Ralston Afterbay
Sediment Management Project
Indian Bar Pilot Project

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Introduction and Background

PCWA operates a series of reservoirs and powerhouses as part of the American River Hydroelectric Project on the Middle Fork American River (MFAR) and Rubicon Rivers (Middle Fork Project) in the central Sierra Nevada watershed. The proposed project is located on the border of Placer and El Dorado Counties, in both the Tahoe and El Dorado National Forests. Ralston Afterbay Reservoir (Afterbay) is about 5 miles east of Foresthill, California, or 11 miles by road (figure 1). PCWA issued and adopted an Initial Study/Mitigated Negative Declaration for the Ralston Afterbay Sediment Management Project in August 2001.

The primary purpose of the sediment management project is to create sediment storage capacity within Afterbay, maintain operational flexibility of Ralston Dam and Oxbow Powerhouse, and delay the complete sedimentation of Afterbay. A secondary objective is to restore natural migration of coarse and fine sediment in the MFAR downstream of Ralston Dam. The sediment poses a threat to the reliability of power generation at Ralston Powerhouse. The sediment will be placed downstream of the dam on a 1.96-acre portion of Indian Bar.

The sediment management project consists of 2 independent components. In the first component, PCWA proposes to remove sediment at the upstream end of Afterbay. Approximately 75,000–100,000 cubic yards of sediment will be removed from the reservoir, and about 48,000 yards will be stored downstream of the dam on a 1.96-acre portion of Indian Bar. The remaining 27,000–52,000 cubic yards of material will be transported to the agency's permitted site at Ralston Ridge. The second component of the project consists of reoperating Ralston Dam during high-flow events and allowing finer sediment to pass through the dam's low-level outlet gate. The *sediment-pass-through*

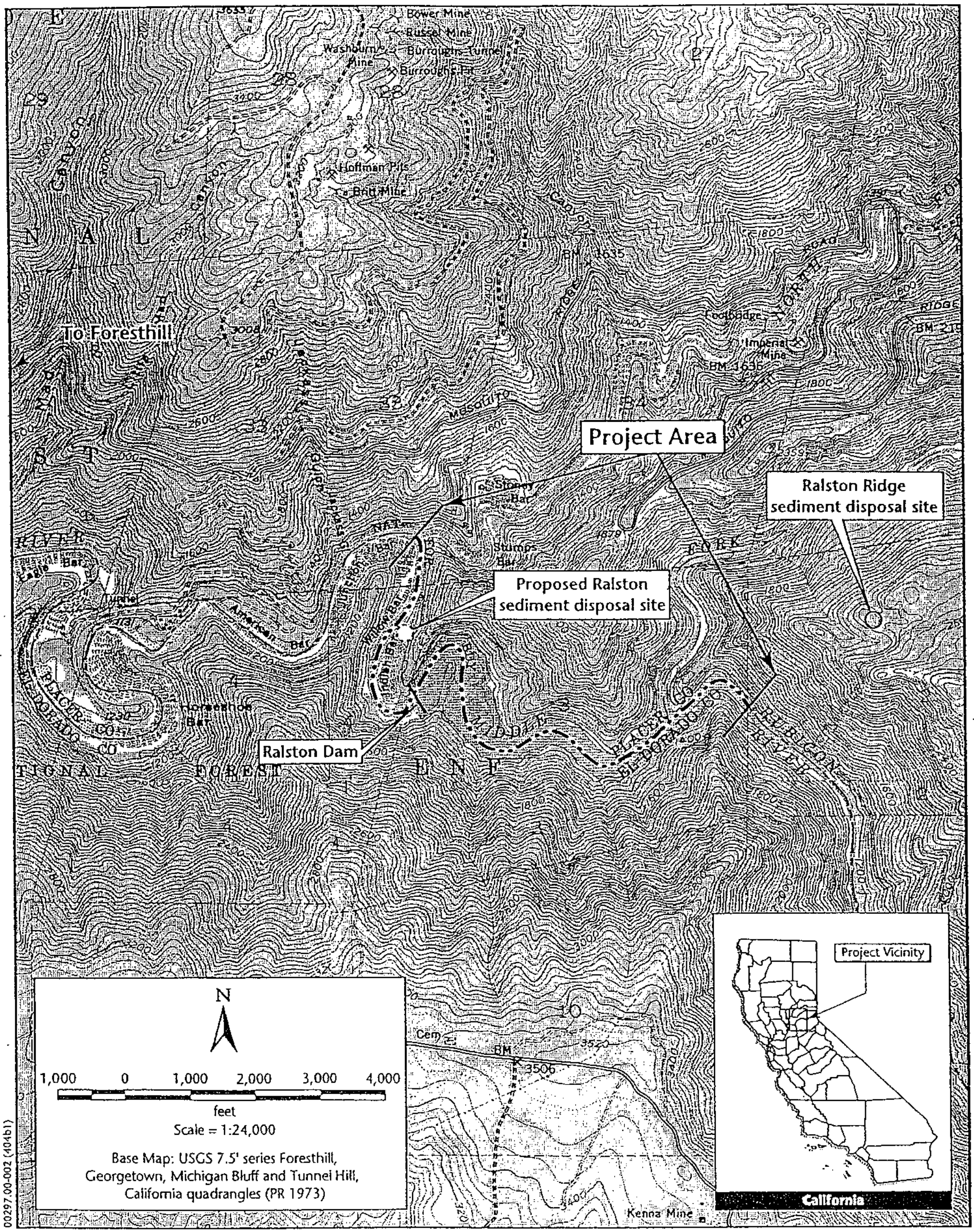

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Figure 1
Vicinity Map

(SPT) operations would be conducted whenever river flows exceed approximately 3,500 cubic feet per second (cfs).

PCWA has consulted with state and federal resource agencies during the CEQA phase and has initiated several meetings with California Department of Fish and Game (DFG), United States Fish and Wildlife Service (USFWS), Federal Energy Regulatory Commission (FERC) and both the Tahoe National Forest (TNF) and El Dorado National Forest (EDNF). PCWA invited agency representatives to an escorted tour of the project facilities in February 2001 to visit the proposed placement site and to learn more about the proposed sediment management project. PCWA also conducted several subsequent meetings in 2001 and early 2002 with technical staff and district rangers from the EDNF and TNF to maintain dialogue and provide a forum for discussing concerns and issues.

The proposed project originally involved the proposed placement of approximately 76,000–100,000 cubic yards of material in the area of Indian Bar immediately downstream of Ralston Dam (figure 1). The revised project essentially would place only approximately 48,000 yards on a smaller footprint.

Indian Bar has been used in the past by PCWA, with approval from TNF, as a location for placement of river sediment primarily during emergencies caused by past large storm events. The Indian Bar location is one of several sites being considered for long-term management of sediment in PCWA reservoirs in the watershed. If the pilot project proves successful, other locations along the river will be considered, such as Junction Bar, for similar future sediment reuse activities. The resource agencies involved in the watershed generally recognize that a long-term solution to the sediment issue is needed for continued operation of the Middle Fork Project.

The project's primary objective is to place material in a strategic location along Indian Bar that will allow the MFAR to naturally entrain the sediment during peak winter flows. As material is entrained from the site, new material would be actively placed at Indian Bar or existing material would be moved into the "entrainment zone" for the river to rework and transport sediments downstream. Indian Bar is located on lands within TNF boundaries, but it is also within the FERC boundary for the Middle Fork Project.

During several meetings with TNF and EDNF, concerns were expressed regarding incidental recreation uses of Indian Bar and a desire to maintain those uses with the proposed project. Recreational uses of the MFAR in the Indian Bar area include fishing, picnicking, sunbathing, and other activities. A small sandy beach on the southern end of Indian Bar probably receives the most recreational use (figure 1). According to TNF, the Indian Bar location is one of the few areas on the MFAR where the public can easily access the river to sunbathe, picnic, swim, and fish. TNF recommended that the project should be modified to eliminate placement of sediment in the general area of the beach to maintain these recreational activities at Indian Bar. Specific data on the frequency or magnitude of these recreation uses are not available from TNF, but it is recognized that because of the limited river access, maintaining the existing recreational uses is preferable. The predominant recreational use in the project area is an informal raft-launching area used by commercial rafting companies immediately adjacent to the Oxbow Powerhouse tailrace. According to records obtained from California Department of Parks and Recreation, approximately 20,000 people rafted the MFAR with the commercial rafting companies in 2001 (Tebbe pers. comm.).

Pilot Project Purpose and Objectives

The purpose and objectives of the pilot project are:

- to allow the resource agencies and PCWA scientists to test the project on a small scale and monitor the river downstream to determine whether the project will achieve its goals of enhancing spawning gravels downstream and replenish beaches with needed sand and small gravel;
- to provide an open forum for discussion of pilot project results and to potentially refine the placement site design or modify the river monitoring plan; and
- to minimize the risks and magnitude of adverse effects to the river environment by having a smaller site.

If the pilot project proves to be a success, PCWA will discuss the potential of increasing the original yardage amounts while maintaining or enhancing recreation at Indian Bar. Other locations downstream on the river, such as Junction Bar, may be considered in the future.

In addition, in response to a request made by TNF, State Department of Parks and Recreation, and others, PCWA has also agreed to improve the raft launch area and expand the parking lot to accommodate more vehicles during peak rafting season. In general, the parking lot will be extended to the west to the maximum extent practicable, and a new 400-to-600-square-foot staging area will be created next to the existing launch area to relieve congestion that currently occurs in the rafter put-in area because of tight access. The trail to the put-in site is quite narrow and will be widened by about 6 feet to allow safer and more convenient portage of rafts. The improvements involve simple earthwork and can be accomplished during construction of the project.

The revised smaller project does not have any new significant impacts that would require disclosure under CEQA. The initial study/mitigated negative declaration should be referenced for discussion of environmental impacts and more in-depth information on the long-term monitoring of the MFAR downstream of the project.

Proposed Demonstration Pilot Project

At the request of TNF, PCWA has agreed to conduct a first phase pilot project, reducing the volume of material placed at Indian Bar and avoiding the placement of sediment near the small beach area and its access. Approximately 48,000 cubic yards of dredged material will be placed on a reduced footprint, avoiding the beach area, to maintain recreational use of the beach and access to the river. A map showing plan and cross-sectional views of the smaller placement-site footprint is shown in figure 2. A photo of the Indian Bar area without the project is shown in figure 3, and computerized photosimulation of the final project, based on actual survey data, is shown in figure 4.

The top of the rock pile will be at the same elevation as the current parking lot. The slope of the rock pile near the river's edge will be about 1.5:1–2:1. As shown in figure 2, the site is about 750 feet long and ranges in width from 97 feet to 155 feet. The engineered pile will be its highest at the southern terminus near the dam at an elevation of 1,118 feet and have a gentle slope downstream to elevation 1,111 at its the northern terminus. The average rock depth with this design is about 19 feet.

Sediment Pass Through

The proposed project also includes reoperation of Ralston Dam during high-flow events to allow suspended sediments to be passed through the reservoir to the river downstream, rather than being trapped in the reservoir. Currently, the rate of suspended sediment transport to Ralston Afterbay is estimated to be about 175,000 cubic yards annually. As storm events intensify and stream flows start to increase, large amounts of fine-grained sediment become mobile and get transported along the bottom of the river channel. The majority (about 80%) of this suspended sediment wash load is sufficiently mobile to pass over the dam through the spillway gates and continue downstream. The remainder of these sediments are heavier and have slowly accumulated near the dam in a series of submerged bars. These bar deposits have largely developed during large individual flood events, with bars expanding in size particularly during the extreme flood events in 1986 and 1997.

The proposed Sediment Pass Through operations would involve opening a low level outlet gate during the relatively larger storm events. The 72-inch diameter low-level outlet gate is located at the base of the dam and

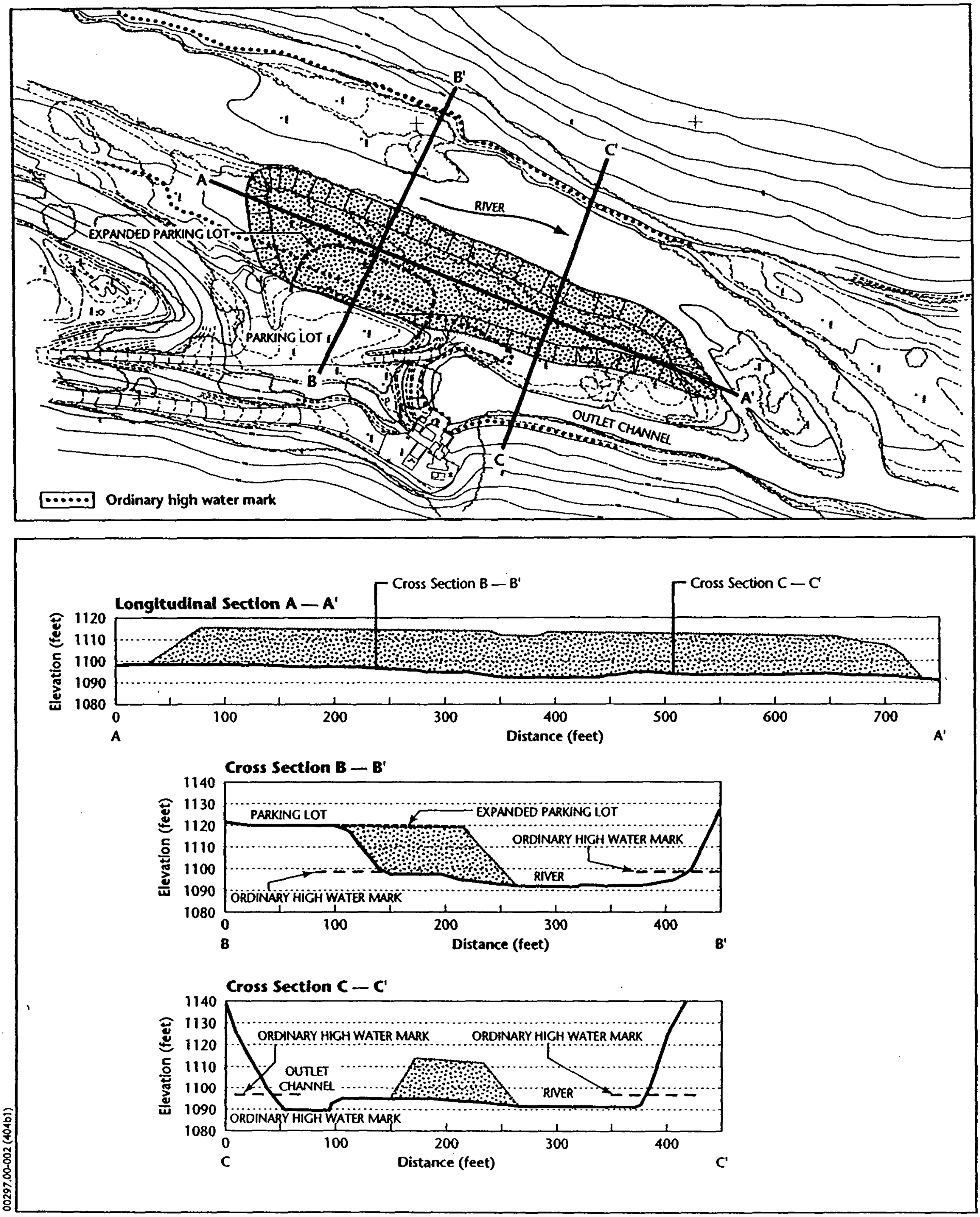

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Figure 2
Plan View and Cross Sections of Proposed Disposal Pile at Indian Bar

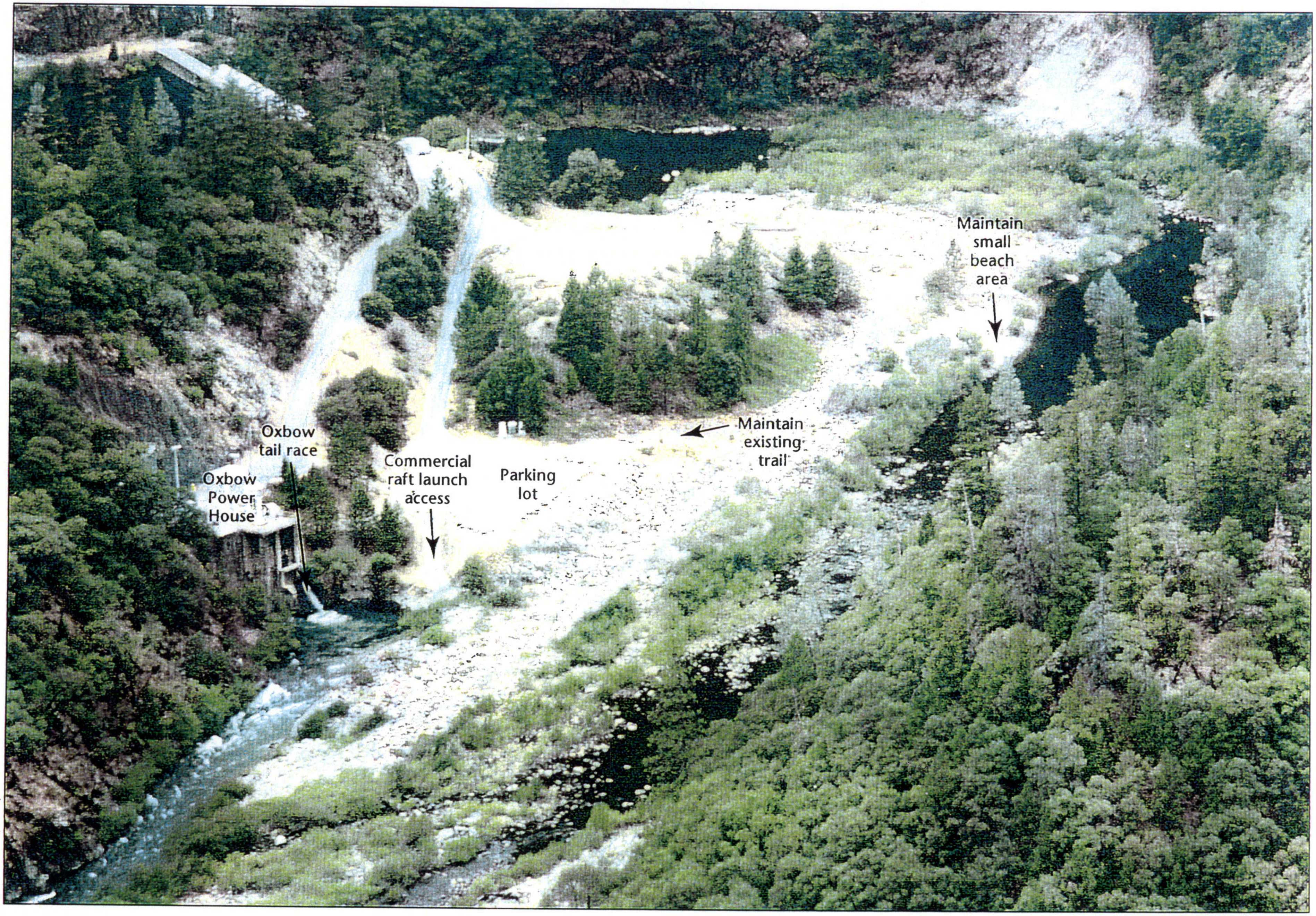

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Figure 3
Existing Conditions at Indian Bar

