale Reservoir, the Eel River turns northwestward, descending an average of 16 feet per mile to its confluence with the Middle Fork Eel River located 55 miles downstream (Brown and Ritter 1971). Major tributaries of the Upper Eel River include (from upstream to downstream) the Rice Fork, Soda Creek, Benmore Creek, Bucknell Creek, Tomki Creek, Thomas Creek, Garcia Creek, Salt Creek, Twin Bridges Creek, Fish Creek, Indian Creek, and Outlet Creek (Figures 1 and 3).

Hillslope geomorphology in the Upper Eel River basin can be generally characterized as “hard” or “soft” based on contrasting topography, morphology, and surface processes (Kelsey 1980, Muhs et al. 1987, Mackey and Roering 2011). The harder and more competent sandstone rocks in the Franciscan Complex typically form steep, well-organized ridge and valley drainage networks with erosion dominated by debris slides, debris flows, and fluvial incision (Kelsey 1980; Kelsey et al. 1995, Stock and Dietrich 2006). In contrast, the weaker and finer-grained mélange units typically form “soft” topography with dense but poorly developed drainage networks and longer, low-gradient slopes where erosion is dominated by earthflows and gullies (Mackey and Roering 2011, Roering et al 2015). More competent blocks or slab-like bodies of rock within the mélange have a significant local influence on topography, persisting as erosion-resistant topographic highs.


Eel River
Rice Fork Eel River
○ Sediment Supply Nodes
Elevation, feet
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10
20
30
40
50
60
70
80
Distance upstream of Middle Fork Eel River confluence, miles
Middle Fork Eel River
Outlet Creek
Indian Creek
Fish Creek
Twin Bridges Creek
Salt Creek
Garcia Creek
Thomas Creek
Tomki Creek
Cape Horn Dam
Bucknell Creek
Benmore Creek
Scott Dam
Soda Creek
Eel River upstream of Lake Pillsbury
Rice Fork of the Eel River upstream of Lake Pillsbury
Salmon Creek and Smokehouse Creek upstream of Lake Pillsbury

3 SEDIMENT SUPPLY

The mass balance between sediment supply and transport fundamentally controls channel sediment storage, morphology, and the grain size distribution of mobile bed material. Sediment supply can be estimated through various methods, including (1) estimating the amount of sediment delivered to the channel network through an accounting of erosion features and processes within a drainage basin over a specific time interval, (2) evaluating the volume of sediment deposited within an impoundment over a specified time period and apportioning that sediment as a unit-area rate of mass sediment yield from the contributing watershed area, and (3) computing reach-scale sediment load from long-term measurements of suspended load and/or bedload at a station.

Sediment supply was estimated from within 25 subbasins defined by 17 key locations (referred to as sediment supply nodes): three locations where the larger tributaries draining the upper basin enter the high-water elevation of Lake Pillsbury, 12 locations at the confluences of the largest tributaries entering the Upper Eel River between Scott Dam and the Middle Fork Eel River, and two critical infrastructure locations (Scott Dam and Cape Horn Dam) (Figures 3 and 4). Sediment supply nodes define sediment source areas within either the physical boundaries of individual tributary watersheds or the combined sediment source area between these watersheds. For example, the source areas defined by the nodes "Eel River upstream of Lake Pillsbury," "Rice Fork upstream of Lake Pillsbury," and "Salmon Creek and Smokehouse Creek upstream of Lake Pillsbury" include the drainage area for these subbasins from their headwaters to the approximately high-water level of Lake Pillsbury; whereas the node "Eel River, Lake Pillsbury to Scott Dam" includes all of the remaining source area to Lake Pillsbury. Similarly, the source areas defined by the nodes "Soda Creek," "Benmore Creek," and "Bucknell Creek" include the drainage areas for these subbasins from their headwaters to their confluence with the Eel River; whereas the node "Cape Horn Dam" includes all of the remaining source areas between Scott Dam and Cape Horn Dam. Sediment supply nodes defined in this study will be used as sediment budget nodes in the Study AQ 4 - Fluvial Processes and Geomorphology to be implemented during Project relicensing.

Existing information about sediment delivery, sediment yield, and sediment load in the Upper Eel River basin; as well as methods for using these data to estimate the cumulative average annual background (natural and management-related) sediment supply rates to key locations in the Upper Eel River are summarized below.

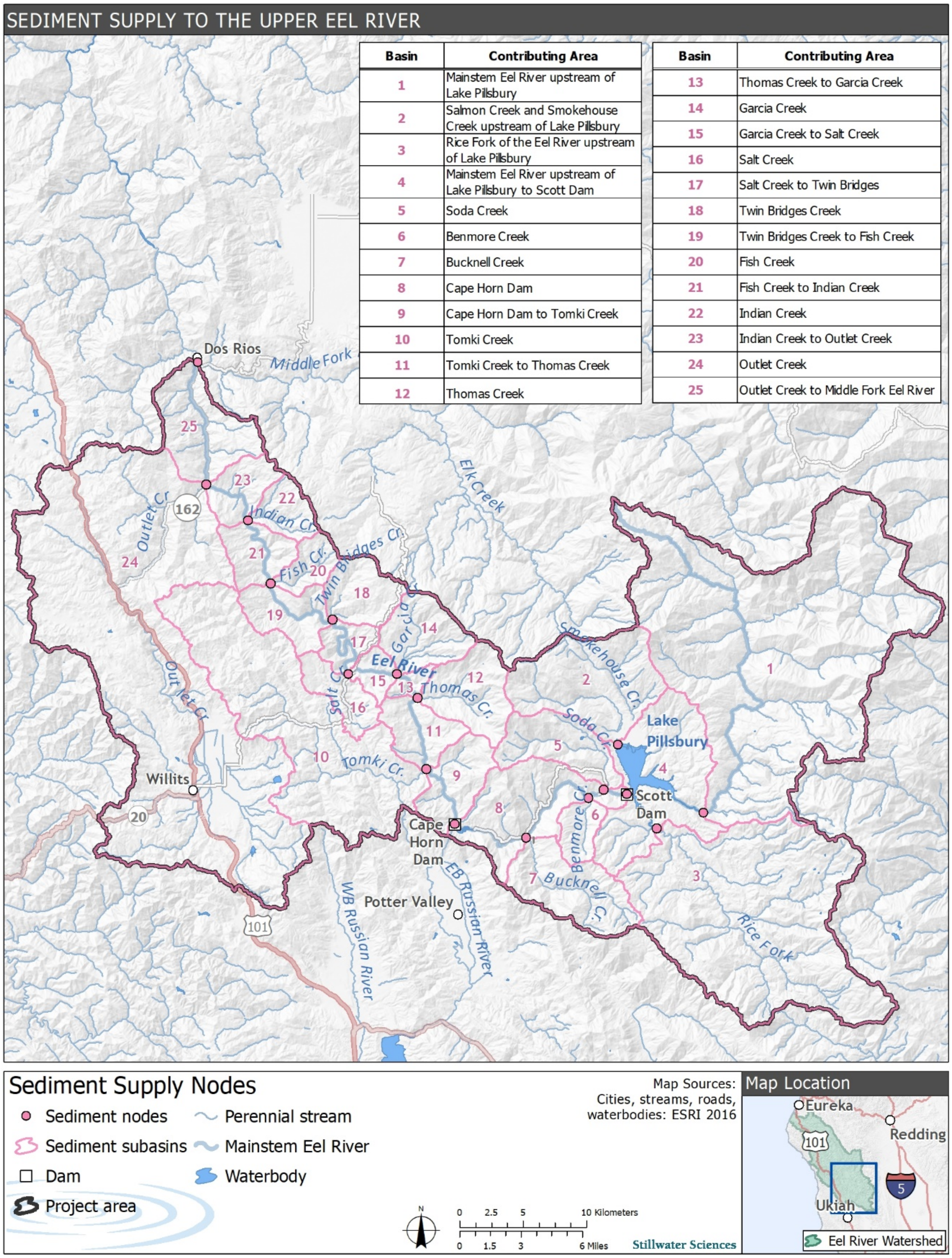
3.1 Sediment Delivery

The primary source of sediment delivery information for the Project area is the Upper Main Eel River and Tributaries (including Tomki Creek, Outlet Creek and Lake Pillsbury) Total Maximum Daily Loads (TMDLs) for Temperature and Sediment developed by the US Environmental Protection Agency (USEPA) Region IX (USEPA 2004). These data and their use in computing average annual sediment supply to the Upper Eel River are described in the following sections.

3.1.1 Upper Eel River Total Maximum Daily Load

The USEPA added the Upper Main Eel River to California's 303(d) impaired water list in 1992 due to elevated sedimentation and temperature. TMDLs for sediment and temperature were established for the Upper Main Eel River in 2004 (USEPA 2004). The sediment TMDL concluded that approximately 13,300,000 yd^3 of sediment was delivered to the Upper Eel River during the period 1940–2004, equating to an average annual delivery rate of 466 tons per square mile per year (t mi^{-2} y^{-1}) (Table 1). About 47% of the total sediment delivery during the period originated from undifferentiated Franciscan terrane (58% of source area), and about 25% originated from Schist terrane (21% of source area). Melange (9% of watershed area) accounted for 15% of the delivery, and Coastal belt terrane (9% of watershed area) accounted for 11% of the delivery. The small remaining fraction of the sediment delivery was attributed to alluvium. The primary sources of sediment (94% of the total delivery) were shallow debris slides, debris flows, gullies, and streambank erosion unrelated to earthflows. About 33% of the total sediment delivery was related to human disturbance (primarily associated with roads and timber harvest).

