SACRAMENTO

PCWA-L-107

PRELIMINARY FEASIBILITY ANALYSIS OF ALTERNATIVE SEDIMENT MANAGEMENT OPTIONS FOR RALSTON AFTERBAY RESERVOIR

Prepared for

Placer County Water Agency

Prepared by

EA Engineering, Science, and Technology

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Prepared for

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1. INTRODUCTION AND SUMMARY

The Placer County Water Agency owns and operates hydroelectric projects on the Middle Fork American River and Rubicon River. Ralston Afterbay Reservoir is the farthest downstream of the impoundments in this system, and is located at river mile 24 on the Middle Fork American River. The Ralston Powerhouse is located at the upper portion of the reservoir, and the Oxbow Powerhouse is located at the Ralston Afterbay dam. Both powerhouses have a history of operational curtailment and shutdown associated with high water events and sedimentation.

In April of 1990, the Placer County Water Agency (PCWA) solicited proposals for a Ralston Afterbay Reservoir Sediment Removal Feasibility Study. EA Engineering, Science, and Technology (EA) was awarded a contract for conducting this study in July, for a total cost of $30,200. The initial contract deliverable, provided to PCWA in September, derived an annualized cost of roughly $600,000 associated with the existing sedimentation problems at Ralston Afterbay Reservoir. This estimate has been revised to an annualized cost between $750,000 and $800,000 for continuation of existing practices.

This report presents the feasibility study and its conclusions. Section 2 covers existing conditions and system dynamics that relate to sedimentation and sediment disposal in the vicinity of the reservoir. The topics presented include hydrology, sedimentation, operations, economics, land use, fisheries, vegetation, recreation, aesthetics, and public health and safety. A single copy of calculations, computer printouts, and other materials used in preparing these sections have been provided to PCWA as appendixes.

Section 3 of this study presents and discusses alternatives for dealing with sediment accumulation in Ralston Afterbay Reservoir. These include

- 5 alternatives to reservoir management,
- 8 potential structural modifications, and
- 4 alternative sediment disposal options.

The relative feasibility and costs associated with each alternative are discussed, and the potential effects on existing resources and uses are described.

Section 4 of this report concludes that sediment removal operations, more extensive than those that have taken place in the past, will eventually be required in order to maintain powerhouse operations. Management measures are described that could delay the time at which sediment must be routinely removed. Some structural changes also are likely to be cost effective in minimizing the effects of high water and sedimentation. Sediment disposal is likely to become more expensive and more constrained by permitting than in the past. This will probably mean that upland sites constitute the only alternative that is feasible for disposal of the volumes anticipated.

It is important to note that this study is a preliminary analysis of a broad variety of alternatives, and has been completed based on existing information and a minimal budget. A more detailed analysis of the alternatives that appear attractive would be required prior to further planning or design work.

2. EXISTING CONDITIONS AND SETTING

This section describes existing conditions that are relevant to sedimentation, power production, and spoil disposal issues at Ralston Afterbay Reservoir. Information is based on existing records and studies provided primarily by PCWA, the USGS, and the Tahoe and Eldorado National Forests. Analyses performed by EA are described briefly in appropriate sections and are documented in appendixes that have been provided to PCWA.

2.1 HYDROLOGY

The Ralston Afterbay Dam is located 5,600 feet downstream of the Middle Fork American River and Rubicon River confluence. Approximately 428 square miles of watershed lie above Ralston Afterbay Dam.

2.1.1 Development of the Watershed

Flows in the Middle Fork American and Rubicon are regulated by a network of reservoirs, tunnels, canals, and powerhouses. Most of these developments were built during the mid-1960s to supply water and generate electricity. Placer County Water Agency's American River Project and Sacramento Municipal Utility District's South Fork American River Project account for most of the water development affecting the watershed. Three storage reservoirs, French Meadows, Hell Hole, and Loon Lake, provide a total usable storage capacity of approximately 407,000 acre-feet, and control 169 square miles of tributary area.