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Figure 4
Proposed Conditions at Indian Bar

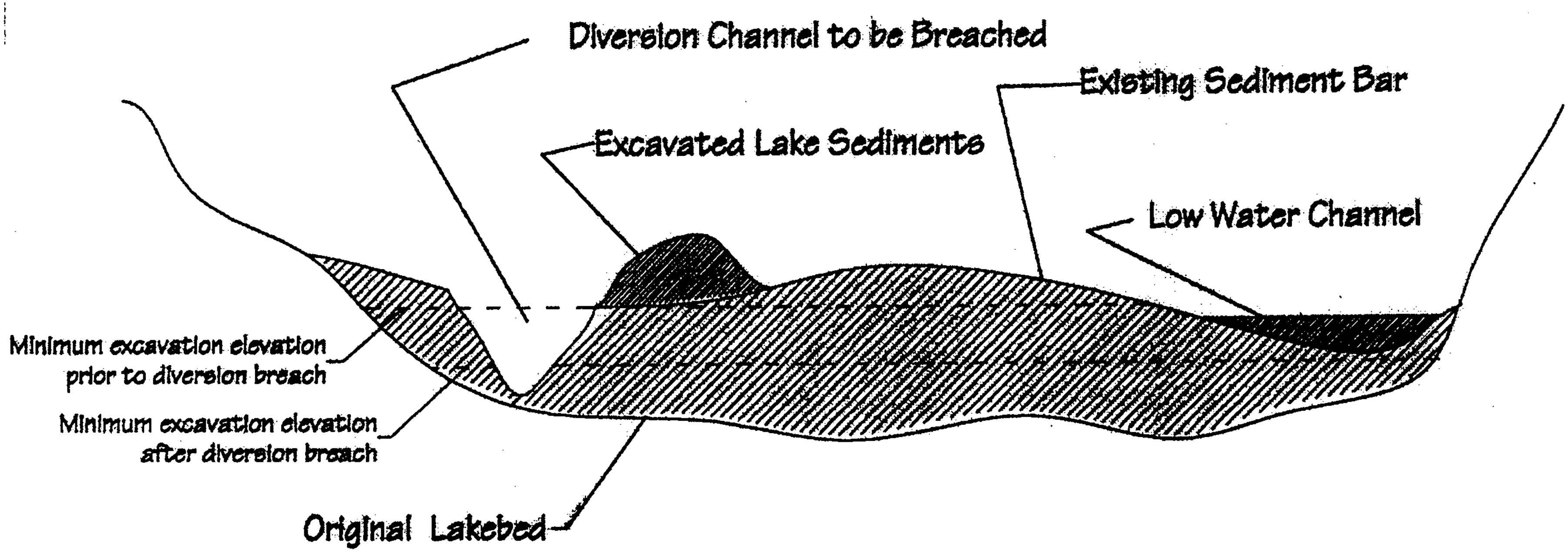
can be automatically opened and closed. The SPT operation mode would facilitate the downstream transport of a larger fraction of the suspended sediment load that would otherwise be trapped in Afterbay. SPT operations would not cause any appreciable changes in the configuration of the existing submerged sediment bars upstream of the dam. Simply, SPT would increase the life of the dam before sediments completely fill Afterbay. Powerhouse operation would continue if sufficient flows are available during these events. SPT operations would be conducted when storm flows exceed 3,500 cfs. In addition, PCWA staff will determine if the 3500 CFS event is likely to sustain for multiple days (based on weather forcasts). Once the flow exceeds 3,500 cfs, and PCWA staff has determined that the event will sustain for a time long enough for SPT to operate efficiently, PCWA will open the low-level outlet valve on the dam and operate in a SPT mode until storm flows begin to subside. SPT operations will occur relatively infrequently because on average, only 1 or 2 storms each year produce enough runoff that exceeds 3,500 cfs at Ralston Dam. This component will help satisfy the project purpose of restoring natural downstream migration of fine sediments.

Project Construction

The project construction activities will consist of 3 primary operations: excavation, hauling, and placement.

Excavation

Excavation of sediments in Afterbay will be performed in an unwatered condition, with the reservoir water elevation drawn down about 30 feet (ft) to the base of the spillgates at elevation 1149. This will leave several large bar areas exposed, with the river flow following a low water channel between the sediment bars until it enters the reservoir pool at 1149. Excavation will be performed on these bar areas, which will be connected to the Blacksmith Flat haul road via a minimum of 2 river crossings constructed of large steel culverts backfilled with granular river sediments. Diversion channeling will also be necessary to keep the water table low. A large excavator with about a 6-cubic-yard bucket (Komatsu 750 or equal), supported by a large loader with about a 5-cubic-yard bucket (Cat 980 or equal), will remove the sediment and load it into the haul trucks. A medium-sized excavator (JD690 or equal) will be used to install culvert crossings and dig diversion channels. A small bulldozer may be used for access road preparation. This method of excavation was used successfully in the 1994 sediment removal job at Afterbay and had the concurrence of the resource agencies. Preliminary plans for excavation are shown in figures 5 and 6.



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Source: PCWA

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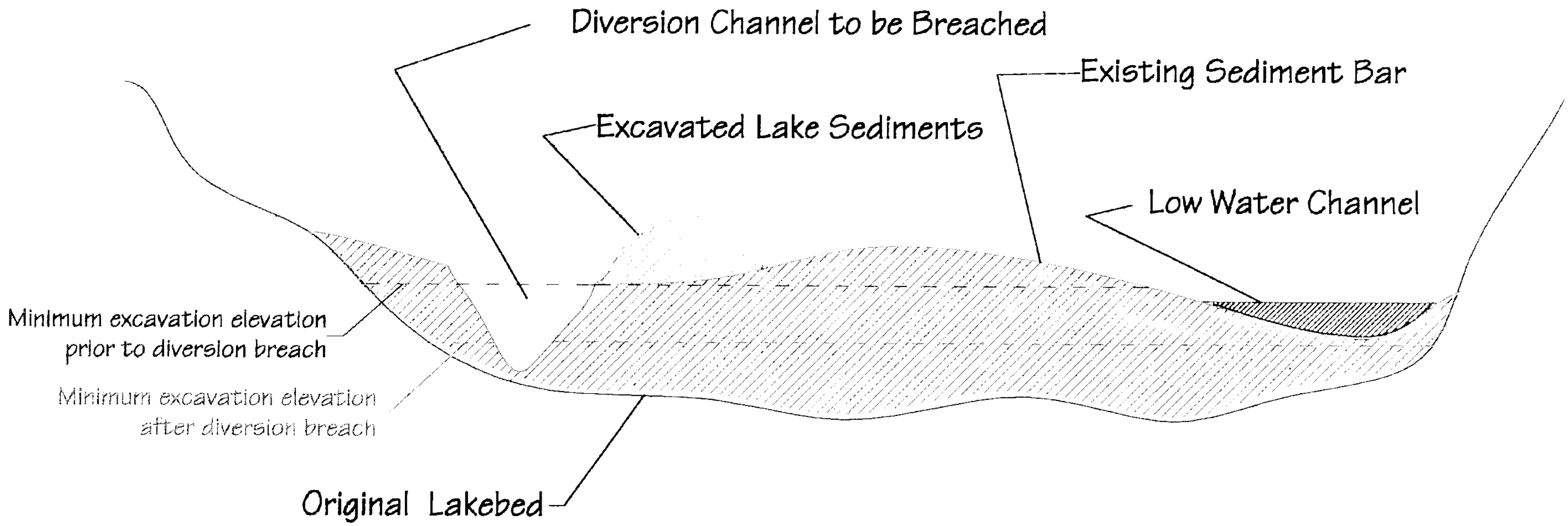
Figure 5

Ralston Afterbay Sediment Removal Project: Typical Reservoir Cross Section



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Source: PCWA

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Figure 6
Ralston Afterbay Sediment Removal Project–2001:
Typical Reservoir Cross Section

Hauling to the Ralston Ridge Site

The hauling to Ralston Ridge will be conducted using highway trucks such as belly dumps and end dumps, off-highway trucks such as the articulated Volvo A-35, or a combination of the 2 types. Portions of the Blacksmith Flat haul road are steep and narrow, so traffic control measures will be implemented. It is anticipated that about 12 trucks per shift will be required to maintain an efficient operation. There are no inhabited structures near, or in view of, the haul road.

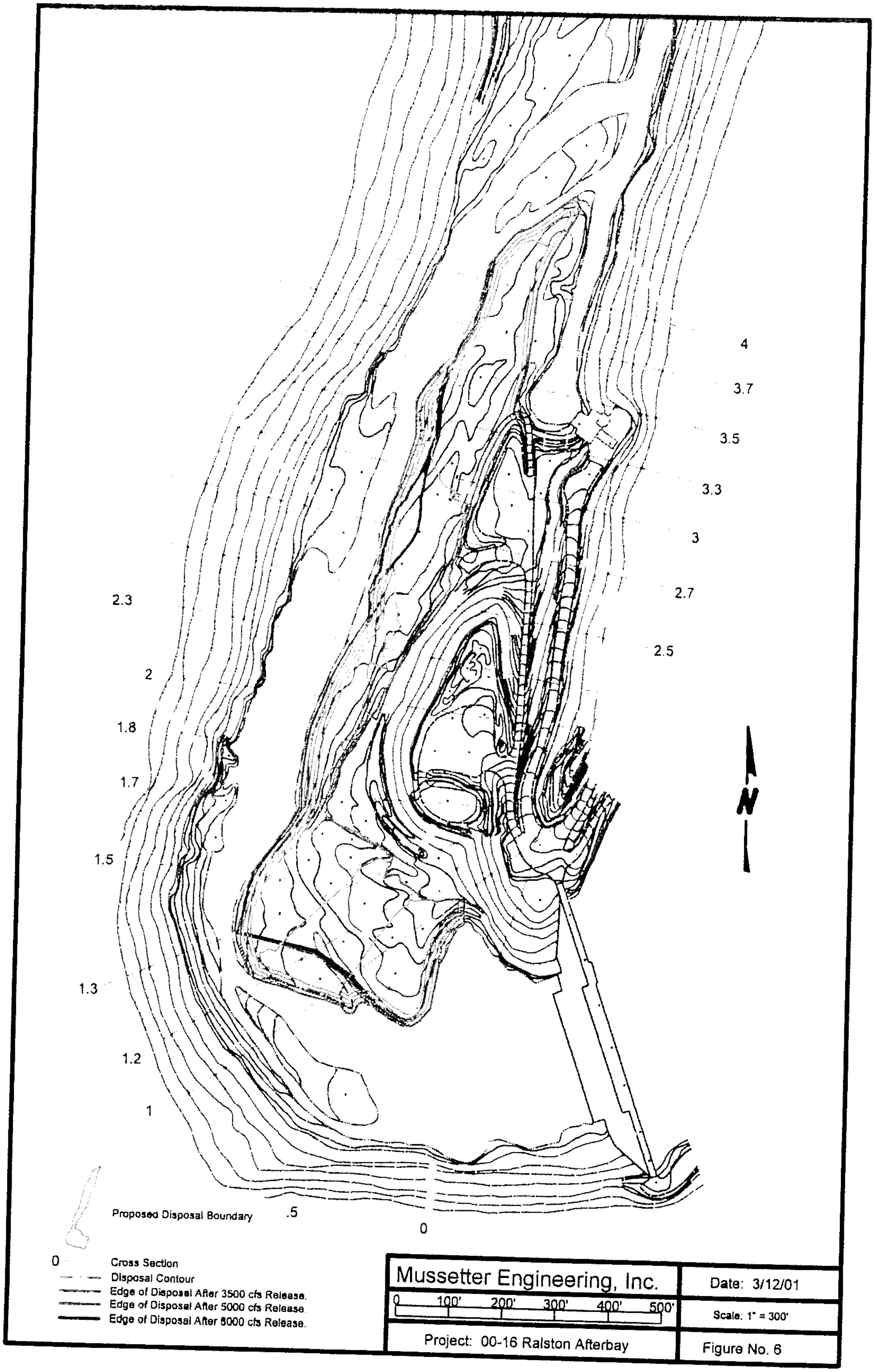
Hauling to the Indian Bar Site

The haul road to the Indian Bar site is less severe, and a portion can be closed to public access. The hauling will be done by trucks similar to those described above. To minimize hauling over the USFS bridge over the Middle Fork when hauling to Indian Bar, another entry point to the reservoir will be made at the old boat ramp next to the bridge, near the picnic area. The haul distance to Indian Bar is less than half the distance to the Ralston Ridge site, the road is not as steep, and the total vertical climb is only about 280 ft versus more than 1200 ft to the Ralston Ridge site. Therefore, the hauling costs, number of trucks, and fuel consumption will be much less per cubic yard, when compared with hauling to the Ralston Ridge site. Traffic control measures will be implemented to ensure safety of the public and employees. It is anticipated that about 8 trucks per shift will be required to maintain an efficient operation. There are no inhabited structures near, or in view of, the haul road.

Indian Bar Site Sediment Placement

Figure 7 shows the site location downstream of the dam and estimated boundaries for sediment placement based on the original proposal to haul approximately 75,000 cubic yards of sediment to Indian Bar. The yellow line is the project's maximum boundary. The total area begins about 200 feet downstream of Afterbay dam, is about 380 feet wide at its widest point and has a total length of about 1600 feet. The total area is within PCWA's Federal Energy Regulatory Commission (FERC) Project boundaries. The green, red, and blue lines in figure 7 show the new area of the site that would erode with single flow events of 3,500, 5,000 and 8,000 cfs based on 2-D hydraulic modeling and sediment transport analyses performed by Mussetter Engineering (2001). Figure 8 shows a 3-dimensional rendering of the sediment disposal site under existing conditions, 3,500, 5,000, 8,000, and 105,000 cfs. The highest flow (105,000 cfs) represent the 100-year flow event for the MFAR.

DFG determined that the particle size of sediment in Bar F is too fine to be the only sediment placed at Indian Bar. However, as previously discussed with DFG, PCWA will mix sediment from Bar F with coarser



Source: Mussetter Engineering, Inc. 2001

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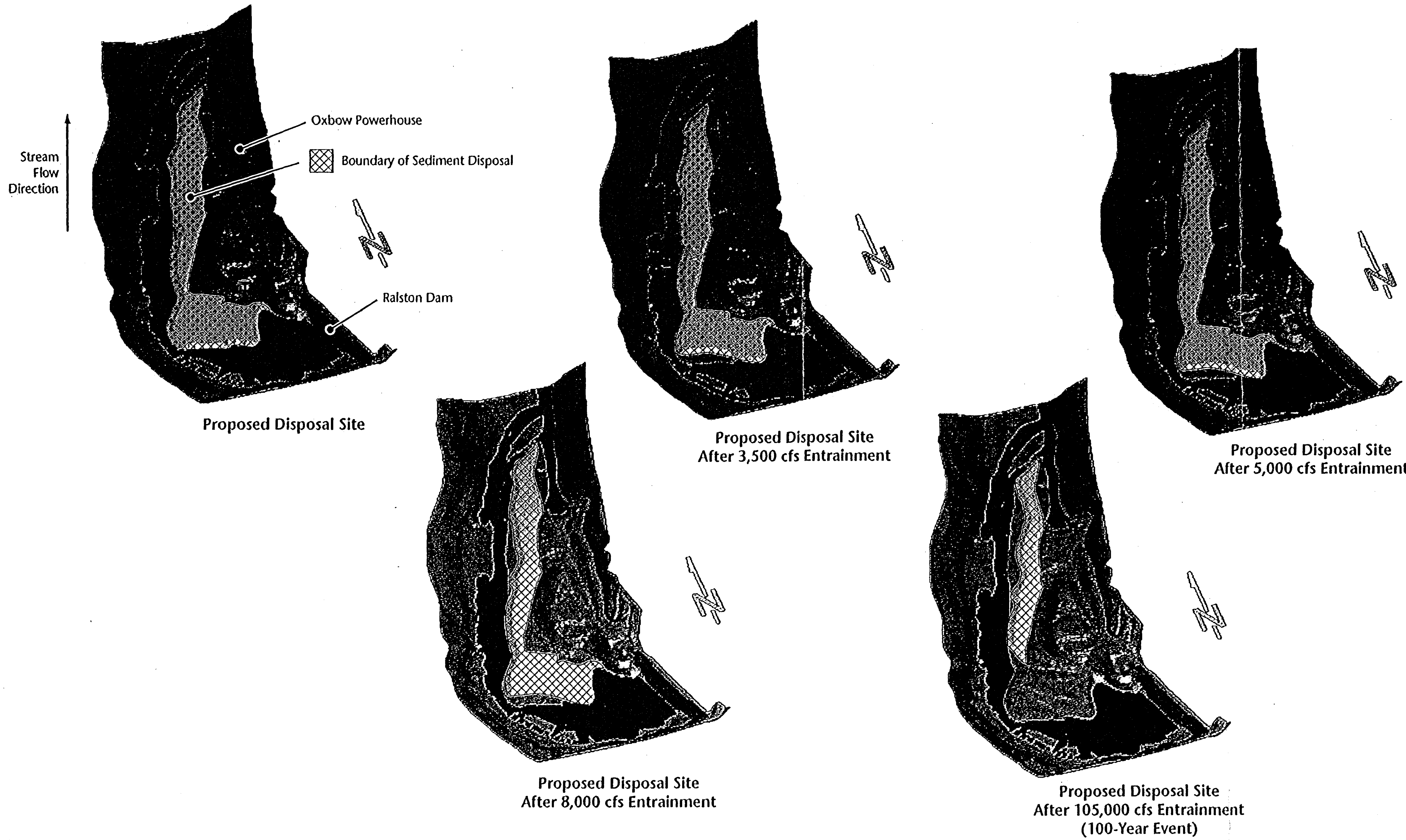
Figure 7
Map of Indian Bar Site Showing the Outline and Elevations of the Proposed Disposal Site and Boundaries of Entrained Material at 3,000, 5,000 and 8,000 cfs



Source: Mussetter Engineering, Inc. 2001

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Figure 8
Three-Dimensional Rendering of Indian Bar Disposal Site and Boundaries of Sediment Pile

sediments excavated from the either the Middle Fork bar or bar D (Sediments from bar D will only be used after they are sampled, analyzed, and approved by DFG). The mixed sediment will be of a size classification acceptable by DFG for placement at Indian Bar.

In order to mix sediment from different bars, PCWA will ensure that sediment from Bar F will be hauled to Indian Bar for one hauling shift, and then haul sediment from either the Middle Fork bar or bar D for the next haul shift, and then continue to alternate the source with each shift. Also, additional mixing will be completed with a dozer and/or some other piece of equipment at Indian Bar.

Because the purpose of the proposed Indian Bar sediment pile is to allow the entrainment of sediments in high-flow events, and because of the coarse nature of the sediments to be placed there, sediment will not be compacted. The pile will be created as a series of lifts to maintain a well-sorted distribution of particle sizes and prevent compacted conditions. The sediment pile will be placed to the designed lines and grades, subject to approval by the various resource agencies. It is planned that a bulldozer similar in size to a Caterpillar D8 will be used to do any required foundation preparation and to spread, track-walk, and grade the sediment being hauled from the reservoir. Final sloping, mixing and grading will be done by a medium-sized excavator or a small bulldozer.