Terrane-specific unit-area sediment delivery rates reported in the Upper Eel River TMDL for the period 1940–2004 were used in combination with available digital geologic mapping to estimate average annual sediment supply from the 25 subbasin areas defined by the 17 sediment supply nodes (Figure 5, Appendix A). Two digital data sets were combined to define geologic terranes within the Project area to which unit-area sediment delivery rates were assigned. The first is detailed geologic mapping and supporting attribute information compiled by McLaughlin et al. (2018) at a scale of 1:100,000 for the area within the Bartlett Springs Fault Zone and adjacent areas from Round Valley to Wilbur Springs. The mapping generally encompasses the Upper Eel River and contributing areas to approximately Dos Rios but excludes portions of the Project area lying west of the mainstem Eel River downstream of Outlet Creek. Geology in areas absent from the McLaughlin (2018) data were described using digital geologic mapping data at a scale of 1:750,000 compiled by Ludington et al (2007). The compilation of digital data by Ludington et al (2007) occurs at a coarser scale and does not aggregate geologic units into as detailed of terranes as McLaughlin et al. (2018)



SEDIMENT SUPPLY TO THE UPPER EEL RIVER

Basin	Contributing Area
1	Mainstem Eel River upstream of Lake Pillsbury
2	Salmon Creek and Smokehouse Creek upstream of Lake Pillsbury
3	Rice Fork of the Eel River upstream of Lake Pillsbury
4	Mainstem Eel River upstream of Lake Pillsbury to Scott Dam
5	Soda Creek
6	Benmore Creek
7	Bucknell Creek
8	Cape Horn Dam
9	Cape Horn Dam to Tomki Creek
10	Tomki Creek
11	Tomki Creek to Thomas Creek
12	Thomas Creek

Basin	Contributing Area
13	Thomas Creek to Garcia Creek
14	Garcia Creek
15	Garcia Creek to Salt Creek
16	Salt Creek
17	Salt Creek to Twin Bridges
18	Twin Bridges Creek
19	Twin Bridges Creek to Fish Creek
20	Fish Creek
21	Fish Creek to Indian Creek
22	Indian Creek
23	Indian Creek to Outlet Creek
24	Outlet Creek
25	Outlet Creek to Middle Fork Eel River

Table 1. Summary of sediment delivery rates reported in the Upper Main Eel River Total Maximum Daily Load (TMDL) for sediment and temperature (USEPA 2004).

Delivery rate class	**Terrane**	**Area (mi^2)**	**Percent of basin**	**Total Sediment delivery [a]**	
				$t\ y^{-1}$	**$t\ mi^{-2}\ y^{-1}$**
1	Schist	145.1	21.1	81,561	562
2	Mélange	64.4	9.4	47,489	737
3	Alluvium	16.9	2.5	5,471	324
4	Coastal belt	64.9	9.4	36,671	565
5	Franciscan undifferentiated	396.8	57.7	149,572	377
Total		**688.1**	**100**	**320,765**	**466**

Notes: $t\ y^{-1}$ = tons per year, $t\ mi^{-2}\ y^{-1}$ = tons per square mile per year.

Source: Upper Eel River TMDL (USEPA 2004) Appendix B Sediment Source Analysis

[a] Density of 1.54 $t\ yd^{-3}$ calculated from unit area volume and mass reported from in the TMDL (USEPA 2004).

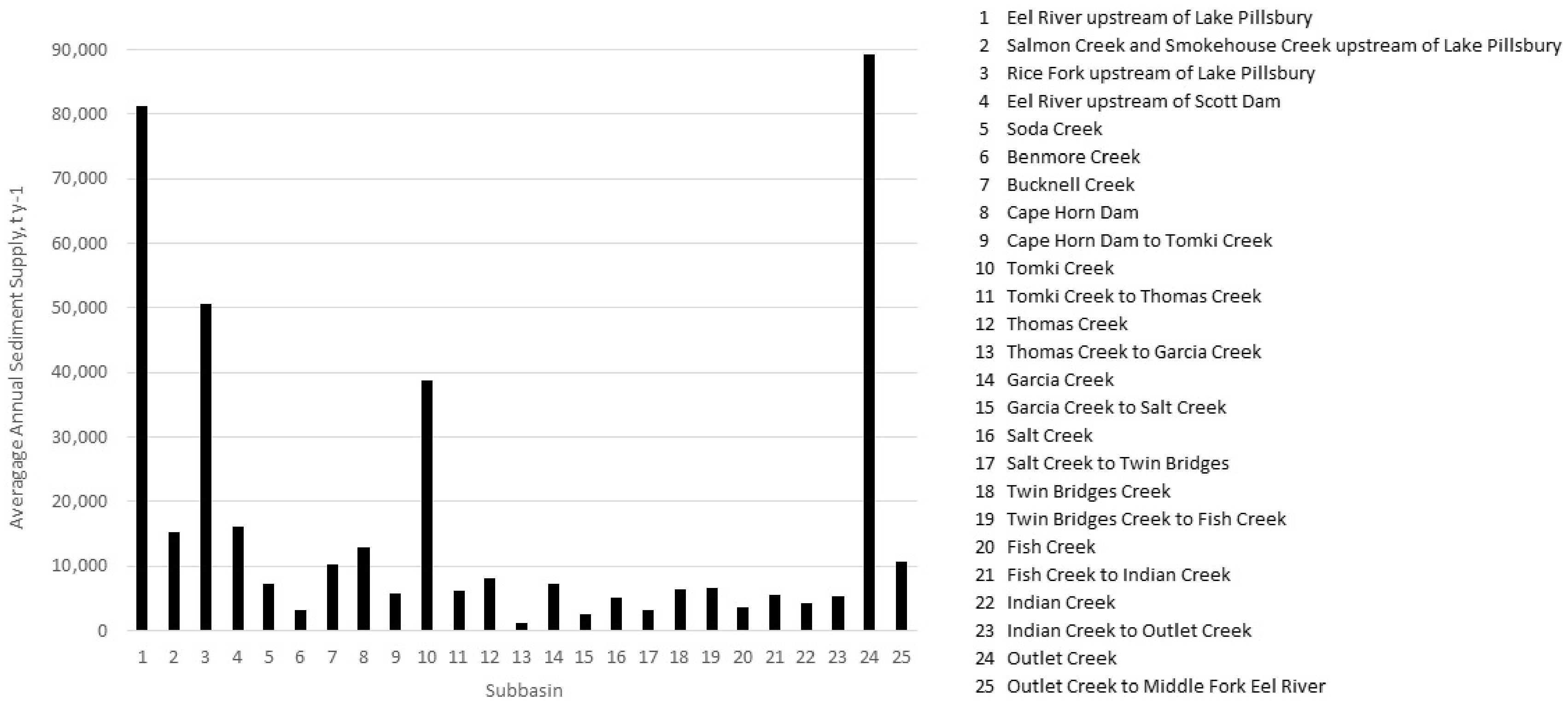


Figure 5. Summary of average annual sediment supply estimates in the Upper Eel River based on terrane-specific unit-area sediment delivery rates reported in the Upper Eel River Total Maximum Daily Load.

3.1.2 Other Existing Sediment Delivery Information

Selective additional key sources of sediment delivery information for the Eel River basin downstream of the Project area (i.e., Middle Fork Confluence) are summarized here to put supply estimates in the Upper Eel River basin into context, and because the information may be important in refining estimates of sediment supply during implementation of the sediment budget component of Study AQ 4. These information sources include TMDLs for other major Eel River tributary watersheds (i.e., Middle Fork Eel, North Fork Eel, South Fork Eel, Van Duzen River, and the Lower Eel), sediment source analyses reported by Pacific Lumber Company in their Upper Eel Watershed Analysis (Pacific Lumber Company 2007), and other published research on process-specific sediment delivery to specific basin areas or river reaches.

The USEPA developed sediment TMDLs for the six major Eel River watershed areas (including the mainstem and tributaries), five of which are located downstream of the Project area (i.e., Middle Fork Eel River, North Fork Eel River, South Fork Eel River, Van Duzen River, and the Lower Eel River; Table 2). Total unit-area delivery rates generally increase from upstream to downstream and from east to west within the Eel River basin, with the highest rate occurring in the Van Duzen River. Sediment supply downstream of the Project area exceeds that estimated for the Upper Eel River basin by about 41 percent in Middle Fork, a factor of 1.6 in the North Fork, a factor of 3.3 in the South Fork, and by about a factor of 4.3 in the Van Duzen. This pattern can largely be explained by a westerly transition to more unstable geologic terranes, steeper topography, more effective rainfall, and more pervasively disrupted rock associated with active tectonic uplift and deformation. The pattern is also explained, in part, by higher management-related sediment production from more extensive land use disturbances associated with road building, mechanized timber harvest, and settlement.