Trans-basin diversions occur at several locations (see Appendix A). Water is diverted from the Middle Fork to the Rubicon via the French Meadows Tunnel linking the French Meadows Reservoir and Powerhouse, and from the Rubicon to the Middle Fork American via the Middle Fork Tunnel. Water is also exported out of the South Fork Rubicon basin into the South Fork American River basin by SMUD's project. USGS reports that an average of 183,300 acre-feet per year (based on water years 1963-1985) were exported from the South Fork Rubicon to Union Valley Reservoir via Robbs Peak tunnel.

About 205 square miles of the watershed tributary to Ralston Afterbay is unregulated. Most of this area lies at middle and lower elevations where the terrain is steep and soils are relatively unstable.

2.1.2 Gaging Station Data, Flow Duration, and Flood Frequency

Placer County Water Agency and USGS cooperatively monitor the flow at several stations within the Middle Fork American River watershed. The two stations of primary importance to this study are USGS station #4333, Middle Fork American River near Foresthill, and #4332, Rubicon River near Foresthill.

Gaging station #4333 is located on the Middle Fork American 1.6 miles downstream of the Oxbow Powerhouse and downstream of the confluence with the North Fork of Middle Fork. The 524 square mile tributary area has a mean elevation of 5,300 feet, mean annual precipitation of 60 inches, and mean annual flow of 1,186 cfs (based on water years 1966-1988). The basin is comprised of three principal sub-basins: Middle Fork American, North Fork of Middle Fork American, and Rubicon.

The North Fork of Middle Fork American flows into the Middle Fork American approximately 0.6 miles downstream of the Oxbow Powerhouse. PCWA and USGS monitored the flow 2 miles upstream of the mouth of the North Fork American from 1965 through 1985, and reported a mean annual flow of 278 cfs based on the 20 year monitoring period. The tributary area upstream of the gage consists of 89 square miles with a mean elevation of 4,200 feet, and an average precipitation of 61 inches.

Rubicon flow was previously monitored 1.2 miles upstream from the confluence with the Middle Fork American (0.6 miles upstream of the Ralston Powerhouse). The mean annual flow of the 315 square mile watershed is 332 cfs, based on water years 1966 through 1983.

EA performed flow duration and flood frequency analyses in order to quantify the frequency and magnitude of flows occurring in the Middle Fork American and Rubicon rivers. The base period for the Middle Fork American and Rubicon studies were water years 1966 through 1988 and water years 1966 through 1983 respectively.

Flow duration curves (based on mean daily flows) were established following methods outlined by Chow (1964). Figures 2-1 and 2-2 display the resulting flow duration curves for the Middle Fork American and Rubicon rivers, respectively. The percent of time that any specific flow is exceeded, on a mean daily flow basis, can be determined from these figures (e.g., Middle Fork American station #4333 exceeds a mean daily flow of 2,500 cfs 10 percent of the time).

A flood frequency analysis was conducted following guidelines set in Bulletin #17B published by the U.S. Department of the Interior, 1982. Peak mean daily flows were recorded for each water year and keypunched into digital files, which served as input to the U.S. Army Corps of Engineers (USACE) HECWRC flood flow frequency analysis program. The recurrence interval of peak events is displayed in Appendix A for the Middle Fork American and Rubicon, respectively, assuming a log Pearson Type III distribution. The peak daily flow associated with the 10 year event exceeds 30,000 cfs for the Middle Fork American and is approximately 15,000 cfs for the Rubicon gage.

2.1.3 HEC-2 Modeling

The U.S. Army Corps of Engineers HEC-2 model was used to investigate the high tailwater problem at Ralston Powerhouse. This program calculates water surface elevations based upon