Before excavated sediments are placed at the Indian Bar site, site preparation work (consisting of clearing vegetation, surveying, and preparing the site to receive the sediments) will be conducted.

Best Management Practices

To protect water quality during construction of the Ralston Afterbay Sediment Management Project, the following best management practices will be implemented. The project construction areas including the Ralston Ridge spoil site, access roads, the Indian Bar sediment pile, and the reservoir sediment removal operation within Ralston Afterbay.

Access Roads

With the exception of access roads in the reservoir and at the spoil site, which have rocky surfaces, all project roads have either asphalt concrete or chip seal pavements, which will minimize erosion potential.

- Maintain existing drainage measures, such as ditches, culverts, and energy dissipators, and the patch pavement where damaged.

- Install excelsior-type erosion control logs and straw bale checks where necessary to reduce sediment.

- Construction traffic/vehicles will stay on pavement where practical.

Work In Reservoir

Immediately downstream of the project area is the lowered reservoir pool. This pool is largely filled with several hundred thousand cubic yards of fine silts and sands, but there is still 100 - 200 acre feet of water storage capacity, which the stream must flow through prior to being released through the dam or powerhouse. This will act as a large settling basin, which is adequate for the 75 cfs streamflows, and the limited periods of turbidity caused by rechannelling and culvert installation. Seventy-five cfs flow into this pool is equivalent to a change of water about every 24 hours.

- With the reservoir drawn down, water is anticipated to flow at 75 cfs in the normal low-water channel. Storms can increase this flow.

- Perform excavation of sediments in Afterbay in an unwatered condition, with the reservoir water elevation drawn down about 30 feet to the base of the spillgates at elevation 1149.

- Observe a maximum drawdown rate of 2 foot per hour to minimize turbidity in the lake.

- Route truck traffic in the reservoir on dry surfaces. If wet spots do develop, do not allow turbid water from these areas to enter the flowing water.

- Install water diversion trenches to lower water levels around the sediment bars areas. Prior to installing a diversion trench, excavate sediment on the sediment bar down to within about a foot of the water table, to lessen the required trench height to minimize raveling of the trench wall.

- Excavate trenches using an excavator. Leave the ends of the trench in place during excavation, to contain turbid water in the trench and separate from flowing water. After excavation of the trench is complete, allow water to settle, then carefully breach the downstream end of the trench where it will enter the main water flow. Then breach the upstream end, and water will be diverted and will flow in the trench. Continue this process until the sediment on the bar which can be removed practically and efficiently is removed.

- Construct stream crossings with culverts to pass about 200 cfs, for trucks and excavation equipment to access each bar. If large, unseasonal storms occur that are anticipated to exceed the culvert capacity, remove the culvert crossings until the storm flows subside. Remove all equipment from the reservoir if large storms are anticipated. If only one or two crossings to any sediment bar is required, excavation equipment only may make a "wet"crossing, otherwise culverted crossings are required.

- Steam clean all equipment, including excavators and trucks, prior to arrival on site. Check all equipment daily for fuel, hydraulic fluid, and lubrication fluid leaks. Contain any spills immediately, and remove any contaminated materials immediately, per local and state regulations. Report spills as required.

- Use only excavators and loaders for excavating sediment. Other than for developing access roads, bulldozers will not be used for excavation.

- Use care when creating a diversion channels through bars where the sediment is mostly sandy, such as by creating extra width to reduce velocities.

- Install an oil absorbent boom across the reservoir pool just downstream of the project area, in a location where the water surface is quiet enough for the boom to function properly.

- If excavated sediment is too wet for hauling, stockpile temporarily to drain before hauling. Haul truckloads consisting primarily of silts and fines to the Zone 2 area of the Ralston Ridge spoil site.

Indian Bar Sediment Pile

Due to the purpose of the proposed Indian Bar sediment pile, and the overall coarse nature of the sediments to be placed there, compaction of the pile will not be required. Erosion control measures will be minimal due to the nature of the sediment, which is mostly coarse, free draining, and erosion resistant to rainfall. No revegetation of the area is necessary, other than by natural propogation.

- Place excavated sediments in heavy lifts using a large bulldozer to the lines and grades shown in the Indian Bar Pilot project description. Do not end dump sediments over a slope. Verify that sediment is placed to minimize separation of gradations.

- To minimize any sediment from entering flowing water during construction of the sediment pile, place silt fence or excelsior erosion control logs between the edge of the pile and the flowing water. If necessary, install strawbale checks and filter fabric in the flowing water to provide additional filtration.

- Steam clean all equipment, including excavators and trucks, prior to arrival on site. Check all equipment daily for fuel, hydraulic fluid, and lubrication fluid leaks. Contain any spills immediately, and remove any contaminated materials immediately, per local and state regulations. Report spills as required.

- Verify required fire prevention and fighting measures, such as fire extinguishers, shovels, water pumps, etc. are available, per the Eldorado National Forest.

Project Schedule

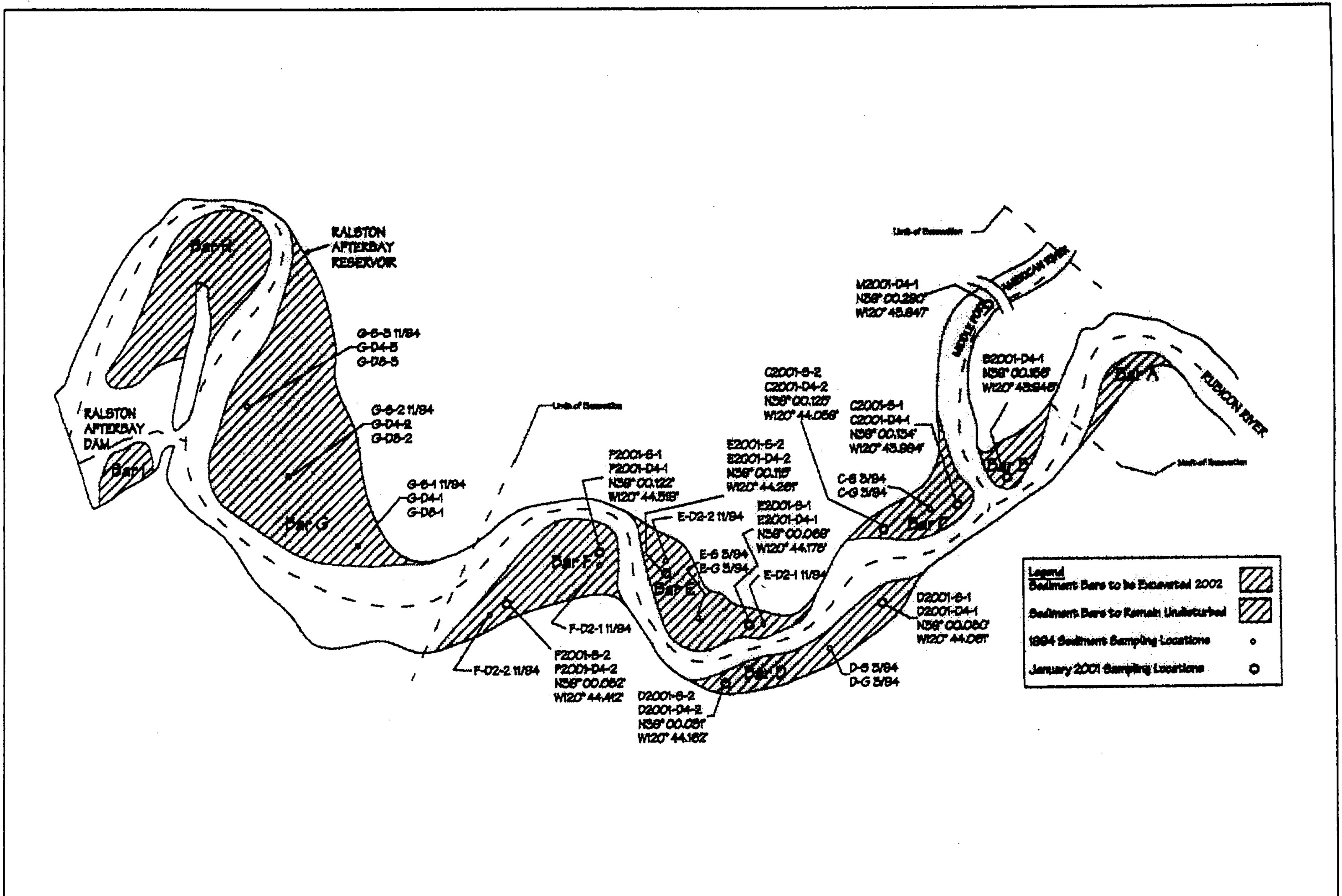
Project excavation activities are scheduled to begin about August 2002. Work in the reservoir should begin about September 15 and should be complete before October 31, 2002. Final demobilization, cleanup, and erosion control should be complete by mid-November 2002. Work during the 3–4 week reservoir outage will be performed up to 7 days per week, 2 shifts per day. SPT will be implemented as storm and river flow conditions allow.

Testing of Sediments

Sediment samples have been collected twice in the past from Afterbay, in 1994 and 1995. The purpose of the sampling was to test for concentrations of metals that would be injurious to people or aquatic life. The tests were conducted following California Waste Extraction Test (WET) procedures and showed no unacceptable heavy metals concentrations.

Because additional sediments have been deposited in Afterbay since the 1994 sampling, additional sampling was done in January 2001 using the approved 1994 sampling plan as a guideline. Eight samples from 6 locations (figure 9), were analyzed for total threshold limit concentration (TTLC) for the CAM 17 metals, using EPA 6010, 7471, 7760, 7740, and 7841. Three of these samples were analyzed for Acid Generating Potential, EPA 670. Based on the favorable TTLC results, soluble threshold limit concentration (STLC) testing was not performed on the samples. The sample results showed heavy metal concentrations were well below the California Regulatory Limits (figure 9).

After further discussions with the Central Valley Regional Water Quality Control Board (RWQCB), additional sediment sampling and testing was performed in October 2001 to verify previous test results for contaminants, characterize sediment size gradations to assist in planning and permitting, and provide background data for 401 certification and waste discharge requirements. Contaminant testing included the same



Source: Modified from PCWA

Figure 9
Ralston Afterbay Sediment Removal Project–2001: Past and Proposed Sediment Sampling Locations

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tests used previously as well as STLC testing. Testing of 22 samples from 13 locations confirmed the conclusions of past results (figure 9).

Quantities and Gradation of Sediment in the Reservoir

Sediment gradation analyses of reservoir sediments were performed by Alpha Geotechnical consultants in 1988, Bechtel Corporation in 1996, and PCWA in October 2001 (in conjunction with contaminant testing). Based on the October 2001 samples, the average gradation of sediment samples from bars proposed for excavation (excluding particles larger than 6 inches diameter) were as follows: 0-49% small cobble (76-152 mm), 38-63% gravel (5-76 mm), 10-54% sand (0.07-5 mm), and 0.4-4% silt/clay (<0.07 mm).

Mussetter Engineering's sediment entrainment modeling for the Indian Bar disposal site was based on the sediment gradation of a sample collected from Bar D in 1987 (TP5 in the 1988 Alpha Geotechnical report). This sample was assumed to be representative of the material that would be deposited at Indian Bar. However, because this sample and subsequent samples did not include particles greater than 6 inches diameter, Mussetter Engineering performed a sensitivity analysis to investigate the effect of this coarser material on entrainment estimates. The results, based on reasonable adjustments of the 2001 gradation data, indicated that the volume of sediment entrained from Indian Bar could be 20-46% lower than original estimates (for the same flow events: 3,500 cfs, 5,000 cfs, and 8,000 cfs) if sediments consisted only of the coarser sediments in the reservoir.

PCWA developed, in consultation with DFG, a sediment testing and hauling strategy to minimize the effect of coarser sediment on performance of the Indian Bar disposal site. An examination of the October 2001 gradation data indicated that Bars B and C are coarser than assumed in the original entrainment analysis. The sediment in Bar MF and D appears to be most similar in composition to that assumed in the original analysis, while Bars E and F are finer. Therefore, the excavation of sediments from the reservoir will entail selective excavation and hauling of sediment from different locations in the reservoir to ensure a suitable gradation of sediment at Indian Bar, as described under Project Construction.

As requested by DFG, additional gradation analyses will be performed in September 2002 to evaluate the suitability of Bar D as a source of sediment for Indian Bar. Immediately after Ralston Afterbay is lowered and Bar D is exposed, sediment samples will be collected from Bar D and sieved in the field using the procedures and guidelines described in Section 2.1.3.10 of Bunte and Abt (2001). Sample locations, depths, and volumes will be determined after digging several shallow test pits to examine spatial variability in sediment size composition across the bar and with respect to depth (Section 4.2 of Bunte and Abt [2001]). A complete gradation analysis (including particles larger than 6 inches in diameter) will be performed based on the Wentworth scale. Immediately after data collection, sediment gradation curves and the corresponding D84, D50, and D16 values will be plotted for each sample and transmitted to DFG. DFG and PCWA will be prepared to review the data and determine whether and to what extent Bar D will be used as a source of sediment for Indian Bar.

Monitoring Plan for SPT and Gravel Recruitment

A monitoring plan for SPT and the gravel recruitment at the Indian Bar site, in and along the river immediately downstream of Afterbay Dam as shown in appendix A, was developed by Jones & Stokes. The monitoring program is an integral component of the proposed project and will be implemented by PCWA. The monitoring program is designed to evaluate the proposed sediment management activities and ensure that adverse water-quality and aquatic-habitat effects do not occur downstream of Afterbay in the MFAR. Jones & Stokes biologists collected and reviewed available data and information on water quality, fish, benthic macroinvertebrate populations, and aquatic habitat in the reservoir and river areas. These data and information were used to develop a list of key evaluation parameters.

The monitoring plan includes aquatic habitat and BMI sampling at representative transects upstream of Afterbay (control reaches) and transects below the Indian Bar site (test reaches). The location of transects downstream of the Indian Bar site are based in part on the modeling and sediment transport analyses performed by Mussetter Engineering. Transects will be placed in representative habitats determined to be sensitive to deposition of sediment. Water quality monitoring stations were selected to provide data from upstream control areas and downstream areas that might be affected by the project.

Aquatic habitat parameters that will be monitored include substrate size composition, embeddedness, channel cross sections, and water temperature. Macroinvertebrates will be evaluated using standard species composition and abundance parameters. Water quality sampling will include automated turbidity probe measurements and manual grab samples for total suspended solids (TSS).

In 2002, several monitoring components were added or revised at the request of the U.S. Forest Service and DFG. These components include:

- identification of target flows and conditions for triggering postproject monitoring and evaluation of SPT operations and Indian Bar sediment disposal,
- surveying and pebble counts of the Indian Bar disposal site after significant entrainment events,
- an evaluation of pebble counts as an alternative method for assessing the size composition of riffle substrates at aquatic habitat/BMI monitoring sites,
- modifications and additions to BMI sampling protocols to ensure consistency with the California Stream Bioassessment Procedure,
- monitoring of channel cross-sections at selected pools upstream and dpwnstream of Ralston Afterbay, and
- continuous water temperature monitoring at the water quality monitoring stations.
- These components are described further in the attached monitoring plan.

Plans for Protecting the Environment during Project Construction

The preventive measures described below would be incorporated into the construction specifications of the proposed project to address project-related impacts on water quality, air quality, biological resources, and cultural resources.

Erosion Control during and following Construction

Erosion control measures at the Ralston Ridge storage site will be used to help prevent erosion and reduce sedimentation during the establishment of a vegetative cover both during and following the construction period. Mechanical erosion control measures include mulching, hay bale checks, silt fencing, velocity dissipaters, culverts, excelsior blankets, etc. Erosion control of the engineered fill will be in accordance with the Ebasco specification and the El Dorado National Forest special use permit. Following construction, the appropriate mechanical measures will be left in place permanently to promote the establishment of vegetative cover, where necessary. Seeding will be performed according to the special use permit.

With the exception of access roads in the reservoir and at the spoil site, which have rocky surfaces, all project roads have either asphalt concrete, or chip seal pavements, which will minimize erosion potential. Existing drainage measures, such as ditches, culverts, and energy dissipators, will be maintained, and the pavement patched where damaged.

Silt fence and/or straw bales will be installed as necessary around the site, where turbid runoff could occur during rainstorms. Silt fence and/or straw bales will also be installed in ditches or drainage swales, to slow water velocity and provide settlement areas. Final erosion control measures include riprap drainage channels and placement of topsoil, which will be hydroseeded, mulched, fertilized, and covered with excelsior blanket, unless otherwise approved by the U.S. Forest Service.

Erosion control measures at the Indian Bar site will be confined largely to water bars, hay bale checks, ditch maintenance, and energy dissipators, where necessary. The nature of the sediment is coarse, free draining, and resistant to rainfall erosion. If there is any initial turbid runoff, silt fence or erosion control excelsior logs will be used to contain and filter the runoff. No revegetation is planned at the Indian Bar site other than through natural propagation.

Streamflow Maintenance in the Reservoir during Construction

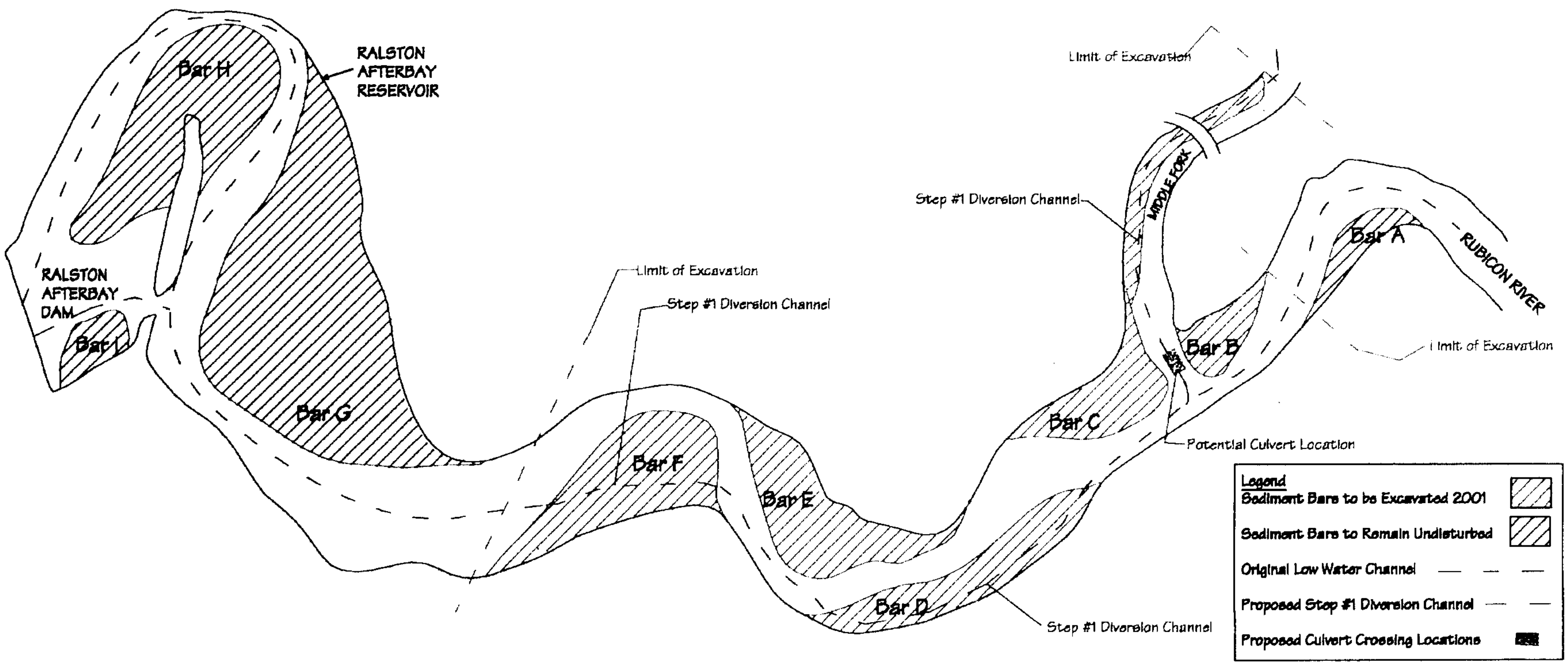
Because of the reservoir size, the large streamflow maintenance requirement of 75 cubic feet per second (cfs) minimum, and construction techniques to minimize impacts to water quality, a pumped bypass of the entire work area is neither practical nor warranted. It is anticipated that about 15–20 cfs will normally flow during September and October in the MFAR upstream of Afterbay; therefore at least 55–60 cfs will be necessary from the Rubicon River. The Rubicon flow can be supplemented by larger releases at Hell Hole Dam or at Ralston Powerhouse, if the plant is operational during the outage period. The 75 cfs either will follow the existing low level channels, which are naturally armored, or will be temporarily diverted into bypass channels around the sediment bars that will serve to lower the water levels around the excavation areas. Where equipment crossings are necessary over the streamflow, large culverts will be installed, then backfilled with granular river sediment. If a large storm occurs that could potentially overwhelm the culverts, equipment will be available to remove the culverts.