Table 2. Summary of Total Maximum Daily Load (TMDL) sediment delivery information for mainstem and major Eel River tributary areas

TMDL sediment source area	**Drainage area, mi^2**	**Time period**	**Unit-area sediment delivery (t mi^{-2}y^{-1})**		
			Natural	**Management-related**	**Total**
Upper Eel River	688	1940–2004	312	154	466
Middle Fork Eel River	753	1985–2002	574	82	656
North Fork Eel River	289	1940–2000	830	399	1,229
South Fork Eel River	690	1981–1996	1,095	946	2,005
Van Duzen River	422	1955–1999	1,500	959	2,458
Lower Eel River	299	1955–2003	718	776	1,493

The Pacific Lumber Company (PALCO) completed watershed analyses on the Upper Eel Watershed Analysis Unit (WAU) in 2007, per the requirements in PALCO's Habitat Conservation Plan (Pacific Lumber Company 2007). The purpose of the watershed analysis was to determine the conditions of erosion and riparian processes in the watershed and their influence on aquatic habitat and their sensitivity to past and future forest management. As part of the watershed analysis, a sediment budget was prepared as a quantitative accounting of estimated sediment delivery to streams for the period 1988–2003. Sediment delivery was assessed using a variety of methods, including historical air photo analysis, field inventories, and modeling. Figure

6 summarizes sediment delivery from 20 subbasins within the Upper Eel WAU.

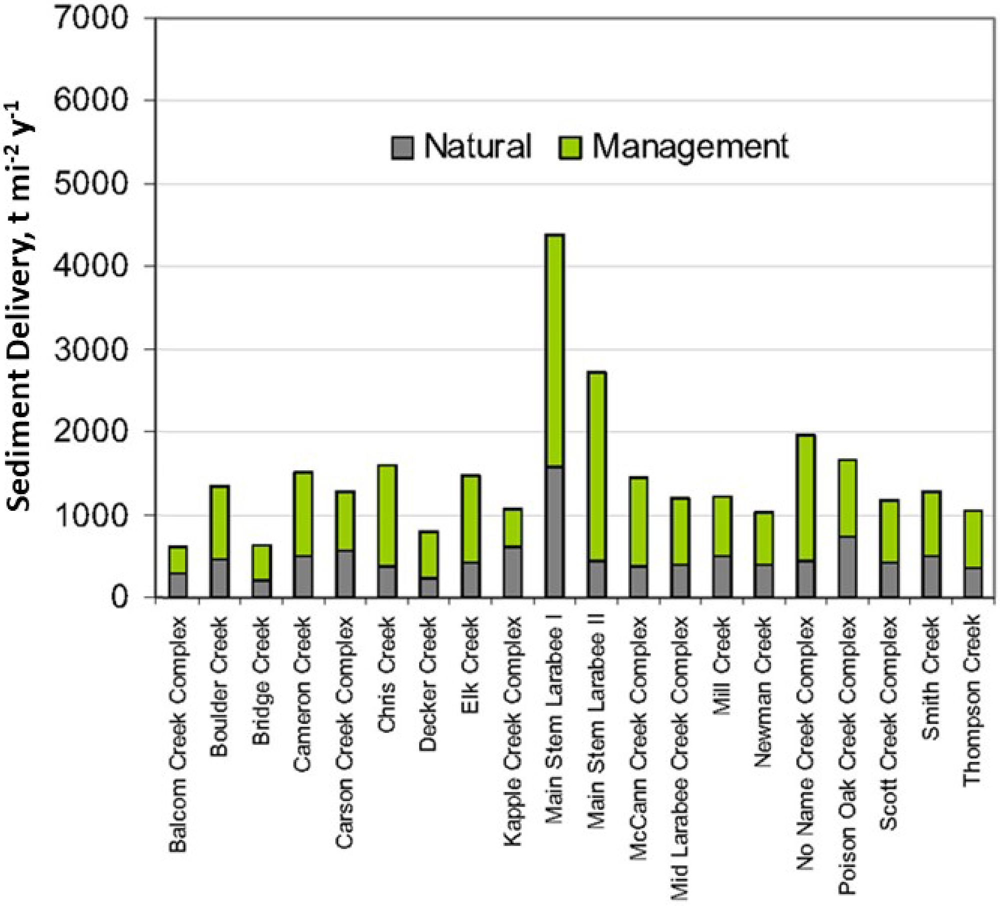


Figure 6. Estimated average annual sediment delivery in subbasins within Pacific Lumber Company's Upper Eel Watershed Analysis Area (modified from Pacific Lumber Company 2007).

Mackey and Roering (2011) estimated sediment delivery from deep-seated landslides in an 87 mi^2 area of the mainstem Eel River between approximately Dos Rios and Alder Point. Approximately 6% of the area, which is dominantly Central belt Franciscan geology, is composed of earthflows that connect to major channels. Mackey and Roering (2011) estimated that the average annual sediment delivery from deep-seated landslides extrapolated across the entire 87 mi^2 area over the period 1944–2006 was 3,140 t mi^{-2} yr^{-1}. In comparison, Wheatcroft and Sommerfield (2005) estimated that the total average annual sediment discharge from the Eel River to the Pacific Ocean over the period 1950–2000 was 6,281 t mi^{-2} yr^{-1}. These results demonstrate that the relatively small portion of the Eel River watershed between Dos Rios and Alder Point, where large deep-seated landslides are prevalent within the Central belt, accounts for about half of the total average annual sediment yield from the entire Eel River watershed (Mackey and Roering 2011).

3.2 Sediment Yield

The volume of sediment accumulated in a reservoir reflects sediment yield from the source area and can be used to estimate an average annual unit-area rate of mass sediment yield. Calculating sediment yield to a reservoir requires measuring or estimating: (1) the volume of accumulated sediment, (2) bulk sediment properties (e.g., density, grain size, and percent organic matter), (3) reservoir trap efficiency, and (4) connected source area to the impoundment. Two approaches are commonly used to estimate the total volume of sediment accumulated in a reservoir: (1) the storage loss determined from change in reservoir storage capacity over time and (2) the volume difference between two spatially explicit bathymetric surfaces.

This study reviews past estimates of sediment accumulation in Lake Pillsbury based on changes in reservoir storage capacity estimated from area-capacity curves, computes the sediment volume accumulated in Lake Pillsbury 1922–2015 based on surface differencing of historical topography prior to construction of Scott Dam and more detailed modern bathymetry of the reservoir basin, and uses this information to compute average annual unit-area sediment yield from the reservoir source area. This study also reviews existing information from PG&E regarding sedimentation in Van Arsdale Reservoir (PG&E 2005).

3.2.1 Sedimentation in Lake Pillsbury

The USGS photogrammetrically developed topography within the Lake Pillsbury basin area in 1922 prior to construction of Scott Dam. The 1922 topography was typically represented by 10-ft contour intervals. Topography and bathymetry of the reservoir basin was resurveyed by the USGS in 1959 (Porterfield and Dunnam 1964) and again in 1984 (Brooks et al. in USFS 1995). Article 55 in PG&E's 2004 license amendment for the Potter Valley Project specified that PG&E conduct bathymetric surveys of Lake Pillsbury every ten years, beginning in 2005. More detailed bathymetric surveys of Lake Pillsbury were conducted in 2005 and again in April 2015 (PG&E 2016b). The bathymetry survey in 2015 occurred April 21–23 and June 17 with the lake elevation at 1894.5 feet (PGE) and 1886.0 feet (PGE), respectively; and was conducted using a combination of multibeam sonar, single beam sonar, and LiDAR that resulted in a more accurate and precise bathymetric surface compared to previous surveys.

Analysis of change in reservoir storage capacity based on area-capacity curves developed from topographic surveys in 1922, 1958, 1984, and 2005 indicates that the original 94,400 ac-ft storage capacity of Lake Pillsbury in 1922 was reduced by 7,620 ac-ft (8.1%) by May 1959 (Table 3) (Porterfield and Dunnam 1964). Sediment delivery between 1922 and May 1959 was about 316,000 t y^{-1} (1,097 t mi^{-2} y^{-1}), of which 94% was deposited within the reservoir (Brown and Ritter 1971). Storage capacity in Lake Pillsbury was further reduced to 80,700 ac-ft in 1984 (Brooks et al. 1984 in USFS 1995), resulting in a 14.5% reduction in the storage capacity since 1922. Sediment delivery between 1959 and 1984 was about 373,200 t y^{-1} (1,296 t mi^{-2} y^{-1}). The 2005 bathymetric survey indicated a 20.6% reduction in storage capacity since 1922. Sediment delivery between 1984 and 2005 was about 417,000 t y^{-1} (1,448 t mi^{-2} y^{-1}).

A more detailed and accurate estimate of the total volume of sediment accumulated in Lake Pillsbury between 1922 and 2015 was recently determined using the 1922 pre-construction topography and the more detailed 2015 bathymetry (Stillwater Sciences et al. 2021). The 1922 topography was scanned from the drawings, georeferenced to the NAD 1983 State Plane California Zone 2 coordinate system, and used to screen-digitize elevation contours.

Average annual sediment yield to Lake Pillsbury was estimated using the following procedure:

1. Total storage volume below the maximum reservoir height defined by the elevation at the top of the spillway gates (1910 ft PG&E datum) was calculated for the 1922 topographic surface and for the 2015 bathymetric surface;
2. Total sediment accumulation over the period 1922 to 2015 was estimated by subtracting the total reservoir volumes for each period;
3. Accumulated sediment volume was converted to accumulated mass using an average reservoir sediment density;
4. Total mass yield was calculated from accumulated mass based on trap efficiency; and
5. Average annual, unit-area sediment yield was calculated by dividing the total mass sediment yield by the duration of accumulation and the reservoir source area.