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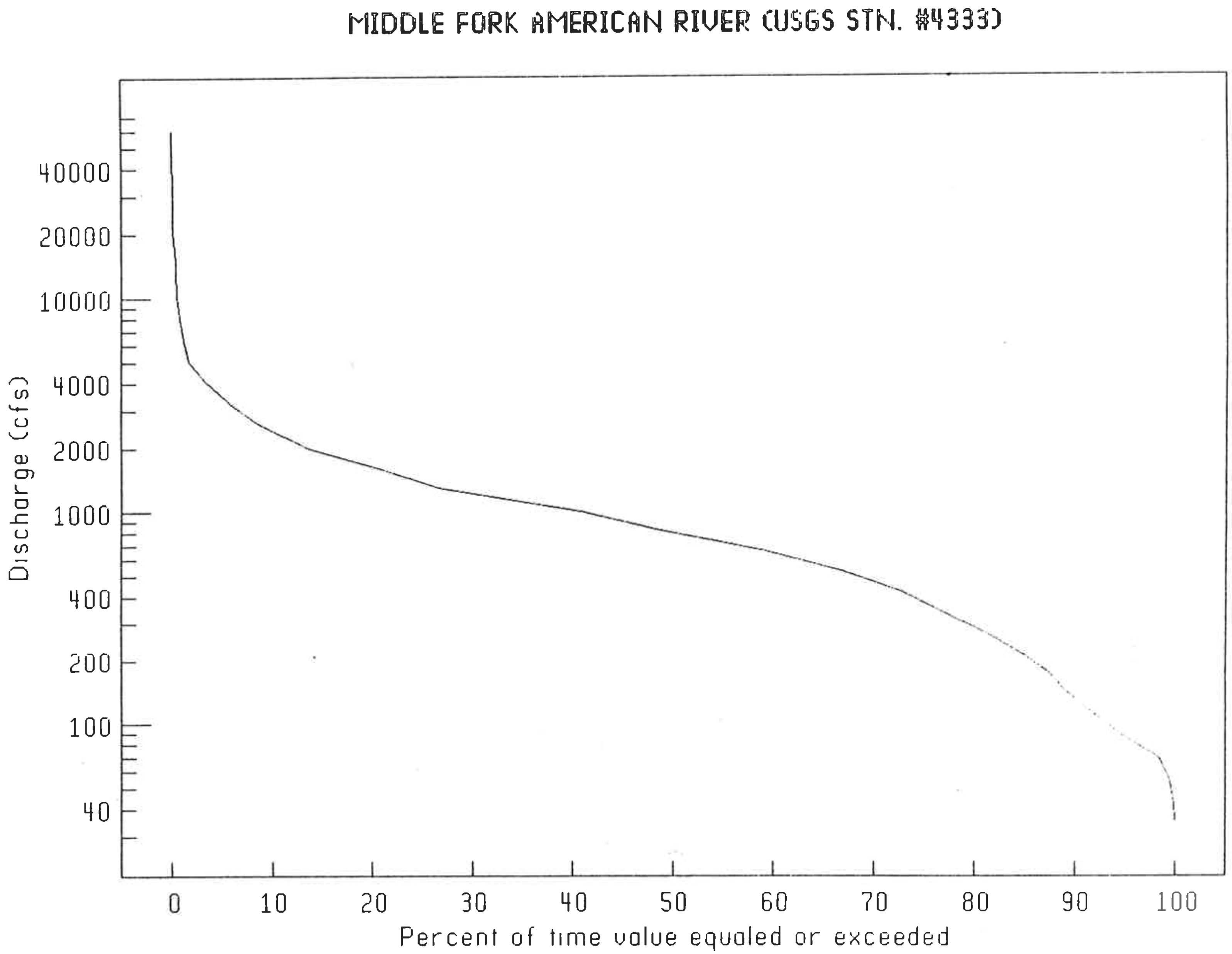

Figure 2-1. Flow duration curve for the Middle Fork American River at USGS Station #4333, 1966-1986.