Protection of Water Quality during Construction Activities

The intent of the project construction plan is to excavate sediments in the dry, in a manner similar to the way it was done in the successful 1994 sediment removal at Afterbay. Even with lowering the reservoir to the spillgate sill at elevation 1149, only a small portion of the sediment bars is exposed. Thus the creek channel above elevation 1149 will need to be lowered to excavate the bars in the dry. The process will involve at least 3 steps, as shown in figure 10. To lower the creek channel, a series of diversion channels will be excavated through the sediment bars. The excavation will be performed with the medium-sized excavator moving in the upstream direction. Although the excavator will need to dig well below the water table surface, it will be far enough from the flowing water that the turbidity should be contained in the channel excavation. At the same time, the excavator will be pulling up material into stockpiles for easy loading. Once the new diversion channel is complete, the upstream end will be breached slowly, and the streamflow will be allowed to follow the new course. Because the depth of sediment in the project area averages around 10 ft, and because of the configuration of the reservoir, at least 3 series of diversions will be required. Where equipment needs to cross flowing water, large culverts will be installed and backfilled with coarse reservoir sediments. It is anticipated that a minimum of 2 culverted stream crossings will be required. In a few instances, the excavator will make a "wet" crossing of the stream in order to create a diversion channel on 1 of the bars. Because the equipment is required to be steam-cleaned before arriving on-site and will be inspected daily for leaks, this method of crossing is superior to installing a culvert when only 1 or 2 crossings by the excavator are needed to set up a diversion channel.

All excavation work will be below the normal high-water mark of the reservoir. No streambed alteration will be performed in the river channels above the high-water mark. The excavation procedure described above will result in short periods of turbidity when a channel is breached or a culvert installed. With the exception of bar F, and portions of bars D and E, most sediments in the project area are relatively coarse, and will armor the diversion channels in short order. Care will be taken when creating a diversion channel through bars where the sediment is mostly sandy, such as creating extra width to reduce velocities. The gradients through these areas will be minimal.

Immediately downstream of the project area will be the lowered reservoir pool (100–200 acre feet (af) of water storage capacity), that the stream must flow through before being released through the dam or powerhouse. This pool will act as a large settling basin, which is adequate for the 75-cfs streamflows and the limited periods of turbidity caused by rechannelling and installing culverts.



Source: PCWA

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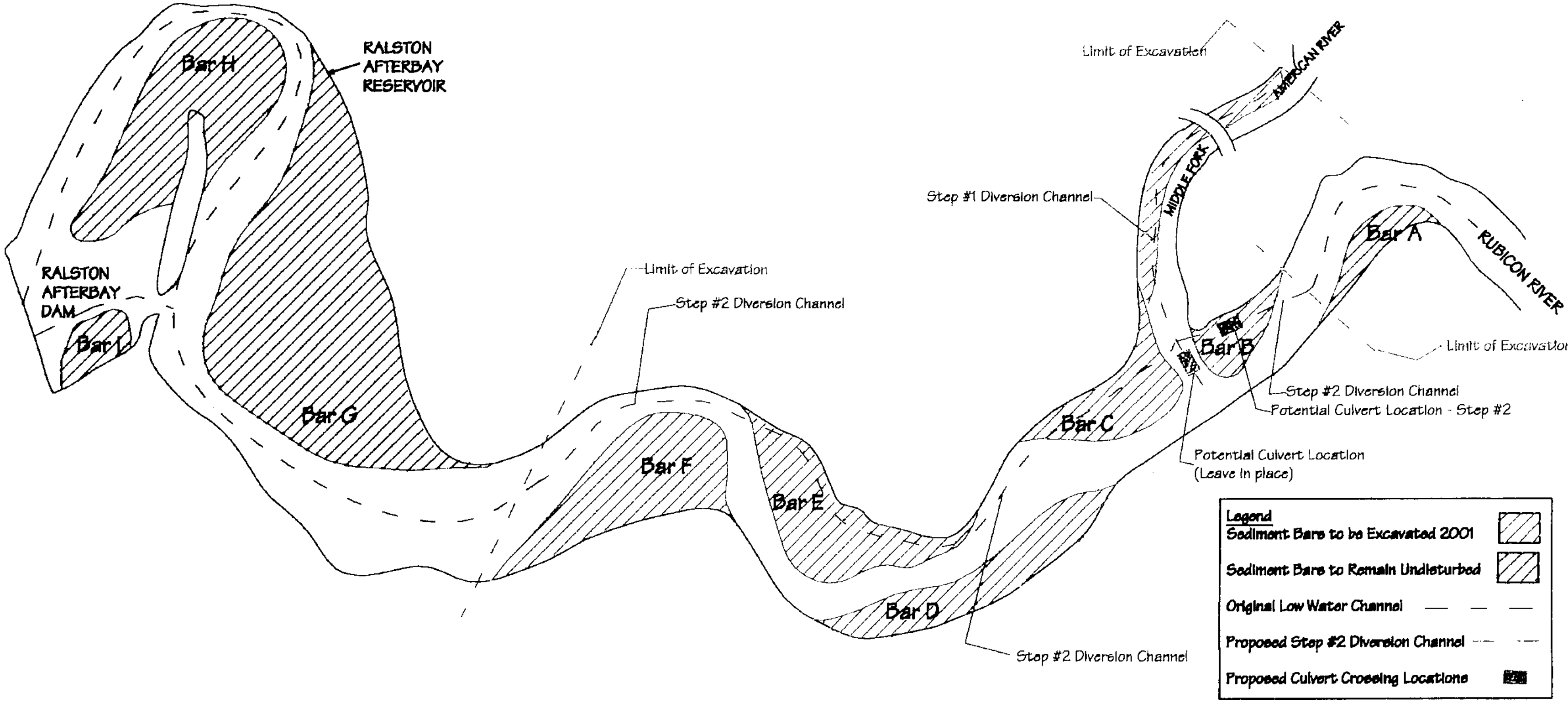
Jones & Stokes

Figure 10
Ralston Afterbay Sediment Removal Project–2001:
Preliminary Plan for Step #1–Initial Access and Diversion Channels



Source: PCWA

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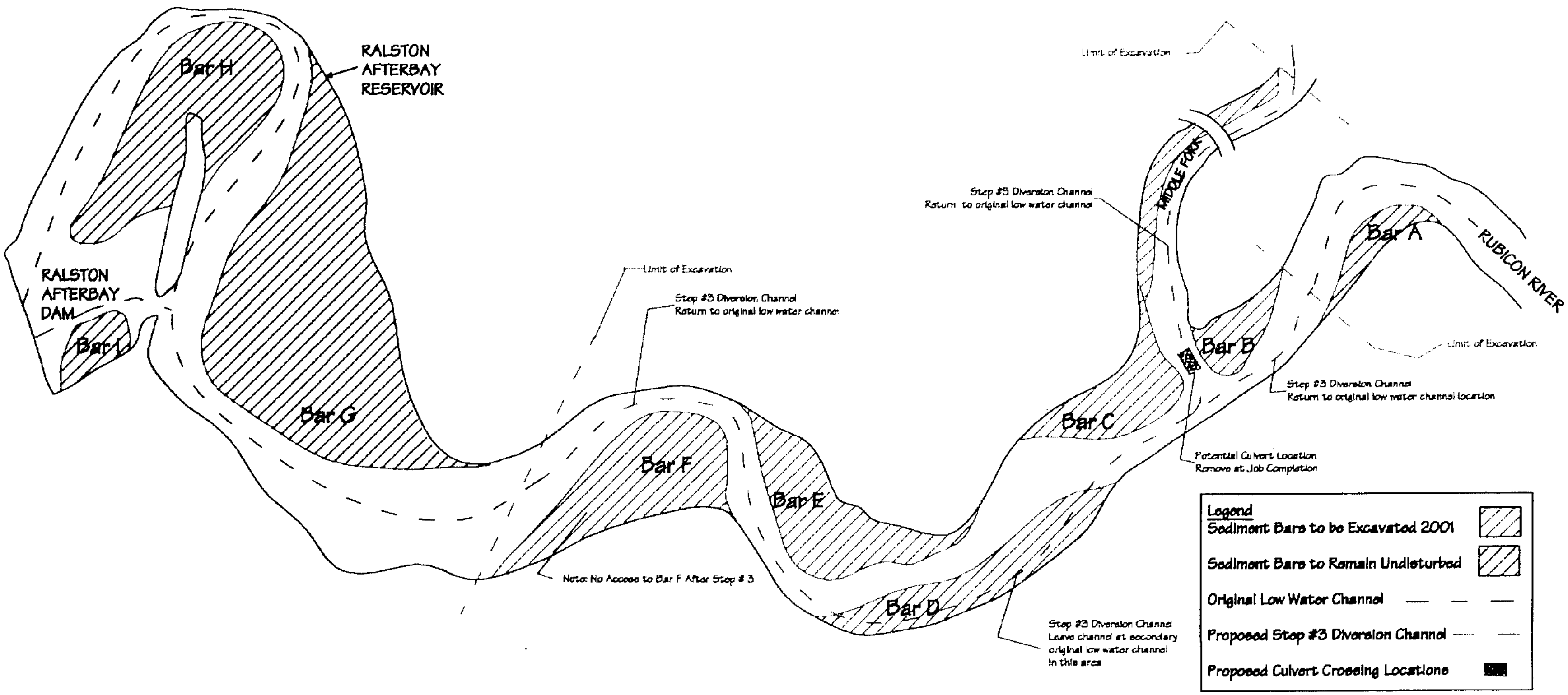
Jones & Stokes

Figure 10 (cont.)
Ralston Afterbay Sediment Removal Project–2001:
Preliminary Plan for Step #2–Move Diversion Channel North



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Source: PCWA

Jones & Stokes

Figure 10 (cont.)
Ralston Afterbay Sediment Removal Project–2001: Preliminary Plan for Step #3–Final Relocation of Channel

Seventy-five-cfs flow into this pool is equivalent to a change of water about every 24 hours. Also, an oil absorbent boom will be placed across the reservoir pool just downstream of the project area, in a location where the water surface is quiet enough for the boom to function properly.

To minimize turbidity when drawing the lake down to elevation 1149, a maximum rate of 2 ft per hour will be observed. Annual drawdowns of the reservoir are required for normal maintenance and usually result in some level of reduced clarity of the reservoir. If required by the regulatory agencies, daily monitoring downstream of Afterbay Dam and upstream of the project site during excavation will be done for turbidity and settleable solids. If monitoring is required, PCWA proposes that turbidity reaching 10 nephelometric turbidity units (NTU) will result in interruption of project activities in the reservoir until the cause can be determined and corrective measures taken.

Improvements to Oxbox Tailrace

In order to maintain full electrical generating capacity at oxbow powerhouse, PCWA proposes to lower the bed of a section of the Oxbow tailrace channel, approximately 250 feet downstream of the Oxbow Tailrace. Currently, river sediments have built up and constricted the channel. This constriction has raised the water level at the Oxbow Powerhouse Tailrace. As a result, the Oxbow Powerhouse is generating power at a level below full capacity.

In order to lower the water level at Oxbow Tailrace, PCWA will remove the constriction. During the removal process, PCWA will shut down operations at the powerhouse in order to shut off water to the tailrace and channel. PCWA will use an excavator from the bank of the tailrace channel to excavate the sediments causing the constriction. All work will be conducted in the dry channel. No in water work will occur.

APPENDIX A

Water Quality and Aquatic Habitat Monitoring Plan for the Ralston Afterbay Sediment Management Project Indian Bar Pilot Project

Executive Summary

Placer County Water Agency (PCWA) is proposing to initiate a pilot sediment management project at Ralston Afterbay Reservoir (Ralston Afterbay), a component of the American River Hydroelectric Project on the Middle Fork American River (MFAR). The primary purpose of the sediment management project is to create sediment storage capacity in Ralston Afterbay, maintain operational flexibility of Ralston Dam and Oxbow Powerhouse, and delay the complete sedimentation of Ralston Afterbay.

The sediment management project consists of 2 components. The first component consists of dredging approximately 75,000 cubic yards (yds) of sediment from the upstream end of the reservoir and placing approximately 48,000 yds of this material downstream of the Ralston Dam on Indian Bar. The sediment will be configured to allow high flows to mobilize and transport the sediment to reaches downstream of the dam. The second component, termed *sediment-pass-through* (SPT), consists of reoperating Ralston Dam during high flow events to pass greater quantities of fine sediment past the dam than passes under current operations.

A secondary objective of the project is to restore the natural migration of coarse and fine sediment that occurred in the project area before dam construction. This sediment, especially the intermediate-sized material (gravel, pebbles, and cobbles), is critically important for maintaining suitable stream habitat for fish

and benthic macroinvertebrates (BMI) (insects and other aquatic organisms that live in or on the streambed). Since the construction of Ralston Dam in 1966, a portion of the total sediment load transported by high flows from the MFAR and Rubicon River above Ralston Afterbay has accumulated in the reservoir, requiring periodic dredging of the reservoir to maintain the reliability of Ralston and Oxbow Powerhouses. As documented for other rivers, the retention of sediment by dams and corresponding reductions in sediment supply to downstream reaches can lead to a reduction in habitat quality in these reaches as high flows continue to transport cobble and finer materials that are not replaced by upstream sources.

SPT operations and sediment placement on Indian Bar constitute an effective and economic approach for managing sediment at Ralston Afterbay while compensating for the long-term effects of sediment retention on aquatic habitat in potentially sensitive reaches of the MFAR downstream of the dam. The proposed sediment management activities will allow the river to mobilize sediments and carry them downstream as they did naturally before dam construction. The placement of reservoir sediment, composed largely of gravel and larger materials, is expected to have beneficial effects on aquatic habitat downstream of the dam. Analyses of the hydraulic and sediment transport characteristics of the MFAR indicate that increases in the amount of fine sediment resulting from SPT operations and sediment placement will not cause adverse effects on water quality and aquatic resources because the amount of fine sediment affected by the project is small compared to the total amount of fine sediment transported by the MFAR.

In 2001, PCWA initiated a monitoring program to ensure project compliance with established water quality objectives and monitor the effects of the project on aquatic habitat and BMI in the MFAR downstream of Ralston Dam. Potential project effects will be evaluated by collecting a minimum of 1 year of water quality data and 2–3 years of aquatic habitat and BMI data before project activities begin and a minimum of 2–3 years of water quality, aquatic habitat, and BMI data after project activities begin. Key water quality, aquatic habitat, and BMI parameters will be monitored at treatment sites below Ralston Afterbay and at control sites above the reservoir. These parameters will include turbidity, total suspended solids, substrate size composition, embeddedness, and several BMI community and population attributes. Because of the high degree of variability of natural systems and lack of baseline data, an adaptive monitoring approach will be used to regularly evaluate the monitoring program and determine whether modifications are warranted to improve its performance. Evidence for project effects will be a significant postproject change (adverse or beneficial) in water quality and aquatic habitat conditions in the treatment reaches relative to changes in the control reaches. If these changes constitute an adverse effect on water quality and aquatic habitat conditions downstream of the dam, the magnitude of these changes will be compared with established water quality and habitat thresholds to evaluate project performance and determine whether corrective actions are warranted. The need for corrective actions will also be based on the results of BMI monitoring, which will serve as a key indicator of the biological effects of observed water quality and habitat changes. In addition, these changes will be evaluated in the context of other watershed events and trends that may influence the monitoring results and conclusions.

Introduction

PCWA operates a series of reservoirs and powerhouses as part of the American River Hydroelectric Project on the MFAR and Rubicon Rivers (Middle Fork Project) in the central Sierra Nevada (figure 1). The Middle Fork Project includes Ralston Afterbay, created by the construction of Ralston Dam in 1966 (photo 1). The dam and reservoir are located on the MFAR on the border of Placer and El Dorado Counties, California.