Two existing sources of information were available to describe bulk sediment properties in Lake Pillsbury: USGS (1964) and Geosyntec (2020). The USGS (1964) data includes 26 density samples collected with a calibrated density probe and 26 grain size samples collected with a boat-mounted split-core sampler; each of the instruments penetrated to only shallow depths within the deposits. The dry density (dry mass per bulk volume) of the USGS samples ranged from 41–87 lb ft^{-3} (1,096–2,349 lb yd^{-3}). The median grain size ranged from 0.0031 to 0.32 mm, with a median value of 0.011 mm (Figure 7). Approximately 34% of the deposit that was sampled was composed of sand sized-particles (0.0625–2 mm), and the rest was primarily silt and clay (i.e., finer than 0.0625 mm). The Geosyntec (2020) sampling did not provide dry-density and grain-size data, but the fractions of silt and clay data from the samples was consistent with the USGS (1964) data.

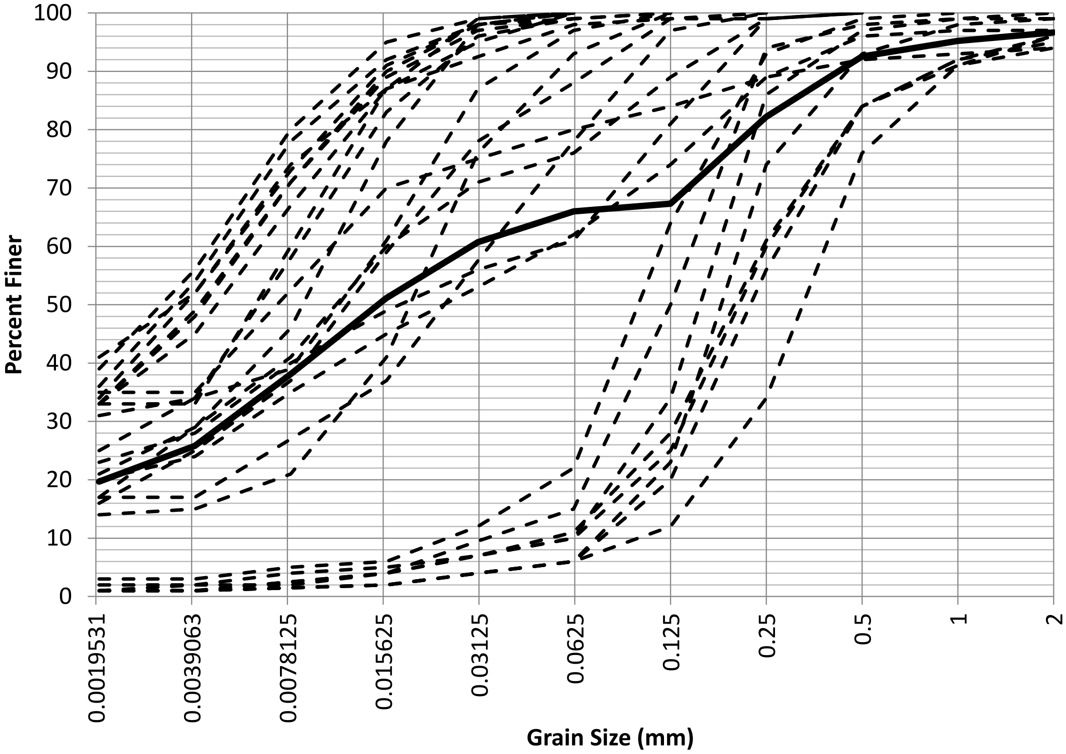


Figure 7. Grain size distributions of reservoir sediment samples collected by the USGS in 1964 (dashed lines); the solid line indicates the average of all the 26 samples.

Both existing data sets describing bulk sediment properties in Lake Pillsbury are comprised of samples collected from a small number of select locations within the reservoir and at shallow depths within the sediment deposits. The sampling methods bias the results toward the finer fractions and are generally insufficient to characterize the area and/or depth weighted bulk sediment properties of the reservoir sediment deposit. Additional investigation and sampling of sediment deposits in Lake Pillsbury and the bulk properties of channel bed material in major tributaries to the reservoir is proposed as part of the Study AQ 4 - Fluvial Processes and Geomorphology and Study AQ 12 - Scott Dam Removal to be implemented during FERC Project relicensing. The results from these future studies will be used to refine estimates of mass sediment yield and to partition yield into relevant grain size fractions.

Reservoir trap efficiency is influenced by sediment transport processes within the reservoir, particle-size distribution of the incoming sediment, the mean flow velocity through the impoundment, and the average length of time water is impounded. These variables were not measured in Lake Pillsbury. In lieu of this information, this analysis used a trap efficiency of 0.94 reported for Lake Pillsbury in Porterfield and Dunnam (1964) based on the relationship developed by Brown and Thorpe (1947) that relates trap efficiency to storage capacity per square mile of drainage basin.

The results of the reservoir sedimentation analysis indicate 20,369,000 cu yds of volume change in Lake Pillsbury attributable to sediment accumulation (Table 3). The estimated average annual sedimentation rate and sediment yield during the period 1922–2015 is 216,691 $yd^3\ y^{-1}$ (134.1 ac-ft y^{-1}) and 227,180 t y^{-1}, respectively (Table 3). The estimated average annual unit-area sediment yield from the connected source area to the reservoir (288 mi^2) during this period is 789 t $mi^{-2}y^{-1}$. Isopach contours of sediment thickness determined by surface differencing were also used to assess the spatial distribution and depth of sediment accumulated in the reservoir and the relative sediment contributions from different source areas (Figures 8 and 9).

Table 3. Sediment yield to Lake Pillsbury based on reservoir sedimentation.

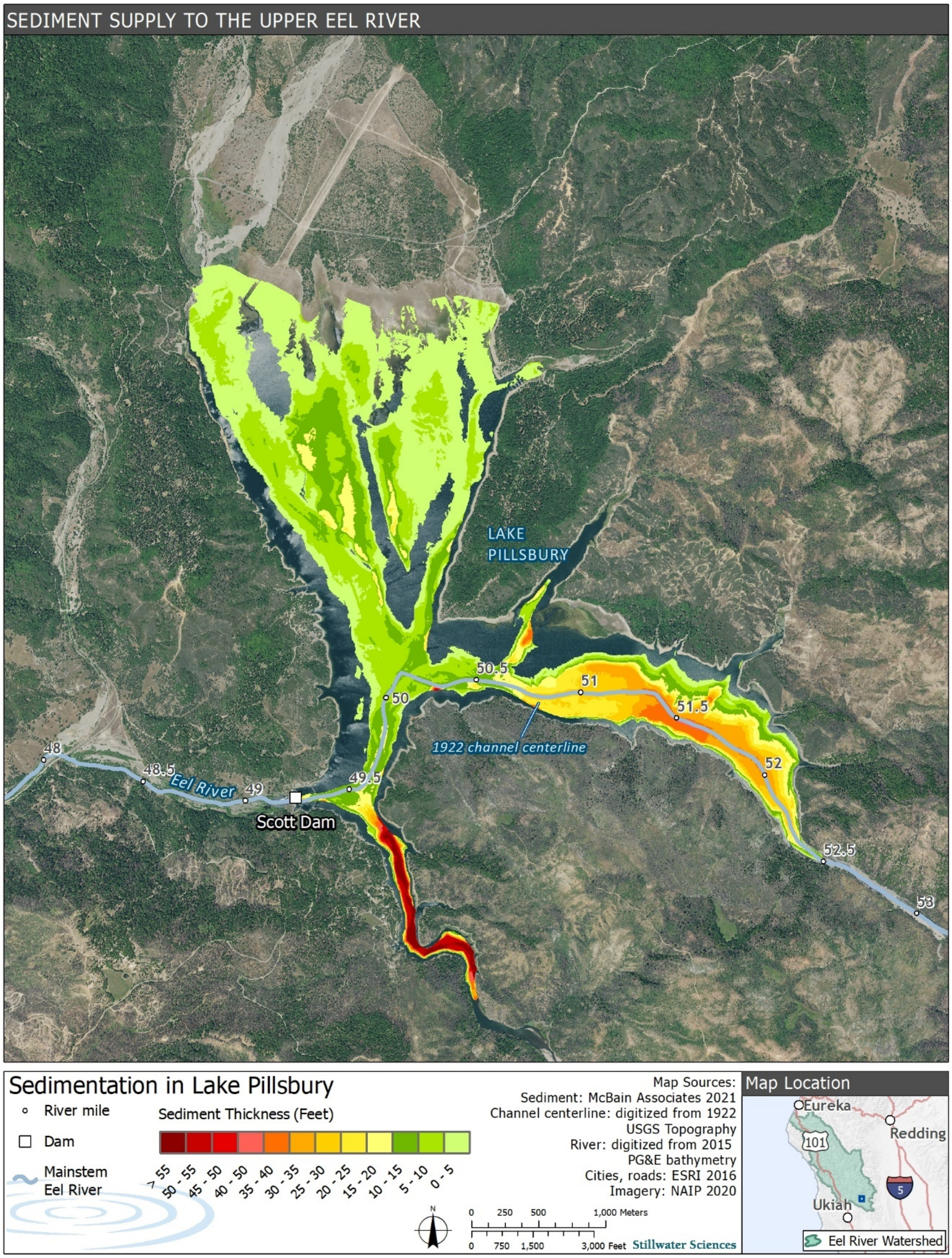
Date	**Reservoir storage capacity**[2]	**Sediment volume accumulated over interval**		**Sediment volume accumulated over cumulative period**		**Average annual sediment yield over interval**[3,4]		**Average annual sediment yield over cumulative period**	
	ac ft	**yd^3**	**$yd^3\ y^{-1}$**	**yd^3**	**$yd^3\ y^{-1}$**	**$t\ y^{-1}$**	**$t\ mi^{-2}\ y^{-1}$**	**$t\ y^{-1}$**	**$t\ mi^{-2}\ y^{-1}$**
1922[1]	94,400	--	--	--	--	--	--	--	--
1959	86,780	12,293,600	323,516	12,293,600	323,516	339,175	1,178	339,175	1,178
1984	80,700	9,809,067	377,272	22,102,667	350,836	395,533	1,373	367,818	1,277
2005	74,993	9,207,616	418,528	31,310,283	372,741	438,787	1,524	390,784	1,357
2015	--	--	--	20,369,000	216,691	--	--	227,180	789

[1] Construction of Scott Dam was completed in 1922.