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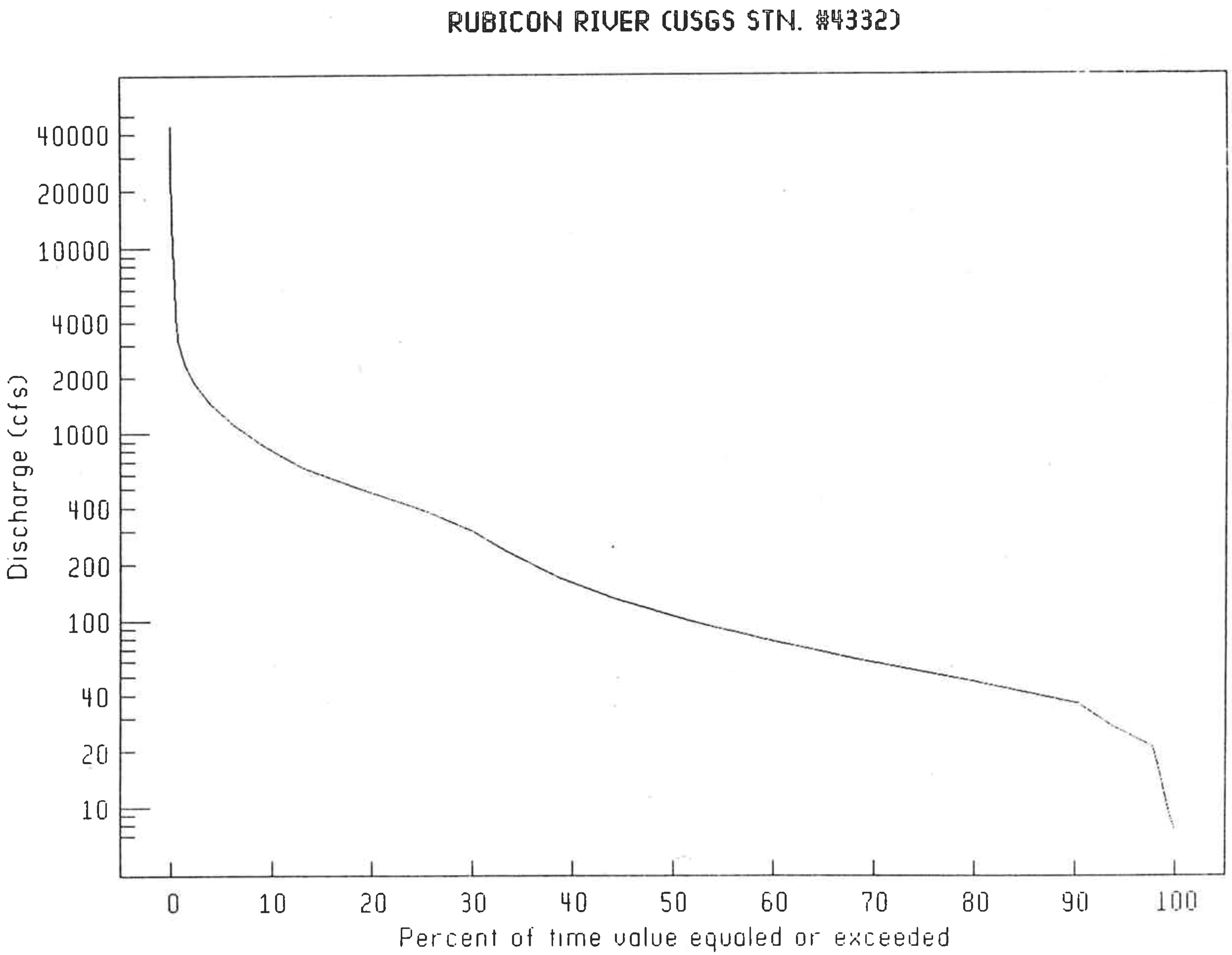

Figure 2-2. Flow duration curve for the Rubicon River at USGS Station #4332, 1966-1983.

the discharge, roughness, and geometry of the channel and valley. Output from the HEC-2 runs are included as Appendix B. A summary of these runs is presented in Table 2-1.

The storms of 15 February 1982 and 17 February 1986, with discharges of 9,565 cfs and 41,600 cfs were used to calibrate the model. Channel cross section data are very limited in the vicinity of Ralston Powerhouse as are coincident flow and stage records. Simulations made to investigate the potential benefit of reducing reservoir levels in order to lower tailwater elevations suggest that a constricted section in the river acts as a hydraulic control that raises tailwaters (see Section 3.1.4). Excavation of previously deposited material appears to be required to significantly reduce powerhouse tailwaters during moderate floods.