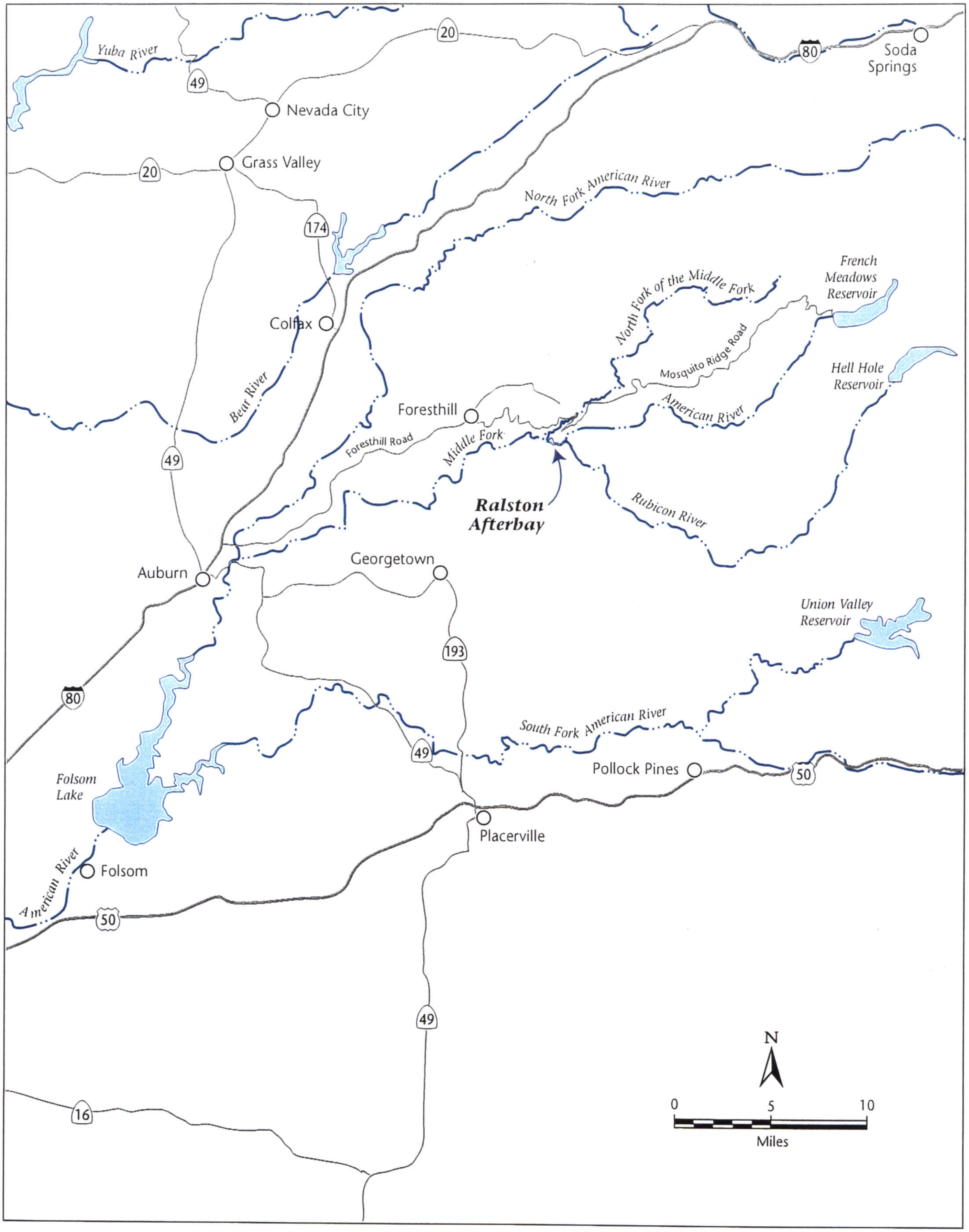
Ralston Afterbay serves 3 primary purposes. First, it protects public safety and fisheries by regulating the rate of river stage change downstream. Second, it allows the 2 largest powerhouses of the Middle Fork Project—Middle Fork and Ralston Powerhouses—to quickly respond to system electrical needs. Third, it impounds water for power generation at Oxbow Powerhouse.

PCWA is proposing to initiate sediment management at Ralston Afterbay to address continuing sedimentation of the reservoir that threatens the reliability of power generation at Ralston and Oxbow Powerhouses. PCWA issued and adopted an initial study/mitigated negative declaration for the Ralston Afterbay Sediment Management Project in August 2001. The primary purposes of the sediment management project are to create sediment storage capacity within Ralston Afterbay, maintain operational flexibility of Ralston Dam and Oxbow Powerhouse, and delay the complete sedimentation of Ralston Afterbay.

The sediment management project consists of 2 independent components. The first component consists of dredging approximately 75,000 cubic yds of sediment from the upstream end of the reservoir and placing this material downstream of the dam on a 1.96-acre portion of Indian Bar (photo 2). The sediment will be configured to allow high flows to mobilize and transport it to the river downstream of the dam. The second component of the project will consist of reoperating the dam during high flow events to pass greater quantities of fine sediment beyond the dam. SPT operations will be conducted whenever river flows exceed approximately 3,500 cubic feet per second (cfs).

PCWA is proposing an initial placement of 48,000 cubic yds of sediment on Indian Bar to evaluate the project at a pilot level and to address concerns regarding recreational uses at Indian Bar (Jones & Stokes 2002). This evaluation will include consideration of potential strategies for increasing the sediment volume while maintaining or enhancing recreational opportunities at Indian Bar. Other sediment placement locations (e.g., Junction Bar) may also be considered.

A secondary objective of the project is to restore the natural migration of coarse and fine sediment that occurred in the project area before dam construction. This sediment, especially the intermediate-sized material (gravel, pebble, and cobble), is critically important for maintaining suitable stream habitat for fish and BMI



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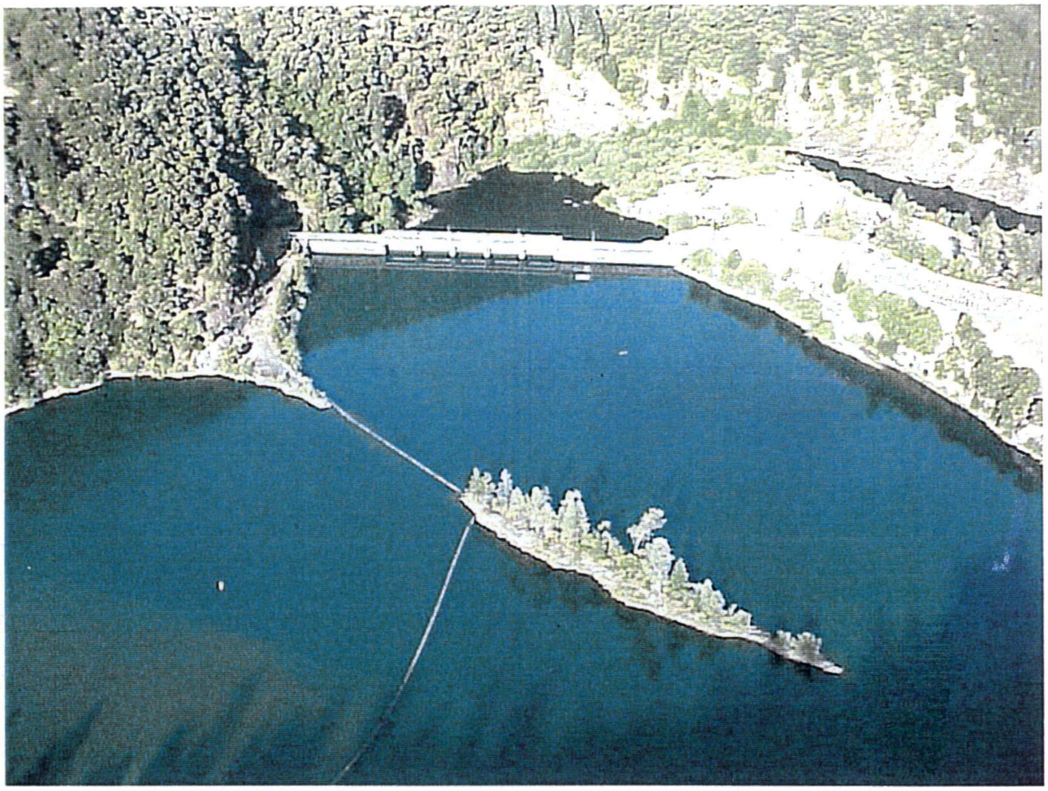
Jones & Stokes

Figure 1
Regional Location



Photograph 1. Ralston Afterbay Dam and Reservoir

Photograph 2. Indian Bar

(Waters 1995). Following construction of dams, these materials continue to be transported from the reaches below dams but without replacement from upstream sources, resulting in loss of important habitat (Kondolf and Matthews 1993). Other effects include scouring and deepening of the channel and associated increases in substrate size (i.e., channel armoring), a process that has been occurring below Afterbay Dam since its construction (Stiehr, pers. comm.). Efforts to mitigate these effects on salmon and trout streams in California have focused primarily on augmenting the supply of spawning-size gravels (Parfitt and Buer 1980). These efforts, which include placing gravel on bars and riffles and installing artificial and natural gravel-retaining structures downstream of dams, can be costly and ineffective over the long term. A more satisfactory alternative is to attempt to maintain natural channel features below dams by managing water releases and sediment in ways that preserve, as much as possible, the predam geomorphic processes (Ligon et al. 1995).

SPT operations and placement of sediment on Indian Bar constitute a viable and economic approach for managing sediment at Ralston Afterbay while mitigating for the long-term effects of sediment trapping on aquatic habitat downstream of the dam. The proposed sediment management activities will allow the river to mobilize sediments and carry them downstream as occurred naturally before dam construction. Preliminary analyses indicate that these activities will not cause adverse effects on aquatic resources. For reasons cited above, the reintroduction of sediment below the dam is expected to have beneficial effects on stream habitat and aquatic resources downstream of the dam. Both SPT operations and sediment disposal at Indian Bar are expected to result in relatively small, temporary increases in turbidity and suspended sediment above ambient levels during high flow events. In addition, past analyses and modeling of the hydraulic and sediment transport characteristics of the MFAR indicate that the channel is inherently stable and therefore relatively insensitive to changes in discharge and sediment supply (Harvey pers. comm.).

In 2001, PCWA initiated a monitoring program to test these predictions and ensure compliance of the project with established water quality objectives. The following report presents the monitoring plan and the results of the first year of baseline monitoring activities.

Purpose and Objectives

The purpose of the monitoring program is to evaluate the potential effects of the Ralston Afterbay Sediment Management Project on water quality, aquatic habitat, and BMI in the MFAR downstream of Ralston Dam. The primary objectives of the monitoring program are to:

- quantitatively evaluate project compliance with the water quality objectives established by the Central Valley Regional Water Quality Control Board (RWQCB) in the Water Quality Control Plan (Basin Plan) (Regional Water Quality Control Board 1998), and

- quantitatively evaluate project effects on aquatic habitat based on changes or trends in streambed and BMI populations downstream of the reservoir (treatment area) relative to changes or trends in unaffected areas (control areas), and

PCWA will use the results of annual monitoring to evaluate project effects and implement appropriate corrective measures if the data indicate that the project is adversely affecting water quality and aquatic resources in the MFAR.

Project Area

Ralston Afterbay is located at the confluence of the MFAR and Rubicon Rivers at an elevation of approximately 1,200 ft. Indian Bar is located immediately downstream of Ralston Dam. The project area includes the MFAR watershed from French Meadows Reservoir (5,200 ft elevation) to the confluence the NFAR (600 ft elevation), the Rubicon River watershed from Hell Hole Reservoir (4,600 ft elevation) to Ralston Afterbay, and the North Fork of the MFAR watershed from its headwaters (6,000 ft elevation) to its confluence with the MFAR (1,000 ft elevation). The North Fork of the MFAR enters immediately downstream of Ralston Dam and Oxbow Powerhouse (figure 1).

Climate

The MFAR watershed is dominated by a Mediterranean-like climate (warm, dry summers and cool to cold, wet winters). Air temperatures vary widely during the year and there is no appreciable precipitation in the summer except for scattered thunderstorms. Average annual precipitation in the form of rain and snow ranges from 60 to 65 inches per year with the majority of it falling between November and April (El Dorado National Forest 2001a). A portion of the watershed lies in the transient rain-on-snow zone, which occurs at elevations between 3,500 and 6,000 ft. Areas experiencing rain-on-snow events are considered to have a higher sensitivity to watershed disturbance than areas with rain- or snow-dominated climates (El Ddorado National Forest 2001a and b).

Geology

The MFAR and North Fork of the MFAR watersheds include 2 different geologic units: the Shoo Fly Complex and the Mehrten formation (California Department of Conservation 1992). The rocks of the Shoo Fly geologic unit, comprising approximately 90% of the watershed, are relatively impermeable (El Dorado National Forest 2001a, b, and c). The Mehrten formation comprises approximately 10% of the watershed.

The Rubicon River watershed includes 5 different geologic units: Paleozoic metasedimentary undifferentiated rocks, the Mehrten formation, Mesozoic granitic rocks, Cretaceous-Jurassic plutonic rocks (gabbro), and glacial moraine deposits (California Department of Conservation 1981 and 1982). Paleozoic metasedimentary undifferentiated rocks, comprising approximately 60% of the watershed, are relatively erodible, and are especially erodible when unvegetated. The Mehrten formation comprises approximately 20% of the watershed. The contact zones between the Mehrten formation and adjacent units are often locations where landslides occur (El Dorado National Forest 2001c). Mesozoic granitic rocks, Cretaceous-Jurassic plutonic rocks, and glacial moraine deposits comprise the remaining 20%.

Soils

The MFAR and North Fork MFAR watersheds contain a diverse set of soils with 6 different soil map units described. The major soils in the watershed are the Hurlbut, Rock Outcrop, and Deadwood series associated with the Shoo Fly Complex and the Waca, Ledmount, and McCarthy series associated with the Mehrten formation. With the exception of Rock Outcrop, these soils have a moderate to very high erosion hazard, depending on the slope.

The Rubicon River watershed contains 7 different soil map units. Major soils in the watershed are the Hurlbut and Deadwood series associated with the Shoo Fly Complex; the Waca, Ledmount, and McCarthy series associated with the Mehrten formation; and the Chaix and Zeibright series associated with the granitic rocks and glacial deposits. These soils have a moderate to very high erosion hazard, depending on the slope.

Vegetation

Vegetation within the MFAR, Rubicon River, and North Fork of the MFAR watersheds consists mostly of mixed conifers with true firs at higher elevations. Major species of mixed conifer include ponderosa pine, sugar pine, incense cedar, white fir, Douglas-fir, big leaf maple, California black oak, and interior live oak. Shrub species include deerbrush, mountain whitehorn, Sierra mountain misery, green leaf manzanita, thimble berry, and Sierra currant.

Hydrology

The MFAR watershed upstream of Ralston Afterbay covers approximately 115 square miles. The nearest U.S. Geological Survey (USGS) flow gage, 10 miles upstream at Interbay Dam, represents flow from 90 square miles of the watershed. Flows in the MFAR are substantially attenuated by upstream reservoir storage facilities, including French Meadows Reservoir. A full-range gaging station was in service 500 feet downstream from Interbay Dam from October 1965 until the February 1986 flood, which destroyed the gaging station. According to the 1985 USGS yearbook, the maximum discharge was 9,900 cfs on January 13, 1980. USGS flow records indicate that the average daily flow in the MFAR is about 50 cfs (Hydrosphere Data Products 2000).

The Rubicon River watershed covers about 315 square miles and provides the majority of flow to Ralston Afterbay with an average daily flow of 332 cfs. The unregulated portion of the Rubicon River watershed extends 32 miles upstream to Hell Hole Reservoir. Flows in this reach exhibit large annual and seasonal variation. An historical peak flow of approximately 300,000 cfs occurred when Hell Hole dam failed in December 1964. The North Fork MFAR has an 92-square-mile watershed and enters immediately downstream of Ralston Dam and Oxbow Powerhouse. The North Fork MFAR is unregulated by reservoirs and contributes a substantial amount of flow to the MFAR with an average daily flow of 285 cfs, a 1% exceedance flow of 2,400 cfs, and a peak flow of 30,100 cfs recorded in 1980.

PCWA operates a flow gage on the MFAR immediately downstream of the North Fork MFAR confluence and upstream of Horseshoe Bar. The flow records for this site indicate that the average daily flow is 1,150 cfs and the 1% exceedance flow is 6,900 cfs. The January 1997 storm was considered to generate peak flows in the American River basin and its tributaries that were nearly as large as the projected 100-year flood event; however, peak flows were not recorded for the Rubicon River, North Fork MFAR, or MFAR at the Horseshoe Bar gage. PCWA estimated the peak 1997 flow passing Ralston Dam to be about 100,000 cfs. The highest recorded peak flow at the Horseshoe Bar gage, excluding the peak caused by the December 1964 Hell Hole Dam failure, was 123,000 cfs on January 2, 1997.

Geomorphology

The MFAR, Rubicon River, and North Fork MFAR are characterize primarily by steep, canyon-bound channels with a step-pool morphology. Average stream gradient ranges from <1% in the lower reaches of the MFAR to 2% in the MFAR and Rubicon River above Raslton Afterbay. Sediment transport capacity in these systems generally exceeds sediment supplied by eroded canyon walls and upper portions of the watershed. Consequently, fine sediments are easily transported through the system even during relatively small storm events. The channel bed consists largely of bedrock, boulders, and cobbles. The presence of these larger bed materials indicates that transport of larger material occurs only during large storm events (Bechtel Corporation 1997). The sediment transport and geomorphic characteristics of the MFAR watershed are further described below.

Sediment Transport and Geomorphic Characteristics of the Middle Fork American River

For large river basins like the MFAR basin, the amount of suspended sediment carried in the river will depend on a number of hydrologic and hydraulic characteristics as well as the source of sediment. Particles larger than 1.0 millimeter (mm) typically travel as bedload sediment close to or on the bottom; particles less than 0.1 mm generally travel suspended in the water as total suspended solids (TSS); particles between 0.1 mm and 1.0 mm may travel as either bedload or TSS. Sediment sources include organic litter on the soil surface, soil erosion, landslides, and other mass wasting of debris, as well as scouring of existing channel substrate. Sediment transport will vary during a storm in relation to rainfall, runoff, and streamflow conditions. As streamflow increases during a storm, the TSS load and associated turbidity carried in the flow will rise and then typically decrease as the storm passes and streamflow starts to recede (Environmental Protection Agency 1991). Bedload sediment may be mobilized and transported only during extremely high and infrequent flows. The MFAR has sufficient gradient and hydraulic energy to transport sediment at a faster rate than the natural rate of sediment input from watershed sources (Harvey pers. comm.). Consequently, there is very little deposition of sediment in the high gradient reaches of the river.

Potential sources of sediment transport to Ralston Afterbay vary in space and time and include the Rubicon Rivers and MFAR, upstream of the reservoir. The project area that may be affected by the proposed project also includes the MFAR downstream of Ralston Dam. Additional sources of sediment to the project area include sediments residing in Ralston Afterbay, the North Fork MFAR, smaller tributaries downstream of the North Fork MFAR, and the downstream slopes of the MFAR canyon. Given the large watershed area and variability in flows and erosion rates, background variation in sediment transport is expected to be large. Bathymetric surveys of Afterbay indicate that about 1,205,000 yds of course and fine sediments currently reside in the reservoir (Bechtel Corporation 1997). The estimated annual rate of accumulation since 1966 was estimated at 56,000 yds annually (EA Engineering, Science, and Technology 1990); however, a more recent evaluation indicates that the annual rate between 1987 and 1995 was only 36,250 yds (Bechtel Corporation 1997). It was presumed that the higher rate in previous years was a result of residual contribution of sediments to MFAR from the 1964 failure of Hell Hole Dam, which released large quantities of sediment to the river (Bechtel Corporation 1997). Current estimates of annual sediment transport in the MFAR downstream of Ralston Afterbay from natural sources are about 11,000 cubic yds of bedload sediment and 18,000 cubic yds of suspended sediment annually (Ayres Associates 1997). Field observations indicate that there is no accumulation of sediment upstream of the tunnel at Horseshoe Bar, suggesting that the existing sediment load passes through the tunnel (Mussetter Engineering 2001).