[2] Reservoir storage capacity calculated from top of gates (1910 ft PG&E datum, 1823.3 ft. USGS datum).

[3] Drainage area upstream of Scott Dam = 288 mi^2

[4] Assumes sediment density of 73 lb ft^{-3} and trap efficiency of 0.94 (Porterfield and Dunnam 1964).



Map Sources:
Sediment: McBain Associates 2021
Channel centerline: digitized from 1922
USGS Topography
River: digitized from 2015
PG&E bathymetry
Cities, roads: ESRI 2016
Imagery: NAIP 2020

Figure 8. Isopach map of sedimentation in Lake Pillsbury, 1922–2015.

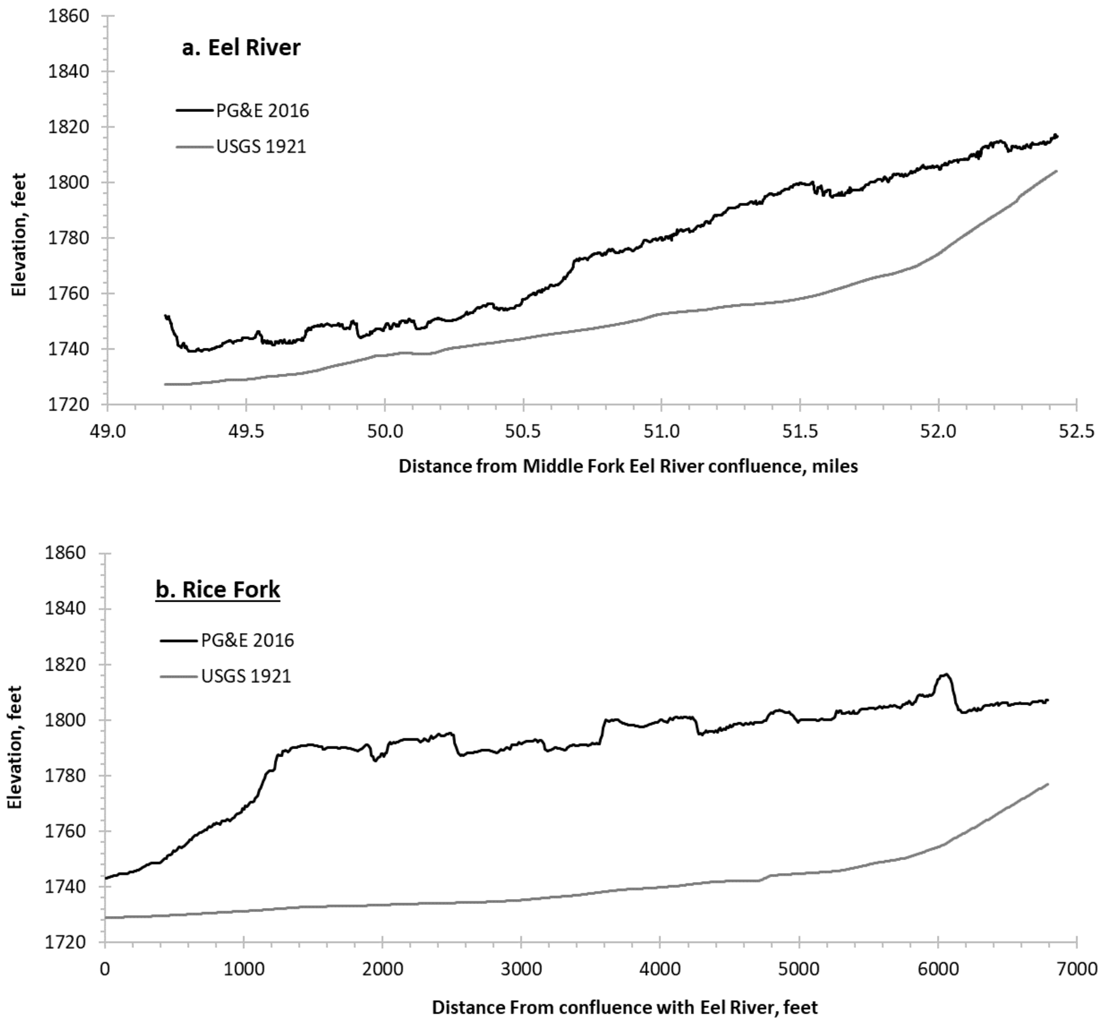


Figure 9. Longitudinal profiles of the Eel River (a) and Rice Fork (b) within Lake Pillsbury.

3.2.2 Sedimentation in Van Arsdale Reservoir

In response to FERC concerns over coarse sediment deposition in the vicinity of the intake to the Van Arsdale Diversion tunnel and associated fish screen at Cape Horn Dam, PG&E evaluated sedimentation in the Van Arsdale impoundment (PG&E 2005). The study analyzed reservoir sediment characteristics, sediment transport, and estimated sediment yield to the impoundment. Results of the study indicated that filling of reservoir accommodation space with predominantly coarse sediment resulted in low trap efficiency, with most incoming sediment transported through the impoundment and past Cape Horn Dam. Fine gravel (3–6 mm) transports through the impoundment under annual flow events, and medium gravel (8–16 mm) transports through the reservoir during flows with a 2- to 5-year recurrence. PG&E estimated that minimum coarse sediment deposition rates averaged approximately 5,000 t y^{-1} (81 t mi^2 y^{-1}), and minimum total sediment yield (i.e., coarse and fine) to the impoundment ranged from 407 to 814 t mi^{-2} y^{-1}. These minimum estimates assume that bedload was deposited in the reservoir during high flow events that occurred during 1993, 1995, 1997, and 1998; reservoir sediment deposits are approximately 10–20% of the total load and have a density of 1.17 t m^{-3}; and sediment delivered to the impoundment was supplied from the 61 mi^2 source area downstream of Scott Dam. The report indicated that Soda Creek, located approximately 10 miles upstream of Cape Horn Dam, is a major source of coarse sediment delivered to Van Arsdale Reservoir.

3.3 Sediment Load

The USGS measured discharge and suspended sediment concentration at a network of gaging stations located in the mainstem and major tributaries of the Eel River watershed (Table 4). In their seminal 1971 Water-Supply Paper, Brown and Ritter use these data to compute suspended sediment loads from the major Eel River subbasin areas defined by the USGS gaging stations. Brown and Ritter (1971) estimated that during the 10-year period from 1958 to 1967, which included the largest flood of record in December 1964, the Eel River at Scotia (3,113 mi^2) discharged an average suspended load of about 31,390,000 t yr^{-1} (10,084 t mi^{-2} y^{-1}) (Table 4). The extremely high erosion and sediment transport rates estimated by Brown and Ritter (1971) for the Eel River during this period were attributed to the severe erosion impacts of the 1964 flood event in combination with rapid uplift and tectonic deformation, erosive bedrock, and anthropogenic disturbance (e.g., mechanized timber harvest, road construction, and settlement). Brown and Ritter (1971) estimated that the Upper Eel River above the Middle Fork Eel River confluence contributed about 6.6% (2,938 t mi^{-2} y^{-1}) of the annual suspended load at Scotia during this period. The smaller load in the Upper Eel River relative to other areas in the watershed was attributed primarily to more competent geology, less extensive land use change related to mechanized logging and road building, and sediment trapping in Lake Pillsbury.

Warrick (2014) reevaluated the historical record of discharge and suspended sediment concentration at the USGS Scotia gage (No 11477000), finding that sediment discharge relationships varied strongly with time and included substantial decreases in suspended sediment concentrations during the latter 20th century following the increases in sediment output during water years 1955 and 1965. To account for these variations in suspended sediment concentrations over time, Warrick (2014) recomputed suspended sediment discharge by applying time-dependent correction factors to the suspended sediment discharge rating curve over the period of record, and using this approach, estimated the average annual discharge from the basin to the Eel River margin for the period 1911–2000 to be 3,614 t mi^{-2} y^{-1} (Table 4).

Table 4. Summary of suspended sediment load estimates at stations in the Eel River and major tributaries.