The quantity of material proposed to be placed at Indian Bar is approximately 48,000 yds. It is unknown how much fine sediment will be transported downstream during SPT operations; however, only about 20% of the total amount of suspended sediment reaching Ralston Afterbay is currently estimated to be deposited in the reservoir (Ayres Associates 1997). Consequently, the amount of sediment affected by the proposed project is a relatively small amount of the total amount transported in the river. Additionally, not all of the sediment stored in Ralston Afterbay or placed at Indian Bar will be transported in any 1 year, so the potential for project-related effects will most likely be further reduced relative to the existing annual sediment transport rates in the river.

The MFAR downstream of Ralston Afterbay is characterized by a steep, canyon-bound channel that is inherently stable and therefore relatively insensitive to changes in discharge and sediment supply (Harvey pers. comm.). In general, the channel form and processes of such rivers are related to infrequent flood events (50-year or greater recurrence interval), structural controls, landslides, human-induced impacts (e.g., hydraulic and placer mining), and discharges that occurred under different climatic regimes. The MFAR exhibits significant bedrock control of channel position, geometry, and gradient. Landslides, rock falls, and tributary-derived debris flows have placed materials with a wide range of sizes in the channel. In addition, mining practices and failure of Hell Hole Dam on the Rubicon River in 1964 (Resource Consultants and Engineers 1993) have modified the terraces and high-elevation boulder bars between Ralston Dam and the North Fork American River (NFAR) confluence.

The MFAR has a step-pool morphology composed of steep, coarse-grained (predominantly bedrock and boulder) reaches interspersed with lower-gradient, alluvial reaches associated with tributary alluvial fans, landslide debris, and bedrock outcrops. These features form localized constrictions that create upstream zones of sediment deposition during flood events. The steeper reaches act as conduits that convey most of the supplied sediment to downstream reaches during floods while the lower-gradient reaches act to temporarily store sediments between flood events. These lower-gradient, alluvial reaches generally exhibit a pool-riffle morphology (alternating pools, riffles, and bars) formed by fine- to coarse-grained alluvial deposits.

Monitoring Approach

The proposed monitoring approach is based on general principles and design of environmental impact studies (e.g., Bernstein and Zalinski 1983, Green 1979). Potential project effects are evaluated by collecting preproject and postproject water quality, aquatic habitat, and BMI data at monitoring sites located upstream and downstream of Ralston Afterbay. The downstream locations serve as treatment sites (areas potentially affected by the project) and the upstream locations serve as control sites (areas unaffected by the project). In this design, preproject (baseline) monitoring of the parameters of interest is conducted to characterize differences or relationships between these parameters in the treatment and control sites before the project begins. After the baseline monitoring period, the project is initiated and monitoring will continue to determine whether the differences or relationships between the treatment and control sites significantly change relative to those measured during the baseline period. Such a change will be evidence of a project effect. This is considered an effective design for detecting environmental impacts because it offers, with proper pairing of treatment and control reaches, a means of separating the effect of a given action from other extraneous sources of variation (e.g., climatic factors).

The monitoring plan proposes acquiring a minimum of 1 year of preproject water quality data and 1–2 years of preproject aquatic habitat and BMI data, followed by 2–3 years of postproject water quality, aquatic habitat, and BMI data. The potential effects of SPT operations and Indian Bar sediment disposal will be monitored concurrently, although the sequence of project activities may permit independent evaluations of these project components. The schedule for postproject monitoring will be subject to the occurrence of SPT operations, significant entrainment of sediment from the Indian Bar disposal site, and an appropriate range of flows for evaluating the performance of sediment disposal relative to model predictions. Accordingly, the target flows for postproject monitoring are 3,500 cfs, 5,000 cfs, and 8,000 cfs. These flows are expected to occur within a reasonable time frame (statistically, every 1 to 3 years), are sufficient to meet the flow threshold for SPT operations (3,500 cfs), and correspond to the flows used to model sediment entrainment from Indian Bar. Because hydrologic conditions needed to achieve these flows cannot be predicted or controlled from year to year, the minimum requirement for postproject monitoring will be the occurrence of at least one year in which flows reach or exceed 3,500 cfs (and SPT operations occur) and at least one year in which flows reach or exceed 8,000 cfs (and SPT operations occur). No post-project habitat or BMI monitoring will be conducted in years following runoff seasons when such events do not occur (e.g., dry years or extended droughts).

The decision to conduct postproject aquatic habitat and BMI monitoring in any given year will also be based on the magnitude of sediment entrainment (i.e., volume of entrained sediment) from Indian Bar following flow events large enough to cause spills over Ralston Dam. Using ground-based surveying techniques, PCWA will survey the Indian Bar sediment disposal site after initial sediment placement (fall 2002) and after each subsequent flow event capable of mobilizing significant quantities of sediment from the site (or after re-grading or moving sediment into the entrainment zone following such an event). The magnitude of sediment entrainment will be determined by PCWA and DFG based on comparisons of photographs of the Indian Bar disposal site (taken at a fixed location) before and after major spill events. If it is concluded that significant entrainment has occurred, the disposal site will be surveyed to document changes in area and cross-section of the site, and to estimate the volume of entrained sediment. Pebble counts (following the methods described in Section 4.1.1 of Bunte and Abt [2001]) will be conducted at the Indian Bar disposal site at the time of surveys to monitor particle size distributions over time.

Monitoring will be terminated after 2–3 sampling events (triggered by the occurrence of the target flows [as described above] necessary to evaluate the performance of sediment disposal relative to model predictions, and following the occurrence of SPT operations and significant entrainment of sediment from Indian Bar) if no significant adverse project effects on water quality, aquatic habitat, and BMI are detected. If such effects are detected, monitoring will be continued for a period of time mutually agreed to by PCWA and DFG to evaluate corrective measures to be implemented by PCWA.

An adaptive monitoring strategy is proposed to address the uncertainties related to the complex behavior of natural river systems. Factors that increase uncertainty and affect the ability of the monitoring program to detect project effects include:

- large natural variability (both spatial and temporal) in water quality, aquatic habitat, and BMI populations and communities;
- lack of sufficient baseline data and limited time frame in which to characterize preproject variability in the monitoring parameters; and
- local variation in flows, sediment loads, and sediment transport capacity that may differentially affect the monitoring parameters in the treatment and control areas.

Detecting the effect of a given management activity on water quality and aquatic habitat requires a demonstration that the change lies outside the normal range of the variable and that the change is attributable to the management activity. Thus, sufficient preproject data are required to adequately characterize preproject conditions and provide a meaningful basis for detecting project effects. In addition, because habitat monitoring sites will be located downstream of the project area and will be influenced by other sediment sources (North Fork MFAR and smaller tributaries), establishing a link between observed changes and the project may be difficult. Accordingly, monitoring data will be analyzed regularly to evaluate the monitoring program and determine whether any modifications can be made to improve its overall effectiveness.

A primary objective in developing the monitoring approach was to maximize the ability of the monitoring program to detect project effects. Accordingly, knowledge of hydraulic, sediment transport, and channel characteristics of the MFAR watershed will be used to select monitoring sites that are most sensitive to changes in sediment loads. Concurrent monitoring of several key water quality, aquatic habitat, and BMI parameters will also provide a more comprehensive and reliable indicator of overall trends in sediment and habitat conditions than 1 or 2 parameters alone. To further address uncertainty, the relative effects of the sediment management program will be evaluated in the context of other management activities or disturbances in the watershed. This task will involve continued coordination with federal, state, and local resource agencies to gather and update information on land management activities and watershed events (e.g., fires, landslides) that may significantly affect sediment loads in the MFAR, North Fork MFAR, and Rubicon Rivers.

After project activities begin, evidence for project effects will consist of significant changes (adverse or beneficial) in the relationships or differences between key water quality and aquatic habitat parameters established between treatment and control sites before project activities begin. If these changes constitute an adverse effect on water quality and aquatic habitat conditions downstream of Ralston Dam, the magnitude of these changes will be compared with established water quality and habitat thresholds to evaluate project performance and determine whether corrective actions are warranted. The need for corrective actions will also be based on the results of BMI monitoring, which will serve as a key indicator of the biological effects of observed water quality and habitat changes. In addition, these changes will continue to be evaluated in light of other watershed events and trends that may influence the monitoring results and conclusions.

A current limitation in determining an optimum sampling design and appropriate statistical model for detecting project effects is the lack of sufficient baseline data to adequately characterize natural variability in water quality, aquatic habitat, and BMI communities in the project area. Therefore, as more data become available, the monitoring program will continue to be evaluated to determine whether any changes in the sampling design or methods are warranted to improve the program's ability to achieve the objectives.

Water Quality and Aquatic Resources Monitoring Plan

Water Quality Monitoring

Objectives

The water quality monitoring program is designed to monitor project compliance with the water quality objectives established by the RWQCB in the Water Quality Control Plan (Basin Plan) (Regional Water Quality Control Board 1998). The Basin Plan objectives constitute allowable changes in water quality from project-related disturbances. Therefore, the main objectives of the monitoring program include quantifying water quality differences between sampling stations located upstream and downstream of Ralston Afterbay and ensuring that project-related changes in TSS and turbidity do not exceed the applicable Basin Plan water quality objectives. The water quality monitoring program will be most useful for evaluating project-related effects from SPT operations. SPT operations have a greater likelihood of affecting fine sediment transport that travels as suspended material because coarse material settles out at the upper end of the reservoir. Placement of reservoir sediments at Indian Bar is presumed to have little effect on background concentrations of suspended sediment because excavated reservoir sediments will consist mostly of coarse material that will be transported as bedload. The effects of the project on the coarser material traveling as bedload sediment will be addressed by the habitat monitoring program.

The RWQCB Basin Plan includes numerical water quality objectives for turbidity; however, there are no numerical standards for TSS. The narrative water quality objective for suspended sediment states that the load and discharge rate shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses. The turbidity water quality objectives vary in relation to the background levels as follows:

- where natural turbidity is between 5 and 50 nephelometric turbidity units (NTUs), increases shall not exceed 20%;
- where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs; and
- where natural turbidity is greater than 100 NTUs, increases shall not exceed 10%.

These objectives will serve as thresholds for evaluating project performance. Accordingly, the water quality monitoring results will be used to test the following null hypotheses.

- **H_0:** During SPT operations, increases in turbidity downstream of Ralston Dam do not exceed 20% of ambient levels when natural turbidity is between 5 and 50 NTUs.
- **H_0:** During SPT operations, increases in turbidity downstream of Ralston Dam do not exceed 10 NTUs of ambient levels when natural turbidity is between 50 and 100 NTUs.
- **H_0:** During SPT operations, increases in turbidity downstream of Ralston Dam do not exceed 10% of ambient levels when natural turbidity is greater than 100 NTUs.

Based on limited TSS data available for the MFAR, background conditions may vary considerably during storm events and all 3 ranges of the numerical turbidity objectives may apply to the proposed project. Preproject monitoring will be conducted to establish this range and determine the relationship between turbidity and TSS at stations upstream and downstream of Ralston Afterbay.

Monitoring Parameters

Turbidity levels are generally correlated to the TSS concentrations, typically accounting for roughly 80% of the variability observed in simultaneous TSS measurements (Environmental Protection Agency 1991). The relationship between turbidity and TSS values is not typically linear and must be determined on a site-specific basis because the relationship can vary as a result of storm size, water color, organic matter, and algae growth. Collecting TSS samples that accurately represent average river conditions depends on hydraulic characteristics such as current patterns, flow velocity, and eddies. A composite sample collected over vertical and lateral intervals in the channel will typically provide a better representation of the average river TSS concentration than a single sample (Environmental Protection Agency 1985).

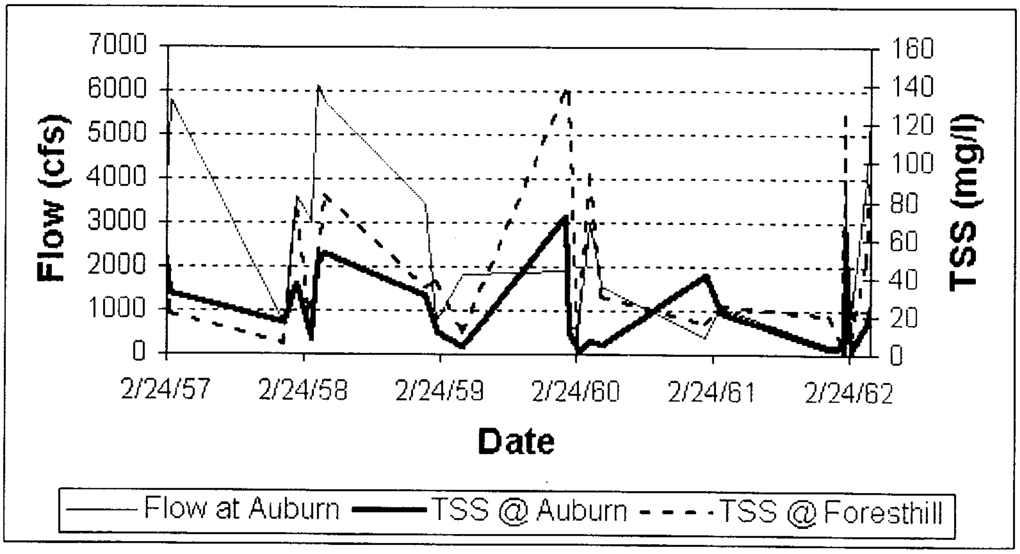
Turbidity measurements are less sensitive to the sampling location because turbidity is primarily a function of finer materials (silt and clay) that are more readily held in suspension and evenly distributed throughout the water. The time required to transport samples to a lab and conduct the analytical procedures for TSS effectively precludes its use as a real-time monitoring tool. Given the practical limitations of TSS sampling methods, need for correlation analysis with turbidity, and lack of regulatory objectives, this monitoring program will be focused on intensive automated turbidity monitoring; TSS data will be collected on a supplemental basis. The site-specific relationship between turbidity and TSS will be determined after sufficient monitoring data have been collected.

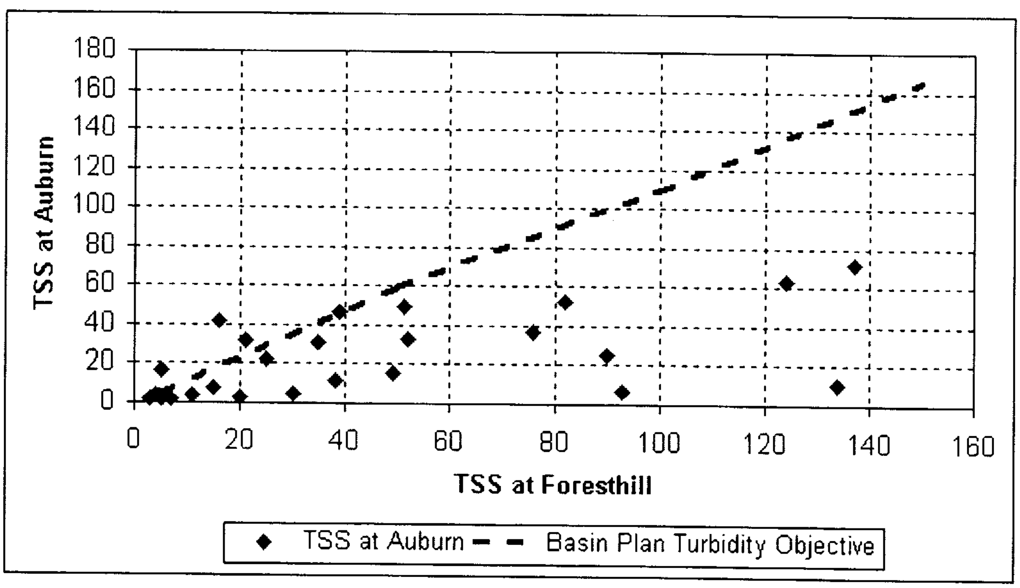
Few water quality data are available for the MFAR downstream of Ralston Dam. Simultaneous grab sample data for TSS are available from the MFAR at Foresthill and Auburn (47 miles downstream) for 25 scattered dates, collected during high flow periods between the years 1956 and 1962 (EarthInfo 1993). Other scattered grab samples are available up to 1985. Given that flow and TSS data are available for a variety of years with differing precipitation patterns, the available data may provide a reasonable estimate of the range of conditions that will be observed under current conditions and when the proposed project is implemented. The data represent sediment transport that is affected by several primary watersheds within the project area, including the Rubicon River (315 square miles), MFAR above Ralston Afterbay (94 square miles), and NMFAR (92 square miles) watersheds. Streamflow and TSS values at Foresthill and Auburn are reasonably correlated with each other (figure 2). TSS values range up to a maximum of about 120 milligrams per liter (mg/l), and values at Auburn are generally lower than at Foresthill. Table 1 presents descriptive statistics for TSS data from all MFAR sample dates. The maximum value recorded at Foresthill and Auburn of 397 mg/l and 537 mg/l, respectively, are considerably larger than the paired data in figure 2. The coefficient of variation (i.e., standard deviation/mean) is large and indicates that variability in the values is high.

Table 1. Summary Descriptive Statistics for TSS Data in MFAR

Statistic	MFAR at Foresthill (mg/l)	MFAR at Auburn (mg/l)
Mean	54.6	45.6
Median	30.0	12.0
Standard deviation	71.3	85.5
Minimum	2	1
Maximum	367	537
95% confidence interval of mean	± 25.3	± 19.7
Sample Size	33	75

Real-time automated turbidity monitoring data will serve as the primary tool for evaluating water quality conditions during SPT operations. Appropriate numerical turbidity objectives for long-term evaluation of water quality conditions during SPT were estimated from the variability in existing TSS data for the MFAR. Numerical data quality objectives are generally stated in terms of a specific level of precision and confidence that is desired in the collected data. Based on the Basin Plan objectives for allowable project-related increases in





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Source: Earth Info Inc. 1993

Jones & Stokes

Figure 2
Flow and TSS in the Middle Fork of the American River

turbidity and lack of existing turbidity values for the MFAR, the monitoring program may need to be able to detect differences between upstream and downstream samples as low as 5 NTUs. Consequently, turbidity monitoring is designed to produce data capable of detecting differences of 5 NTUs with a 95% confidence level. Data will be collected that are sufficient to identify differences in TSS with a precision of 30 mg/l at a 95% confidence interval. Approximately 70–100 samples per year for the range of flows shown in table 1 may be needed to detect significant annual differences between upstream and downstream samples at this recommended level of precision.

Sampling Design

Table 2 presents sampling locations and protocols for the water quality monitoring program, including collection schedule and sampling methods. Figure 3 shows the location of the water quality monitoring stations. It is hypothesized that during SPT operations, water quality conditions will not differ appreciably between upstream and downstream monitoring stations. Therefore, this monitoring program is designed to evaluate the proposed sediment management activities and ensure that adverse water quality effects do not occur. An initial 3-year monitoring period is recommended, consisting of 1 year of preproject monitoring followed by 2 years of monitoring to evaluate the water quality effects of SPT operations. The need for follow-on monitoring after year 3 will be evaluated after the initial data are collected and evaluated. Preproject monitoring data will be used to develop relationships between turbidity and TSS concentrations at stations upstream and downstream of Ralston Afterbay.

To obtain as many data values as possible during storm events and SPT operations, turbidity will be monitored on a real-time basis with automated sensors that can collect data at any desired time interval and relay the data by telemetry to the Ralston Powerhouse and PCWA's Foresthill office. Two sampling locations were selected for installation of automated turbidity monitoring probes to provide the primary compliance monitoring data. The Rubicon River, approximately 200 feet upstream from the Ralston Powerhouse (which is generally discharging about 1,000 cfs to the river), will serve as the primary upstream sample site. The Rubicon River has the largest contributing watershed and generates most of the sediment input to the reservoir (Bechtel Corporation 1997). PCWA's river-gaging station immediately upstream of Horseshoe Bar will serve as the principal downstream compliance monitoring location. The Horseshoe Bar gaging station records river stage and has a telemetry unit with radio link to Ralston Powerhouse. The gage can also be monitored from PCWA's Foresthill office.

Supplemental grab samples will be collected for both turbidity and TSS in the MFAR upstream of Ralston Afterbay at the bridge crossing, MFAR bridge crossing, and in the MFAR between Ralston Dam and the Oxbow Powerhouse tailrace. Samples for TSS will be collected manually by field personnel. Grab sample locations will serve as additional indicators of water quality conditions during the initial years of monitoring and allow site-specific correlation between turbidity and TSS values.

Table 2. Summary of Water Quality Monitoring Locations, Schedule, and Methods

		Constituents Monitored & Frequency of Activity		
		Total Suspended Solids (Grab Samples Only [1])	Turbidity	
Monitoring Locations	Schedule of Sampling Activities		Grab Samples [1]	Automated [2]
Rubicon River	Year 1 preproject monitoring	X		X
Upstream from Ralston Powerhouse				
	Years 2 & 3 monitoring	X		X
	After year 3 follow-on monitoring	X (as needed)		X (as needed)
MFAR Upstream from reservoir at bridge	Year 1 preproject monitoring	X	X	
	Years 2 & 3 monitoring	X (as needed)	X (as needed)	
MFAR Upstream from Oxbow Powerhouse tailrace	Year 1 preproject monitoring	X	X	
	Years 2 & 3 monitoring	X (as needed)	X (as needed)	
North Fork of the MFAR at bridge	Year 1 preproject monitoring	X	X	
	Years 2 & 3 monitoring	X (as needed)	X (as needed)	
MFAR at Downstream gage house	Year 1 preproject monitoring	X		X
	Years 2 & 3 monitoring	X		X
	After year 3 follow-on monitoring	X (as needed)		X (as needed)

[1] Grab samples for turbidity and total suspended solids (TSS) will be collected at a minimum of 4-hour intervals during storm events when water level is rising and starting when streamflow is 3,000 cfs or greater. Sampling should be targeted to include sufficient storm events that provide data from as wide a range of high streamflows as possible. Sampling in successive years should be targeted at storm events that generate flow conditions similar to those sampled during the pre-project monitoring.

[2] Automated turbidity probe and telemetry system can be adjusted as needed based on available battery power. Data will be monitored during storm events and downloaded by telemetry at a minimum of 4-hour intervals. Turbidity recorders need be used only during storm events and at a frequency sufficient to generate at least 70 samples per year. Sampling should be targeted to include sufficient storm events that provide data from as wide a range of streamflows in excess of 3,000 cfs as possible. Sampling in successive years should be targeted at storm events that generate similar flow conditions similar to those sampled during the pre-project monitoring.

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Figure 3
Aquatic Habitat/Benthic Macroinvertebrate (Reaches 1-7)
Water Quality (WQ1-5)Monitoring Sites in Reaches 1 and 2

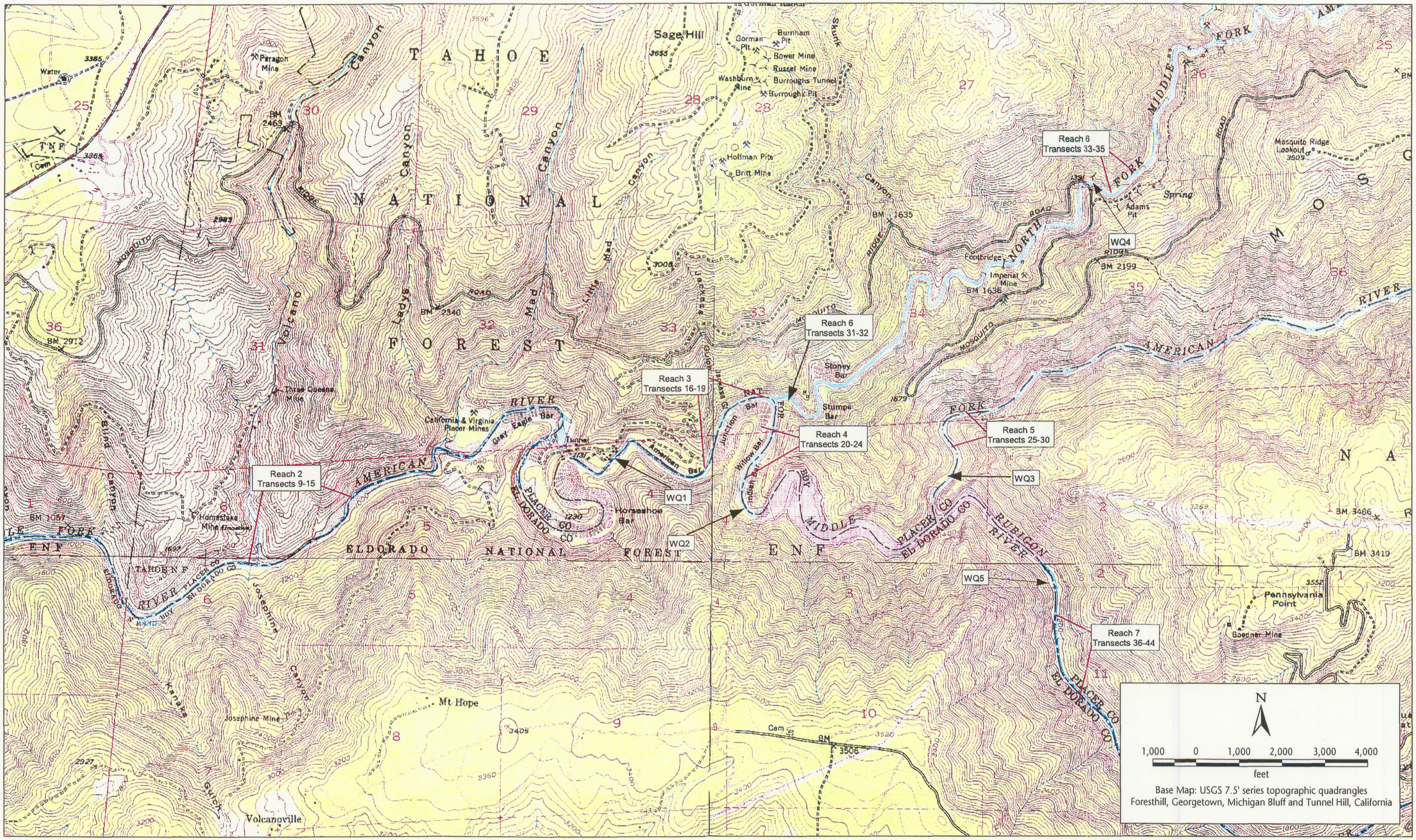

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Figure 3 (continued)
Aquatic Habitat/Benthic Macroinvertebrate (Reaches 1-7) and Water Quality (WQ1-5) Monitoring Sites

If the initial monitoring data indicate that turbidity and TSS data are closely correlated and turbidity measurements are effective for monitoring compliance of SPT operations, compliance monitoring for TSS will be discontinued and the real-time turbidity data will be used as the primary indicator for SPT operations compliance. The TSS data will be used primarily for long-term evaluation of SPT operations and for additional confirmation of real-time water quality conditions as indicated with the automated turbidity sensors.

SPT operations will commence when river flows exceed 3,500 cfs. Therefore, preproject monitoring of turbidity and TSS will be conducted when storms generate river flow rates that exceed 3,000 cfs. Preproject data for low flow events will not be conducted because natural variability in TSS and turbidity will be much lower and not representative of conditions during SPT operations. Both automated turbidity and grab sample data will be collected at a minimum of 4-hour intervals during storm events commencing when streamflows begin to rise and ceasing when the hydrograph has begun to recede or SPT operations are discontinued, whichever occurs first. The trigger for commencing sample collection can be water level in the reservoir or flow at the Horseshoe Bar gage. An additional automated water level recorder is recommended for the Rubicon River site to determine when streamflow starts to increase during storm events and provide time to prepare for the necessary manual sampling activities. This gage does not have to be an approved USGS-type stilling well. The system can be a simple enclosure with a pressure transducer for monitoring water level. A flow-rating curve does not need to be calculated. For monitored storm-flow events, sampling should be targeted to include data from as wide a range of streamflows as possible that exceed 3,000 cfs. Sampling in successive years should be targeted to storm events that generate flow conditions similar to those sampled during the preproject monitoring.

During SPT operations, PCWA staff will monitor the real-time upstream and downstream turbidity monitoring data to evaluate compliance of operations with Basin Plan water quality objectives. All grab sample data collected at field sites will be recorded on a field data form. TSS and turbidity samples will be collected by hand using an appropriate bottle sampling device (e.g., Van Dorn, Kemmerer). Sample bottles will be specified by the laboratory performing the analyses. Samples will be analyzed to provide the lowest practical detection limit for TSS (less than or equal to 5 mg/l) and turbidity (less than or equal to 1 NTU). Field samples will be refrigerated for sample preservation and shipped to a commercial laboratory after each sampling event. A field blank of deionized water and field duplicate samples should be collected once for every 20 samples, with a minimum of 1 replicate per storm event. Automated turbidity probes installed at the Rubicon River and Horseshoe Bar sites will have a minimum detection limit of 1% of full-scale reading. The probe should be capable of measuring a range of turbidity measurements up to 500 NTU.

Data Analysis

Standard data control charting methods will be used to identify the rate and direction of change in real-time turbidity concentrations in the river and detect significant excursions from the Basin Plan water quality objectives. Supplemental information regarding TSS concentration conditions will be evaluated from the grab sample data. The long-term performance of SPT operations with respect to water quality objectives will be evaluated with standard statistical testing of the mean differences between preproject and postproject conditions. Linear regression analysis will also be used for year-to-year evaluations of project-related effects on water quality based on the relationship between values collected at the primary upstream and downstream sample sites. If routine patterns of turbidity and TSS in the tributary streams are constant over the duration of the monitoring program, regression analysis will allow the detection of changes between the Rubicon and the Horseshoe Bar gaging site attributable to the project without explicitly evaluating changes in the tributaries. Consequently, until the initial data collected from the tributaries prove otherwise, it is assumed that the automated turbidity data will be sufficient to establish a statistically significant relationship reflecting differences in water quality conditions between the upstream and downstream sites.

Following collection of the first year of pre-project data, results will be evaluated for statistical variability in turbidity and TSS concentrations. Descriptive and exploratory analysis of the data will be necessary to ensure that the proper statistical tools are applied to the analyses. Issues that may need to be addressed include transformation of data to approximate a normal data distribution and evaluation for autocorrelation among the data points. The estimated number of samples necessary to achieve the desired data quality objectives will be confirmed. Following the second and third years of data collection, means testing and linear regression analysis of turbidity and TSS data will be conducted to identify the differences between preproject and postproject data and the statistical significance of the differences. Adjustments to the data based on related variables such as background TSS and turbidity concentrations or streamflow may be used to improve the sensitivity of the data analyses.

The procedures for determining water quality conditions necessitating corrective actions will be defined in advance in coordination with RWQCB and California Department of Fish and Game (DFG). When the data indicate that downstream turbidity values exceed the water quality objectives, possible corrective actions may include immediately taking additional samples for both turbidity and TSS to provide additional data on the water quality conditions. If SPT operations are presumed to be causing a water quality compliance problem, other possible corrective actions may include reducing the flow through the gates, increasing flow through the spillway gates, or both. As a final action, the low level outlet gate may be closed to cease SPT until more favorable conditions occur. The procedure for ceasing and restarting SPT operations will also be defined before starting SPT.

Two issues described below merit consideration when interpreting project-related water quality monitoring data for SPT operations and to avoid taking corrective actions when they are not necessarily warranted: (a) evaluating effects of water residence time in the reservoir at varying levels of streamflow; and, (b) evaluating the direction of change in turbidity and TSS concentrations.

- **Hydraulic residence time:** Based on the volume of the reservoir, the residence time of a slug of water passing from the upper end of the reservoir to the downstream end will be short at high flows (approximately 40 minutes at 50,000 cfs) and samples collected simultaneously at upstream and downstream locations will presumably be adequately comparable to each other. When SPT operations first begin at a flow of 3,500 cfs, however, the residence time will be approximately 10 hours. TSS values typically rise and fall in correlation with streamflow. Therefore, it is likely that when upstream turbidity concentrations start to decrease as the stormflows recede, simultaneous measurement made downstream may indicate continued increasing concentrations and regulatory exceedances because of the time delay of previously high turbidity water moving downstream. In order to account for water residence time in the reservoir, data charting procedures should account for the time delay at varying flow rates to establish whether an exceedance in the thresholds is truly occurring. The transport time can be reasonably predicted with empirical calculations from bathymetric profile data of the reservoir. In addition, dye tracer tests can be conducted to more accurately characterize flow through the reservoir. The need for dye tracing will be evaluated after the first year of monitoring to determine whether such precision is necessary for the program.
- **Direction of changes in monitored constituents:** As noted above, TSS will typically rise and fall with the streamflow pattern. Following the passage of peak flows and corresponding TSS and turbidity transport during storm events, high variability in upstream and downstream TSS and turbidity may continue despite an overall decreasing trend in their values. Consequently, the absolute differences between upstream and downstream values during the receding period of a storm event may exceed the numerical water quality objectives. Compliance evaluations should account for whether the concentrations at upstream and downstream locations are rising or falling when interpreting the data with respect to this criteria. If concentrations are decreasing overall, yet downstream values are higher, it will indicate that the flush of sediment resulting from initial mobilization and transport is nearing completion. Concentrations at this point in the storm may be relatively low compared to the higher peak values occurring earlier in the storm and should not constitute a violation of the water quality objectives.

Aquatic Habitat Monitoring

Objectives

The primary objective of aquatic habitat monitoring is to quantitatively evaluate project effects on aquatic habitat based on changes or trends in key substrate and BMI parameters upstream and downstream of Ralston Afterbay. The results will be used to test the following null hypothesis:

- **H_0:** Differences between mean substrate size in the treatment reaches and that in the control reaches during preproject years do not change during postproject years.

This hypothesis also may be stated as follows:

- **H_0:** The relationship between mean substrate size in the treatment reaches and that in the control reaches during preproject years does not change during postproject years.

Rejection of either hypothesis will be evidence of significant project effects (adverse or beneficial). The biological significance of these changes will be evaluated based on the general trout- and BMI-substrate relationships and observed changes in BMI population or community attributes measured in the treatment and control reaches.

Stream and laboratory studies have shown that excessive amounts of fine sediments can adversely affect aquatic habitat and the capacity of that habitat to support trout and aquatic invertebrates. Although the results vary with species, life stage, and season, significant declines in fish and aquatic invertebrates were generally associated with riffles in which 50% or more of the coarse particles (gravels and larger materials) were covered or surrounded by fine sediment (embeddedness). This level will serve as a preliminary threshold for evaluating habitat quality during the preproject monitoring period. Additional years of preproject data will be necessary to adequately characterize annual variation in substrate conditions and establish an impact threshold (i.e., change in substrate conditions) that would trigger the need for corrective actions. This impact threshold will also be based on the results of BMI monitoring and any observed relationships between the BMI parameters and substrate conditions during the preproject monitoring period.

The BMI monitoring data will indicate seasonal and annual patterns of abundance, composition, and diversity associated with the ecology and natural history of BMI communities. These patterns will be compared from year to year to detect any change or shift that would indicate a response to an environmental change. More importantly, BMI monitoring will be useful in evaluating the biological effects (beneficial or adverse) of any changes in water quality and substrate conditions observed during the monitoring program.

In addition to monitoring the size composition of riffle substrates, the U.S. Forest Service and DFG requested monitoring of channel cross sections downstream of Ralston Afterbay to detect potential deposition of sediment in pools during the postproject monitoring period. The U.S. Forest Service also requested that water temperature loggers be installed upstream and downstream of Ralston Afterbay.

Monitoring Parameters

Substrate size composition and embeddedness will be used as key monitoring parameters for assessing project effects on aquatic habitat. These parameters were selected because they are sensitive indicators of changes in sediment loads, can be rapidly measured in the field, and provide a direct or indirect measure of factors known to affect the abundance and production of fish and invertebrates in streams.

Substrate Size Composition

The size composition of streambed substrates is a major factor determining the quality of stream habitat for trout and aquatic invertebrates. Changes in substrate size can affect the productive capacity of trout streams by affecting the suitability of substrate for spawning, the availability of suitable cover and shelter for juvenile and adult trout, and the amount of living space for aquatic invertebrates (Waters 1995, Bjornn and Reiser 1991).

Substrate Embeddedness

Embeddedness is the percentage to which coarse sediments (gravel and larger particles) are surrounded or covered by fine sediment (silt/clay and sand). This parameter provides a measure of the amount of interstitial space between coarse sediments and thus reflects the suitability of the streambed for incubation, emergence, and overwintering of trout, and the amount of living space for BMI. Excessive amounts of fine sediments and embeddedness have been shown to affect the abundance of juvenile salmonids and aquatic invertebrates in laboratory and natural streams (Hillman et al. 1987, Bustard and Narver 1975, Bjornn et al. 1977). Although the results vary depending on species, life stage, and season, a general observation was that significant declines in fish and invertebrate abundance were generally associated with embeddedness levels of 50% or more.

Sampling Design

Because of the high degree of spatial and temporal variability in habitat conditions in natural river systems, several criteria were developed to guide selection of monitoring sites. These criteria were based on the need to minimize differences between treatment and control sites, increase sampling efficiency, and maximize the ability of the monitoring program to detect potential project effects. Foremost among these criteria is the need for all monitoring sites, especially those that serve as primary treatment and control reaches, to be equally sensitive to changes in sediment loads and respond similarly to these changes. Second, monitoring sites should have similar channel and substrate characteristics that provide important aquatic habitat for trout and aquatic invertebrates. Third, monitoring sites should be located as close as possible to Ralston Afterbay to reduce the confounding effects of other sediment sources (e.g., tributaries). Finally, as a practical consideration, all sites should be accessible and provide safe conditions for field measurements.

Based on the hydraulic and sediment transport characteristics of the river, these criteria appear to best be met by localized alluvial portions of the river where sediment deposition occurs in response to local channel and valley constrictions that include tributary alluvial fans, landslide debris, and bedrock constrictions (Mussetter Engineering 2001). Mussetter Engineering identified 5 such reaches between the Ralston Dam and the North Fork of the American River confluence (table 3).

Before selecting monitoring sites, a Jones & Stokes fisheries biologist will conduct an aerial survey of the MFAR by helicopter to examine the 5 reaches identified by Mussetter Engineering and identify other potential treatment and control reaches upstream and downstream of Ralston Afterbay. The aerial survey will include the first 5 miles of the MFAR and Rubicon River upstream of Ralston Afterbay, the MFAR from Ralston Dam to Louisiana Bar, and the lowermost 5 miles of the North Fork MFAR. The goal of this initial survey is to evaluate the suitability of potential treatment and control reaches based on the criteria presented above. Preference will be given to those reaches that are closest to the project area and are reasonably accessible by foot. All potential monitoring reaches will be delineated on 7.5-minute topographic maps. Photographs will be taken of representative portions of the potential monitoring reaches.