Location	**USGS gage no.**	**Period**	**Drainage area, mi^2**	**Suspended load**	
				t y^{-1}	**t mi^{-2} y^{-1}**
Mainstem Eel River above Dos Rios[1]	11472500	1958–1965	705	2,071,000	2,938
Black Butte River near Covelo[1]	11472900	1966–1967	162	702,100	4,334
Middle Fork Eel River below Black Butte River [1]	11473000	1963–1967	367	2,983,000	8,128
Middle Fork Eel River near Dos Rios[1]	11473900	1958–1967	745	4,245,000	5,698
Eel River at Fort Seward[1]	11475000	1966–1967	2,107	14,600,000	6,929
South Fork Eel River near Miranda[1]	11476500	1958–1962	537	1,774,000	3,304
Eel River at Scotia[1]	11477000	1958–1967	3,113	31,390,000	10,084
Eel River at Scotia[2]	11477000	1911–2000	3,113	11,251,223	3,614
Van Duzen near Bridgeville[1]	11478000	1958–1967	216	1,557,000	7,208
Eel River discharge to the Pacific Ocean[2]	--	1911–2000	3,629	13,117,489	3,614

[1] Estimates by Brown and Ritter (1971) based on time-stationary sediment rating curves.

[2] Estimates by Warrick (2014) based on time-dependent sediment rating curves.

3.4 Cumulative Sediment Supply to the Upper Eel River

Cumulative average annual sediment supply to key locations (sediment supply nodes) along the Upper Eel River from the headwaters downstream to the Middle Fork confluence was estimated using four methods (Table 5 and Figure 10):

1. Applying the total estimated unit-area sediment delivery rate of 466 t mi^{-2} y^{-1} for the Upper Eel River basin reported in the Upper Eel River TMDL for the period 1940–2004;
2. Applying terrane-specific unit-area sediment delivery rates reported in the Upper Eel River TMDL for the period 1940–2004 (Appendix A);
3. Applying the estimated average annual unit-area sediment yield of 789 t mi^{-2} y^{-1} from the connected source area to Lake Pillsbury during for the period 1922–2015; and
4. Applying the average of the three methods above.

Sediment supply estimates were summed for each nodal subbasin area and the totals for each node were then summed cumulatively from upstream to downstream.

Table 5. Cumulative sediment supply to the Eel River upstream of the Middle Fork Eel River confluence.

Subbasin	**Mainstem river mile (RM)**	**Cumulative source area, mi^2**	**Cumulative sediment supply, tons y^{-1}**			
			Based on total unit area sediment delivery rate, 1940–2004	**Based on terrane specific unit-area delivery rates, 1940–2004**	**Based on sedimentation rate in Lake Pillsbury, 1922–2015**	**Average**
Eel River upstream of Lake Pillsbury	54.13	140	65,036	81,165	110,052	85,418
Salmon Creek and Smokehouse Creek upstream of Lake Pillsbury	50.03	168	78,130	96,353	132,208	102,230
Rice Fork upstream of Lake Pillsbury	49.54	255	118,804	146,961	201,037	155,601
Eel River, Lake Pillsbury to Scott Dam	49.21	287	133,884	162,955	226,553	174,464
Soda Creek	48.1	301	140,176	170,114	237,201	182,497
Benmore Creek	47.05	306	142,677	173,298	241,434	185,803
Bucknell Creek	41.94	324	151,172	183,486	255,808	196,822
Cape Horn Dam	37.22	347	161,926	196,228	274,006	210,720
Cape Horn Dam to Tomki Creek	33.63	358	167,100	201,966	282,760	217,275
Tomki Creek	33.63	422	196,888	240,782	333,167	256,946
Tomki Creek to Thomas Creek	29.57	432	201,201	246,846	340,465	262,837
Thomas Creek	29.57	446	207,800	254,818	351,633	271,417
Thomas Creek to Garcia Creek	27.86	448	208,826	256,072	353,368	272,755
Garcia Creek	27.86	460	214,578	263,231	363,101	280,303
Garcia Creek to Salt Creek	25.17	464	216,414	265,645	366,209	282,756
Salt Creek	25.17	472	220,010	270,609	372,293	287,637
Salt Creek to Twin Bridges	19.4	477	222,478	273,663	376,469	290,870
Twin Bridges Creek	19.4	487	227,230	280,100	384,511	297,280
Twin Bridges Creek to Fish Creek	14.67	498	231,961	286,662	392,516	303,713
Fish Creek	14.67	503	234,593	290,232	396,969	307,265
Fish Creek to Indian Creek	10.27	512	238,611	295,620	403,769	312,667
Indian Creek	10.27	519	241,712	299,786	409,017	316,838
Indian Creek to Outlet Creek	6.84	527	245,460	305,043	415,359	321,954
Outlet Creek	6.84	689	320,990	394,253	543,168	419,471
Outlet Creek to Middle Fork Eel River	0.00	707	329,529	404,882	557,617	430,676

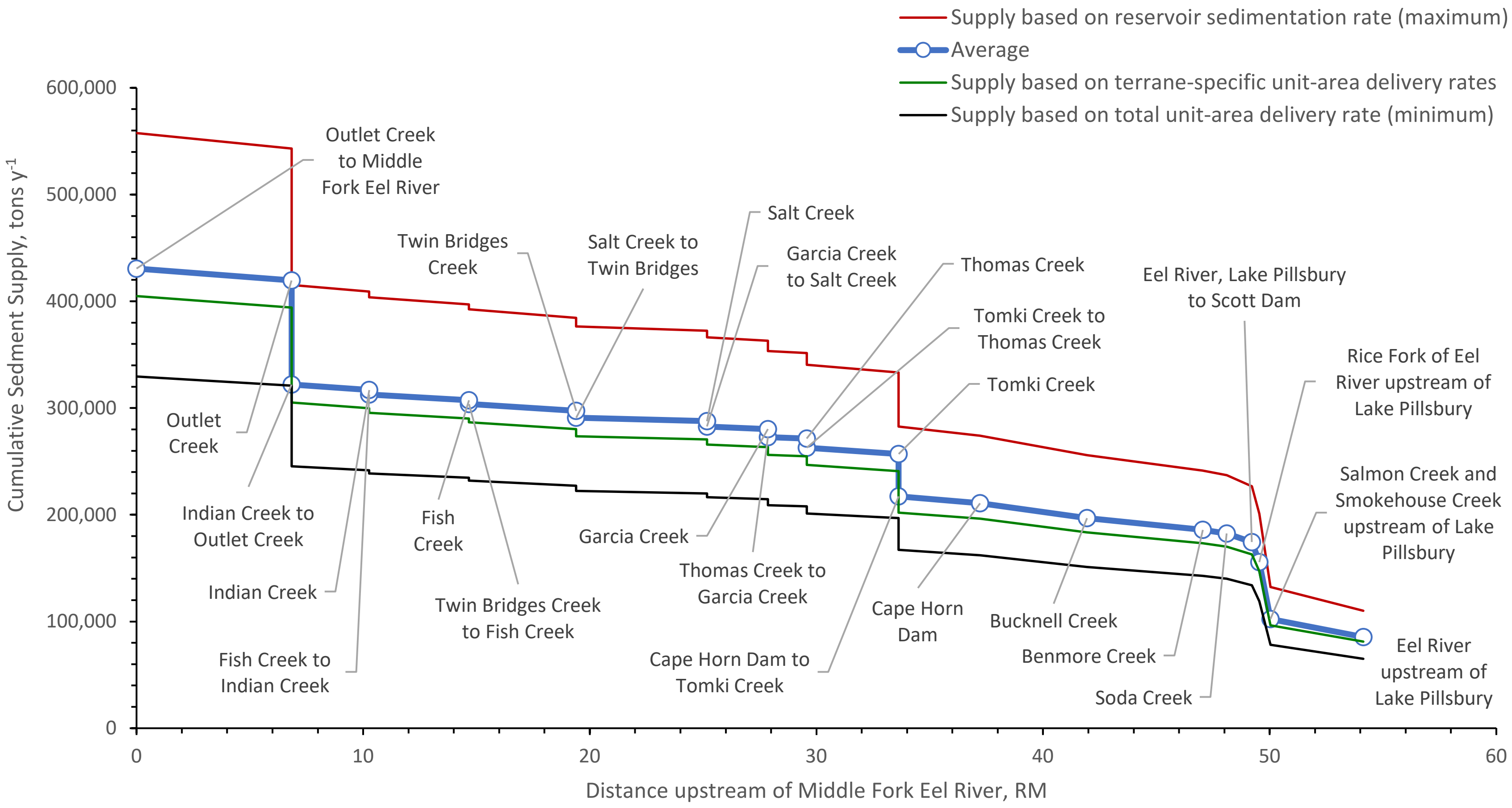


Figure 10. Longitudinal profile of cumulative sediment supply to the Upper Eel River.

4 DATA GAPS AND UNCERTAINTIES

Important aspects of the spatial and temporal variability in sediment supply to the Upper Eel River are not described well by the existing available data and approach. These limitations are related to several key data gaps and uncertainties discussed below.

Site-specific landforms, hillslope morphology, and surface processes are considered at only a coarse level by applying unit-area sediment supply rates to geologic terranes, and therefore, the estimates reported herein do not accurately differentiate sediment supply from basins with similar geologic terranes but differing occurrence and density of active erosion features. Soda Creek, for example, is known to deliver a large quantity of sediment to the Eel River through episodic debris flows and infrequent bedload transport of transient coarse sediment deposits in storage, however, the unit-area approach does not account well for the high rate of sediment production and yield associated with the unique surface processes and landforms in this basin relative to adjacent subbasins that occur predominantly within the same geologic terranes. More detailed assessment of sediment delivery rates from active erosion features within key source areas would help improve understanding of the spatial variability in sediment supply to the Upper Eel River.