Table 3. Locations and Characteristics of Hydraulic Controls for Sediment Transport in the Middle Fork of the American River

Location	River Mile	Comments
Louisiana Bar	50.4	Pool and riffle upstream of bedrock control; road accessible
Mammoth Bar	52.4	Pool and riffle upstream of bedrock constriction at Murderer's Gulch; road accessible
Cherokee Bar	59.0	Head of alluvial reach that extends from Greenwood Bridge to Mammoth Bar; pools and riffles; road accessible
Canyon Creek	61.44	Pool formed by alluvial fan constriction and backwater from Ruck-A-Chucky landslide; not road accessible but can be reached by track in about 20 minutes
Other sites:		
Otter Creek	64.65	Pools and riffles upstream of alluvial fan-induced contractions; neither site is readily accessible but they are closer to Ralston Dam.
Volcano Creek	71.4	

Note: River mile 50.37 is the confluence with the North Fork of the American River.

Table 4 presents the proposed locations and schedule for aquatic habitat and BMI monitoring. Two reaches will be established immediately downstream of Ralston Afterbay between the dam and the confluence of the North Fork MFAR and between the confluence of the North Form MFAR and Horseshoe Bar. These reaches will be used primarily to evaluate changes in substrate composition associated with coarse sediment input from the Indian Bar disposal site. One or more treatment reaches will be established on the MFAR downstream of Horseshoe Bar to evaluate potential changes in fine and coarse sediment associated with SPT operations and Indian Bar sediment disposal. One or more control areas will be established on the Rubicon River upstream of Ralston Afterbay, the MFAR upstream of the reservoir, and on the North Fork MFAR.

Table 4. Summary of Aquatic Habitat and BMI Monitoring Locations, Activities, and Schedules

<table>
<tr><th>Monitoring Reach</th><th>Purpose</th><th>Aerial Survey and Monitoring Reach Selection</th><th>Monitoring Site Selection</th><th>Field Measurements</th></tr>
<tr><td>Rubicon River upstream of Ralston Powerhouse</td><td>Control for SPT operations</td><td rowspan="6">Conduct in first year of preproject monitoring period and in subsequent years only if warranted</td><td rowspan="6">Conduct in first year of preproject monitoring period and in subsequent years only if warranted</td><td rowspan="6">Sample in 2–3 preproject years and 2–3 postproject years following each occurrence of SPT operations.
Schedule subject to change depending on project schedule, the occurrence of SPT-triggering flows, and the occurrence of significant sediment entrainment from Indian Bar.</td></tr>
<tr><td>MFAR upstream of Ralston Afterbay</td><td>Control for SPT operations</td></tr>
<tr><td>MFAR between Ralston Dam and North Fork of the MFAR</td><td>Treatment for Indian Bar sediment disposal</td></tr>
<tr><td>MFAR between North Fork of the MFAR and Horseshoe Bar</td><td>Treatment for SPT operations and Indian Bar sediment disposal</td></tr>
<tr><td>North Fork of the MFAR</td><td>Control for SPT operations and Indian Bar sediment disposal</td></tr>
<tr><td>MFAR downstream of Horseshoe Bar</td><td>Treatment for SPT operations and Indian Bar sediment disposal</td></tr>
</table>

Following selection of monitoring reaches, ground surveys will be conducted to more closely examine the reaches and identify specific habitats that meet the selection criteria above. Riffles will likely be key habitats because they are considered relatively sensitive indicators of bed conditions, provide important habitat for trout and invertebrates, and allow safe conditions for collecting substrate data across the entire channel.

Aerial surveys and monitoring site selection will be conducted in the first year of preproject monitoring. Substrate sampling will be conducted in the first year of preproject monitoring and in subsequent preproject and postproject years. Because substrate conditions are not expected to change significantly after winter and spring storm events, substrate sampling will be conducted once a year during the summer or fall when flows are low enough to permit sampling. Sampling will be conducted at the same time each year to minimize the effects of possible seasonal changes in fine sediments.

Preproject monitoring should begin as soon as possible and be conducted in selected years during the preproject monitoring period to characterize baseline variation in substrate conditions among and within reaches. Ideally, preproject data should include measurements of streambed conditions following flow events equal in magnitude and duration to those that will trigger SPT operations. A minimum of 2–3 years of preproject monitoring may be necessary to provide a meaningful basis for evaluating potential changes in substrate conditions during postproject years.

Monitoring of project effects will be conducted in 2–3 sampling events triggered by the occurrence of the target flows necessary to evaluate the performance of sediment disposal relative to model predictions, and following the occurrence of SPT operations and significant entrainment of sediment from Indian Bar (see Monitoring Approach).

Substrate Composition and Embeddedness

Five to 10 riffles will be established as monitoring sites in each reach. All riffles or a random sample of riffles in each reach will be selected for monitoring. Two transects will be established at each riffle. One transect will be established at a random location in the upstream third of the riffle, and the other transect will be established in the riffle crest or pool tail (immediately upstream of the head of the riffle) in an area equal in length to one-third the riffle length.

Field measurements of substrate composition and embeddedness will follow the methods described by Bain (1999). The location of each transect will be marked with paint and flagging above the high-water mark. Cloth or metal measuring tapes will be suspended above the wetted channel (perpendicular to the channel) between 2 metal stakes secured at the edge of the low-flow channel. Substrate composition will be measured with a 1-meter (m) metal ruler, divided into ten 10-centimeter (cm) sections painted contrasting colors. The first sampling location along each transect will be selected randomly and subsequent locations selected at regular intervals from the first. Sampling locations will be separated by at least 1 m. A maximum of 15 sampling locations will be evenly distributed across the transect, depending on channel width.

At each sampling location, the ruler will be lowered across the stream substrate (perpendicular to the current) and the dominant substrate class under each 10-cm segment will be recorded using the modified Wentworth scale (table 5).

Table 5. Modified Wentworth Classification of Substrate Types by Size

Substrate Type	Particle Size Range (millimeters)	Code
Silt and clay	<0.059	0
Sand	0.06–1	1
Gravel	2–15	2
Pebble	16–63	3
Cobble	64–256	4
Boulder	>256	5

Embeddedness will be visually determined at each transect by examining the coarse sediments (gravel, pebble, cobble, boulder) in the deepest portion of the channel and recording the dominant level of embeddedness (table 6).

Table 6. Embeddedness Rating for Stream Channel Materials*

Level of Embeddedness	Description	Code
Negligible	Gravel, pebble, cobble, and boulder particles have <5% of their surface covered by sediment.	0
Low	Gravel, pebble, cobble, and boulder particles have 5–25% of their surface covered by sediment.	1
Moderate	Gravel, pebble, cobble, and boulder particles have 25–35% of their surface covered by sediment.	2
High	Gravel, cobble, and boulder particles have 50–75% of their surface covered by sediment.	3
Very High	Gravel, pebble, cobble, and boulder particles have >75% of their surface covered by sediment.	4

* Fine sediment includes materials less than 2 mm in diameter: sand, silt, and clay.

As requested by DFG, pebble counts will be evaluated as an alternative method for assessing the size composition of riffle substrates. In fall 2002, pebble counts (following the methods described in Section 4.1.1 of Bunte and Abt [2001]) will be conducted at existing transects in addition to the Bain method. A square-holed template will be used to measure substrate particles based on the standard Wentworth scale (rather than the modified scale used in 2001). The embeddedness of gravel and larger material will be measured as the percentage of the total vertical extent of a particle below the bed surface. Following data collection, Jones & Stokes and DFG will compare the particle size distributions resulting from the two methods. If the particle size distributions produced by the Bain method are reasonably consistent with those produced by the pebble count method, the Bain method will continue to be used to characterize riffle substrates. Otherwise, the pebble count method will be used for the remainder of the monitoring program.

Channel Cross-Sections

Standard surveying techniques will be used to measure channel cross-sections at several pools upstream and downstream of Ralston Afterbay during pre- and postproject monitoring years to detect potential changes in pool habitat that may occur following project activities. Pool cross-sections will be measured at three representative pools downstream of Ralston Dam (in Reaches 1 and 2) and three representative pools above Ralston Afterbay in the Rubicon River (Reach 7). Two to three transect locations will be established in each pool depending on the variability in channel profile along the length of the pool. All transect locations will be marked in the field with permanent markers and recorded with global positioning system unit. Channel cross sections will be measured in October when flows are at minimum levels (100 cfs, approximately).

Water Temperature

Automated water temperature loggers will be installed above and below Ralston Afterbay near the proposed water quality monitoring stations (MFAR at Horseshoe Bar gage, MFAR above Ralston Afterbay, North Fork MFAR, and Rubicon River. The loggers will be programmed to continuously record water temperatures at hourly intervals. The loggers will be installed in July 2002 and the data will be downloaded in the field every three months.

Data Analysis

Substrate composition and embeddedness data will be analyzed quantitatively using statistical techniques developed for control-treatment designs (e.g., Bernstein and Zalinski 1983). As discussed earlier, the applicability of the proposed design depends on proper pairing of the treatment and control reaches and sufficient preproject data to characterize the differences or relationship between streambed conditions in these reaches. Alternatively, the data can be analyzed graphically using descriptive statistics (e.g., means, confidence intervals) and/or regression techniques to characterize trends in streambed parameters over time (e.g., Adams and Beschta 1980).

Because the sampling design may not be able to effectively discern project effects from those of other sediment sources in the MFAR watershed, it will be necessary to complement the monitoring program with additional information to assess the relative magnitude of effects related to SPT and other sources. For example, bathymetric surveys of Ralston Afterbay before and after SPT operations will provide valuable information on the preproject and postproject quantities of fine sediment in the reservoir. In the event that a large amount of sedimentation is detected downstream of Ralston Dam, bathymetric surveys will provide a measure of net changes in reservoir sediment conditions, which will help assess the extent to which SPT operations contributed to the supply of fine sediment. The data then may help in the assessment of whether any net contribution to fine sediment supply in the river is attributable to the reservoir. Other sources of information include ongoing watershed monitoring programs and assessments being conducted by the U.S. Forest Service (Forest Service), U.S. Geological Survey, and other federal and state agencies responsible for resource and land management in the MFAR, Rubicon, and North Fork MFAR watersheds.

In addition, annual reports, maps, and interviews with resource managers will be used to monitor the occurrences of major events (e.g., fires, landslides, intense land use activities) that could influence erosion and sedimentation processes in these watersheds. This information will be used to further evaluate the relative effects of these sediment sources on habitat conditions in the monitoring reaches. The interpretation of monitoring results will also include an analysis of hydrologic parameters that may differentially affect geomorphic conditions in the monitoring reaches from year to year.

Benthic Macroinvertebrate Monitoring

Objectives

The primary objective of BMI monitoring is to provide biological indicators of aquatic habitat health and functionality to be used in conjunction with the water quality and substrate data to evaluate potential project effects on aquatic habitat. Quantitative bioassessment based on BMI was developed by the Environmental Protection Agency (EPA) as a tool for monitoring and assessing the impacts of watershed management activities on water quality, fish, and stream productivity. Quantitative bioassessment has become the legal standard in most states for mitigation and restoration projects. Justifications for the use of BMI as indicators of water and habitat quality have been described by Hutchinson (1993), Resh and Jackson (1993), Rosenburg and Resh (1993), and others. Additional advantages of BMI-based biological assessment include long storage life for preserved samples and the establishment of BMI voucher collections. Voucher collections may be evaluated by other investigators and serve as a source of information for taxonomists and resource managers.

Monitoring Parameters

The following parameters will be used to monitor the overall health and functionality of aquatic habitat in the treatment and control reaches during preproject and postproject periods.

Invertebrate Density

Invertebrate density is the number of individual invertebrates per square meter. This is a measure of overall habitat utilization by BMI, as well as a measure of forage available to fish. Typically, BMI density remains fairly stable. Sudden BMI density fluctuations are indicative of impacts on habitats and water quality. Disturbed systems also may exhibit high BMI densities attributed mainly to opportunistic species. Some opportunistic species include Philippine clam, some crawdad species, chironomid midges (e.g., Chironomus), culicids, and some worms.

Taxa Richness

Taxa richness is the total number of individual taxa and is used as a means of determining the overall health of an aquatic habitat (Plafkin et al. 1989). In general, the higher the water quality, habitat suitability, and variety, the higher the taxa richness. Similarly, sudden drops in taxa richness will indicate a negative impact within the system.

BMI Productivity

BMI productivity is defined as the grams of living invertebrates per square meter within the study area. This measurement yields the biomass per unit area that the habitat is able to support. Diverse, highly functional habitats typically produce higher biomass than is produced by impaired systems. Alternately, disturbed systems that are overrun by opportunistic species may have abnormally high biomass.

Ephemeroptera, Plecoptera, Trichoptera Ratios

By measuring the abundance of invertebrate families most sensitive to changes in water quality and habitat suitability, the relative habitat health can be examined. The Ephemeroptera, Plecoptera, Trichoptera (EPT) index examines nymphal Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), which as a group are generally considered to be pollution sensitive. The abundance index of these families increases with increasing water quality (Plafkin et al. 1989).

Jaccard Coefficient of Community Similarity

Jaccard Coefficient of Community Similarity and Community Loss indices (Barbour et.al. 1999) will be used to determine similarities between the treatment and control reaches and between preproject and postproject years.

$$\text{Jaccard Coefficient of Community Similarity} = \frac{\text{\# of taxa common to both samples}}{\text{\# of taxa in both samples}}$$

The Jaccard Coefficient of Community Similarity estimates the degree of similarity between samples, based on presence or absence of taxa. The coefficient values range from 0 to 1.0. The higher the coefficient, the greater the similarity between the samples.

Community Loss Index

The Community Loss index estimates the loss of taxa between comparison samples and reference samples.

$$\text{Community Loss} = \frac{[\text{\# of taxa in reference sample}] - [\text{\# of taxa common to both samples}]}{\text{\# of taxa in comparative sample}}$$

The index identifies the differences in sample composition. The higher the index value, the greater the dissimilarity between the comparison sample and the reference sample.

Sampling Design

The sampling design for BMI monitoring was based on EPA's quanititative bioassessment protocols for streams and wadeable rivers (Barbour et al. 1999). BMI populations will be sampled in the same pre- and postproject years as substrate monitoring and in 3 of the same riffle transects used for substrate sampling in each monitoring reach. (table 4). Samples will be collected in the late spring (June), midsummer (August), and fall (October). Sampling 3 times per year is a standard protocol to adequately characterize seasonal changes and assess potential seasonal impacts on species and life stage composition of BMI communities. Littoral sampling from Ralston Afterbay will not be necessary because the water in the reservoir fluctuates sufficiently during normal yearly maintenance practices to limit colonization of the littoral zone by BMI.

A standard kick seine will be used to sample BMI at 3 locations along selected transects. These locations were selected to provide samples from a representative range of velocities along each transect. A kick is accomplished by placing the kick net in a stationary position and disturbing 0.33 square meter of substrate immediately upstream of the net. Large cobble and boulders will be dislodged and cleaned by hand to remove attached organisms. Sand, gravel, and pebble substrates will be disturbed by hand and with the toe or heel of a boot and the current will carry dislodged organisms into the net. Sample material from each kick will be combined into a single composite sample, which represents one square meter of substrate area. The material will be placed in an airtight container and preserved immediately in 95% ethanol. All samples will be labeled with the collection number, station, date, and collector. The samples will then be transported to the Jones & Stokes laboratory for analysis. After 24 hours, the ethanol in each sample will be replaced with fresh 95% ethanol.

In the laboratory, chain of custody forms will be used to track the samples. The contents of each sample will be placed into a 300 μm sieve, gently rinsed, and then placed in a Pyrex pan with 30% ethanol. The sample contents will then be examined for BMI by a technician using illuminated magnifying glasses. All BMI will be removed from debris with forceps and placed in containers filled with 70% ethanol. Once a sample presumably has all BMI removed, a second technician will then review the sample to ensure that all BMI are removed. After 2 technicians have searched the sample and found no more BMI, all debris will be discarded. If the second technician finds 4 or more BMI remaining in the sample, the original sorter will repeat the search of the entire sample.

Invertebrate biomass will be estimated using volumetric displacement. BMI specimens from all samples will be dried at room temperature for 15 minutes on size 613 qualitative filter paper and then placed in a 25 ml graduated cylinder with 15 ml of 15°C deionized water. The volumetric displacement will then be determined and recorded.

Specimens collected from each sample will be identified by taxonomists to the lowest justifiable taxon using an Olympus SZ-ST40 zoom stereo scope and the appropriate taxonomic references (Arnett 1968; Edmunds et al. 1976; McAlpine et al. 1981; Merritt and Cummins 1984; Pennak 1978; Usinger 1956; Wiggins 1977) in order to establish diversity, EPT ratios, opportunistic taxa ratios, taxa richness, and abundance, and to develop community indexes.

Starting in 2002, modifications and additions will be made to BMI sampling protocols to ensure consistency with the California Stream Bioassessment Procedure (www.dfg.ca.gov). These modifications include subsampling 300 organisms from each sample for identification purposes and complete counts of the remaining organisms, sending at least 10% of the samples to an independent quality assurance taxonomist to ensure taxonomic accuracy and enumeration, and using the California Bioassessment Worksheet.

Data Analysis

All data analyses will be conducted following the protocols for quantitative bioassessment established by EPA and the scientific community (Plafkin et al. 1989; Resh and Rosenberg 1984; Merritt and Cummins 1984; Hutchinson 1993; Resh and Jackson 1993; Rosenburg and Resh 1993).

Data Management and Reporting

Successful implementation of the water quality and aquatic resource monitoring program requires proper data reduction and analysis procedures, routine quality control checks during sampling and data processing, and annual reporting of results for permit compliance, impact assessment, and performance evaluation. The chain of custody for data handling, storage, and processing will be clearly established. It is best to have a single person responsible for the monitoring program to ensure that all field and laboratory techniques, data entry, quality control and assurance methods, and analytical methods are coordinated and follow established protocols.

Standard field and laboratory data forms will be prepared for each monitoring component. All completed field and laboratory data forms will be kept in a central location or logbook. Duplicates will be made and stored in a separate location. The lead technician will proof all data forms at the end of each day of field or laboratory work. All data will be entered into Microsoft Excel spreadsheets (or equivalent) and maintained in a central database. The original spreadsheets will be checked for errors by comparing all entries in the electronic spreadsheets with the raw field and laboratory entries. The central database will be write-protected and maintained on a main computer server. Working copies of the spreadsheets will be used for data reduction, analysis, and reporting.

The results of the preproject and project operation monitoring will be presented in annual reports prepared at the end of each annual monitoring period. The reports will summarize the methods and results of the current and previous years' monitoring activities. Data and statistical analyses will be presented in summary graphs and tables. The reports will present and update conclusions regarding permit compliance, impact assessment, and monitoring performance and will include recommendations for modifications of sampling design and other program elements, if warranted.

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