Annual and inter-annual climate variability strongly influences erosion and sediment delivery rates and loads that are not described using average annual sediment supply rates. Work by PG&E related to sedimentation in the Van Arsdale Diversion impoundment and analyses of suspended sediment load at USGS gaging stations highlights the variable nature of sediment supply and transport within the Eel River. Measurements of discharge and suspended sediment concentrations at key locations with the Project area, and calculation of sediment loads based on time-dependent sediment rating curves developed from these data, would improve understanding of the temporal variability in sediment supply rates.

The disturbance history (floods, fires, and legacy land use) and the trajectory of recovery from disturbances in a drainage basin also strongly influence annual and inter-annual variability in erosion processes, sediment delivery rates, and sediment load. The Ranch Fire that burned large portions of the upper watershed in 2018 and the August Complex Fire that burned large portions of the upper watershed in 2020, for example, have had and will likely continue to have large, important effects on erosion processes and sediment supply rates. Incorporation of field mapping and/or modeling of erosion and sediment delivery from burned areas over time would improve understanding of these disturbance effects.

Lastly, the lack of information related to the stratigraphy and bulk sediment properties (e.g., density and grain size distribution) of sediment stored in Lake Pillsbury and other sediment sources to the mainstem Eel River downstream of the Scott Dam leads to limitations and uncertainties in estimating mass sediment supply by grain size classes that are relevant to modeling the potential geomorphic and aquatic ecosystem responses to dam removal and sediment management alternatives. Additional coring investigation and sampling of sediment deposits in Lake Pillsbury (e.g., bulk sediment properties and stratigraphy related to flood and disturbance history) and channel bed material in major tributaries to the upper Eel River proposed as part of Study AQ 4 - Fluvial Processes and Geomorphology and Study AQ 12 - Scott Dam Removal will help refine estimates of mass sediment yield, better understand annual and interannual variability in sediment yields, and partition yield into relevant grain size fractions.

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Appendix A

Cumulative Sediment Supply to the Eel River Upstream of the Middle Fork Eel River Confluence Based on Total Maximum Daily Load Estimates of Unit Area Sediment Delivery Rate by Geologic Terrane Type

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Mainstem Eel River upstream of Lake Pillsbury	1	b	USGS	1	562	0.0	4
		c	USGS	5	377	0.0	15
		cy	USGS	1	562	0.1	54
		db	USGS	5	377	0.0	4
		dsm	USGS	5	377	0.1	41
		fcm	USGS	2	737	31.2	22,984
		fmp	USGS	1	562	0.1	40
		fpp	USGS	1	562	67.1	37,745
		fys	USGS	1	562	25.5	14,306
		Josp	USGS	1	562	0.7	397
		KJs	USGS	4	565	0.2	130
		miy	USGS	5	377	0.0	2
		psm	USGS	5	377	0.3	95
		Qal	USGS	3	324	0.0	10
		Qls	USGS	3	324	2.4	777
		Qt	USGS	3	324	0.0	4
		Qto	USGS	3	324	0.0	0
		ss	USGS	4	565	0.0	2
		ssm	USGS	1	562	0.4	224
		un	USGS	5	377	0.0	9
		v	USGS	5	377	0.3	104
		vpp	USGS	1	562	0.2	131
		vsm	USGS	5	377	10.8	4,085
		vy	USGS	1	562	0.0	3
		Subtotal				**139.5**	**81,165**
Salmon Creek and Smokehouse Creek	2	cy	USGS	1	562	0.0	10
		fcm	USGS	2	737	1.5	1,100
		fys	USGS	1	562	22.8	12,825
		Josp	USGS	1	562	0.1	81
		Qal	USGS	3	324	0.2	55
		Qfo	USGS	3	324	0.3	104
		Qfvo	USGS	3	324	0.0	3
		Qfy	USGS	3	324	0.5	147
		Qls	USGS	3	324	2.4	768
		Qoa	USGS	3	324	0.0	6
		Qt	USGS	3	324	0.0	2
		Qto	USGS	3	324	0.1	45
		Qtvo	USGS	3	324	0.1	30
		Qty	USGS	3	324	0.0	9
		vy	USGS	1	562	0.0	1
		Subtotal				**28.1**	**15,188**

Subbasin	**Sediment supply node**	**Geologic unit**	**Source data**	**Delivery rate class**	**Unit-area delivery rate, t mi^{-2} yr^{-1}**	**Area, mi^2**	**Sediment Supply, t y^{-1}**
Rice Fork of the Eel River	3	by	USGS	1	562	0.1	80
		cy	USGS	1	562	0.1	37
		fcm	USGS	2	737	1.9	1,415
		fcm?	USGS	2	737	2.2	1,597
		fpp	USGS	1	562	1.5	867
		fpp?	USGS	1	562	0.0	7
		fym	USGS	2	737	12.3	9,093
		fys	USGS	1	562	37.8	21,234
		Josp	USGS	1	562	2.5	1,406
		KJom	USGS	2	737	12.2	9,004
		Kul	USGS	4	565	0.1	59
		miy	USGS	5	377	0.0	10
		omun	USGS	5	377	0.0	4
		omv	USGS	5	377	0.1	51
		psm	USGS	5	377	0.2	81
		Qal	USGS	3	324	0.6	186
		Qfo	USGS	3	324	0.3	83
		Qfy	USGS	3	324	0.0	4
		Qls	USGS	3	324	7.1	2,309
		Qoa	USGS	3	324	0.1	31
		Qt	USGS	3	324	0.2	80
		Qtvo	USGS	3	324	0.0	11
		Qty	USGS	3	324	0.0	7
		ssm	USGS	1	562	0.0	10
		Tep	USGS	4	565	0.2	98
		v	USGS	5	377	0.1	41
		vsm	USGS	5	377	7.4	2,787
		vy	USGS	1	562	0.0	15
		Subtotal				**87.3**	**50,609**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Maintem Eel River upstream of Lake Pillsbury to Scott Dam	4	af	USGS	3	324	0.0	0
		cy	USGS	1	562	0.0	6
		fcm	USGS	2	737	1.0	704
		fcm?	USGS	2	737	0.0	21
		fpp	USGS	1	562	0.2	93
		fym	USGS	2	737	0.5	333
		fys	USGS	1	562	19.5	10,989
		Josp	USGS	1	562	1.8	988
		KJom	USGS	2	737	1.8	1,323
		omv	USGS	5	377	0.1	21
		Qal	USGS	3	324	0.4	120
		Qfo	USGS	3	324	0.8	257
		Qfvo	USGS	3	324	0.2	53
		Qfy	USGS	3	324	0.6	193
		Qls	USGS	3	324	0.9	295
		Qoa	USGS	3	324	1.4	459
		Qt	USGS	3	324	0.0	2
		Qto	USGS	3	324	0.3	106
		Qtvo	USGS	3	324	0.1	21
		Qty	USGS	3	324	0.0	1
		uny	USGS	0	0	0.0	0
		vy	USGS	1	562	0.0	8
		water	USGS	0	0	2.9	0
		Subtotal				**32.3**	**15,993**
Soda Creek	5	af	USGS	3	324	0.0	1
		fcm	USGS	2	737	1.0	723
		fys	USGS	1	562	8.4	4,719
		Josp	USGS	1	562	0.1	63
		KJom	USGS	2	737	0.2	157
		Kl	USGS	4	565	0.5	291
		Ku	USGS	4	565	0.5	310
		omv	USGS	5	377	0.2	82
		Qal	USGS	3	324	0.1	32
		Qfy	USGS	3	324	0.1	18
		Qls	USGS	3	324	1.9	606
		Qoa	USGS	3	324	0.4	129
		Qto	USGS	3	324	0.0	7
		Qtvo	USGS	3	324	0.1	22
		Subtotal				**13.5**	**7,159**
Benmore Creek	6	fcm	USGS	2	737	1.0	755
		fys	USGS	1	562	4.3	2,403
		Josp	USGS	1	562	0.0	9
		omv	USGS	5	377	0.0	4
		Qal	USGS	3	324	0.0	2
		Qls	USGS	3	324	0.0	11
		Subtotal				**5.4**	**3,184**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Bucknell Creek	7	by	USGS	1	562	0.0	1
		cy	USGS	1	562	0.0	2
		fcm	USGS	2	737	0.6	438
		fym	USGS	2	737	0.0	8
		fys	USGS	1	562	12.7	7,118
		Josp	USGS	1	562	0.0	10
		Kl	USGS	4	565	1.2	701
		Ku	USGS	4	565	2.8	1,581
		Kuls	USGS	4	565	0.0	5
		Qf	USGS	3	324	0.0	8
		Qls	USGS	3	324	0.7	224
		Qty	USGS	3	324	0.0	3
		Tep	USGS	4	565	0.2	89
		vy	USGS	1	562	0.0	2
		Subtotal				**18.2**	**10,188**
Cape Horn Dam	8	af	USGS	3	324	0.0	1
		c	USGS	5	377	0.0	11
		db	USGS	5	377	0.0	14
		fcm	USGS	2	737	4.5	3,326
		fys	USGS	1	562	3.6	2,033
		Josp	USGS	1	562	0.2	95
		KJom	USGS	2	737	0.2	153
		Kl	USGS	4	565	1.5	863
		Klc	USGS	4	565	0.0	1
		Ku	USGS	4	565	8.4	4,722
		Kuls	USGS	4	565	0.0	2
		omc	USGS	5	377	0.0	2
		omv	USGS	5	377	0.0	2
		Qal	USGS	3	324	0.3	89
		Qfy	USGS	3	324	0.0	9
		Qls	USGS	3	324	3.2	1,023
		Qoa	USGS	3	324	0.2	50
		Qsn	USGS	5	377	0.0	0
		Qt	USGS	3	324	0.3	103
		Qto	USGS	3	324	0.1	20
		Qtvo	USGS	3	324	0.0	8
		Qty	USGS	3	324	0.1	32
		spo	USGS	4	565	0.0	10
		vpo	USGS	5	377	0.5	173
		vy	USGS	1	562	0.0	1
		Subtotal				**23.1**	**12,742**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Cape Horn Dam to Tomki Creek	9	c	USGS	5	377	0.0	0
		fcm	USGS	2	737	0.2	164
		Josp	USGS	1	562	0.2	132
		Kl	USGS	4	565	0.4	239
		Klc	USGS	4	565	0.0	5
		Ku	USGS	4	565	7.4	4,183
		Qfy	USGS	3	324	0.3	103
		Qls	USGS	3	324	0.2	64
		Qt	USGS	3	324	0.1	34
		Qtvo	USGS	3	324	0.0	4
		Qty	USGS	3	324	0.2	58
		vpo	USGS	5	377	2.0	750
		Subtotal				**11.1**	**5,737**
Tomki Creek	10	b	USGS	1	562	0.0	8
		c	USGS	5	377	0.0	11
		cgl	USGS	4	565	0.1	42
		fcm	USGS	2	737	17.8	13,098
		fys	USGS	1	562	1.8	985
		Josp	USGS	1	562	0.5	288
		KJf	CAGeo	4	565	31.1	17,583
		Ku	USGS	4	565	0.0	1
		Qal	USGS	3	324	0.1	18
		Qls	USGS	3	324	0.3	85
		Qoa	USGS	3	324	0.1	17
		Qt	USGS	3	324	0.0	4
		ss	USGS	4	565	10.9	6,178
		un	USGS	5	377	0.1	42
		v	USGS	5	377	0.0	5
		vpo	USGS	5	377	1.2	450
		Subtotal				**63.9**	**38,816**
Tomki Creek to Thomas Creek	11	fcm	USGS	2	737	5.1	3,768
		Josp	USGS	1	562	0.3	159
		Ku	USGS	4	565	3.7	2,067
		Qfy	USGS	3	324	0.0	2
		Qt	USGS	3	324	0.1	41
		Qty	USGS	3	324	0.0	2
		ss	USGS	4	565	0.0	5
		v	USGS	5	377	0.1	21
		Subtotal				**9.3**	**6,064**
Thomas Creek	12	cy	USGS	1	562	0.2	137
		fcm	USGS	2	737	0.6	459
		fcm?	USGS	2	737	2.2	1,649
		fys	USGS	1	562	7.5	4,217
		Josp	USGS	1	562	0.0	4
		Kl	USGS	4	565	0.0	0
		Ku	USGS	4	565	1.5	840
		Qls	USGS	3	324	2.1	666
		Subtotal				**14.2**	**7,972**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Thomas Creek to Garcia Creek	13	fcm	USGS	2	737	0.5	400
		fcm?	USGS	2	737	0.1	91
		fys	USGS	1	562	0.1	79
		Ku	USGS	4	565	1.0	544
		Qls	USGS	3	324	0.4	139
		Subtotal				**2.2**	**1,254**
Garcia Creek	14	cy	USGS	1	562	0.4	205
		fcm	USGS	2	737	4.3	3,138
		fys	USGS	1	562	5.4	3,012
		Josp	USGS	1	562	0.0	2
		Ku	USGS	4	565	0.1	71
		Qls	USGS	3	324	2.1	669
		un	USGS	5	377	0.0	19
		v	USGS	5	377	0.1	43
		Subtotal				**12.3**	**7,159**
Garcia Creek to Salt Creek	15	fcm	USGS	2	737	2.0	1,502
		Ku	USGS	4	565	0.3	149
		Qls	USGS	3	324	0.3	89
		Qt	USGS	3	324	0.2	67
		Qto	USGS	3	324	0.2	51
		Qty	USGS	3	324	0.0	6
		ss	USGS	4	565	1.0	542
		un	USGS	5	377	0.0	7
		v	USGS	5	377	0.0	1
		Subtotal				**3.9**	**2,414**
Salt Creek	16	fcm	USGS	2	737	3.5	2,593
		KJf	CAGeo	4	565	0.8	426
		ss	USGS	4	565	3.4	1,945
		Subtotal				**7.7**	**4,964**
Salt Creek to Twin Bridges	17	b	USGS	1	562	0.0	3
		fcm	USGS	2	737	1.2	886
		Josp	USGS	1	562	0.0	16
		Qls	USGS	3	324	0.3	89
		Qt	USGS	3	324	0.2	70
		Qto	USGS	3	324	0.1	28
		Qtvo	USGS	3	324	0.0	4
		ss	USGS	4	565	3.5	1,955
		un	USGS	5	377	0.0	3
		Subtotal				**5.3**	**3,054**
Twin Bridges Creek	18	b	USGS	1	562	0.0	4
		fcm	USGS	2	737	6.8	5,019
		Josp	USGS	1	562	0.1	33
		Qls	USGS	3	324	1.9	618
		ss	USGS	4	565	1.2	691
		un	USGS	5	377	0.0	13
		v	USGS	5	377	0.2	59
		Subtotal				**10.2**	**6,437**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
T`win Bridges Creek to Fish Creek	19	b	USGS	1	562	0.0	14
		fcm	USGS	2	737	5.9	4,330
		Qls	USGS	3	324	0.5	177
		Qt	USGS	3	324	0.1	17
		Qtvo	USGS	3	324	0.1	24
		ss	USGS	4	565	3.5	1,956
		un	USGS	5	377	0.1	43
		Subtotal				**10.1**	**6,562**
Fish Creek	20	b	USGS	1	562	0.0	8
		c	USGS	5	377	0.0	8
		cmg?	USGS	5	377	0.0	12
		fcm	USGS	2	737	2.6	1,886
		Josp	USGS	1	562	0.0	5
		ss	USGS	4	565	2.7	1,551
		un	USGS	5	377	0.0	4
		v	USGS	5	377	0.0	14
		vmg?	USGS	5	377	0.2	83
		Subtotal				**5.6**	**3,571**
Fish Creek to Indian Creek	21	b	USGS	1	562	0.0	17
		c	USGS	5	377	0.0	1
		cgl	USGS	4	565	0.3	159
		fcm	USGS	2	737	3.5	2,604
		Josp	USGS	1	562	0.0	11
		Qls	USGS	3	324	0.3	96
		ss	USGS	4	565	4.4	2,459
		un	USGS	5	377	0.1	27
		v	USGS	5	377	0.0	13
		Subtotal				**8.6**	**5,388**
Indian Creek	22	b	USGS	1	562	0.0	10
		c	USGS	5	377	0.1	24
		cgl	USGS	4	565	0.0	2
		cmg?	USGS	5	377	0.1	32
		fcm	USGS	2	737	3.4	2,480
		Josp	USGS	1	562	0.1	72
		Qls	USGS	3	324	0.3	109
		ss	USGS	4	565	2.3	1,311
		v	USGS	5	377	0.1	55
		vmg?	USGS	5	377	0.2	73
		Subtotal				**6.7**	**4,166**
Indian Creek to Outlet Creek	23	b	USGS	1	562	0.0	18
		c	USGS	5	377	0.0	7
		fcm	USGS	2	737	5.6	4,128
		Josp	USGS	1	562	0.2	114
		Qls	USGS	3	324	0.9	300
		ss	USGS	4	565	1.1	646
		un	USGS	5	377	0.0	16
		v	USGS	5	377	0.1	28
		Subtotal				**8.0**	**5,258**

Subbasin	Sediment supply node	Geologic unit	Source data	Delivery rate class	Unit-area delivery rate, t mi^{-2} yr^{-1}	Area, mi^2	Sediment Supply, t y^{-1}
Outlet Creek	24	b	USGS	1	562	0.0	2
		fcm	USGS	2	737	4.5	3,286
		fys	USGS	1	562	0.4	218
		KJf	CAGeo	4	565	104.8	59,243
		Q	CAGeo	3	324	12.4	4,011
		Qls	USGS	3	324	0.5	154
		QPc	CAGeo	4	565	4.6	2,595
		ss	USGS	4	565	8.3	4,704
		TK	CAGeo	4	565	26.5	14,990
		un	USGS	5	377	0.0	7
		Subtotal				**162.0**	**89,210**
Outlet Creek to Middle Fork Eel River	25	b	USGS	1	562	0.0	1
		c	USGS	5	377	0.0	3
		fcm	USGS	2	737	5.7	4,206
		fys	USGS	1	562	0.1	67
		Josp	USGS	1	562	0.2	130
		KJf	CAGeo	4	565	2.2	1,251
		Qls	USGS	3	324	2.1	677
		ss	USGS	4	565	6.9	3,898
		v	USGS	5	377	1.0	395
		Subtotal				**18.3**	**10,629**
Total						**706.9**	**404,882**