HEC-2 also has been used to develop a tailwater rating curve for the Ralston Powerhouse. This suggests that operations at the powerhouse will become compromised (as the water level approaches 1,178 feet) when discharges at the dam reach 8,000 cfs and the reservoir surface elevation is kept above 1,175 feet.

2.1.4 Mapping of the 100-Year Floodplain

PCWA considered the possibility of placing excavated material in the Middle Fork American River canyon downstream of the Ralston Afterbay Dam. In evaluating this disposal alternative, Sierra Hydrotech was contracted to determine the 100-year floodplain limits for a one and a half mile reach below the Ralston Afterbay Dam.

Sierra Hydrotech's study was composed of two major tasks. First, they determined the flows associated with the 100-year event. Flows were determined for two reaches: (1) between Ralston Afterbay Dam and the North Fork of Middle Fork American confluence and (2) downstream of the North Fork of Middle Fork American. Secondly, they determined the flood elevations within the study area.

The analysis was based on flows monitored at the Middle Fork American near Auburn (USGS station #4335) during water years 1912 through 1988. All instantaneous peaks occurring during water years 1912 through 1963 were assumed to be homogeneous; adjustment was made to peak flows occurring after 1965 to account for the impact of upstream storage in reservoirs.

Sierra Hydrotech 1988, reported a 100-year unimpaired (natural) flood flow of 138,000 cfs at the Middle Fork American, and 113,500 cfs immediately downstream of the Ralston Afterbay. They assumed that the upstream reservoirs could achieve approximately 25 percent of their historic attenuation capability during the 100-year event, resulting in regulated flow estimates of 127,800 and 104,200 cfs for the Middle Fork American near Foresthill and below the Ralston Afterbay, respectively.

Water surface elevations of the 100-year event were computed through application of a HEC-2 backwater analysis. Topographic maps, along with the flood flows previously computed, served

TABLE 2-1 SUMMARY OF HEC-2 RUNS FOR THE RALSTON AFTERBAY SEDIMENTATION STUDY, NOVEMBER 1990

Run	Flow discharge @ Ralston Dam (cfs)	Reservoir Waterlevel (ft)	Description
WSERAL1.OUT	9,565	1,172.50	Simulation of 2-15-82 storm
WSERAL2.OUT	9,565	1,160.00	Simulation of WSERAL1.OUT with lower reservoir
WSERAL3.OUT	9565	1172.50	Simulation with channel widened by 20′ @ 7600′
WSERAL4.OUT	9,565	1,160.00	Simulation with channel widened by 20′ @ 7600′
WSERAL5.OUT	41,600	1,173.70	Simulation of 2-17-86 flow
WSERAL6.OUT	41,600	1,160.00	Simulation of WSERAL5.OUT with lower reservoir
WSERAL7.OUT	41,600	1,173.70	Simulation of WSERAL5.OUT with widened channel
WSERAL8.OUT	41,600	1,160.00	Simulation of WSERAL7.OUT with lower reservoir
WSERAL9.OUT	41,600	1,173.70	Simulation of WSERAL5.OUT with 4′ deepening from 6750′ & 7600′
WSERAL10.OUT	9,565	1,172.90	Simulation of WSERAL1.OUT with 4′ deeper channel @ 6750′ & 7600′
FINAL1.OUT	1,500	1,175.00	Data to constrain rating curve
FINAL2.OUT	3,000	1,175.00	Data to constrain rating curve
FINAL3.OUT	6,000	1,175.00	Data to constrain rating curve
FINAL4.OUT	12,000	1,175.00	Data to constrain rating curve
FINAL5.OUT	24,000	1,175.00	Data to constrain rating curve
FINAL6.OUT	48,000	1,175.00	Data to constrain rating curve
FONAL6.OUT	48,000	1,170.00	Test of reservoir level sensitivity

TABLE 2-1 (continued)

Run	Flow discharge @ Ralson Dam (cfs)	Reservoir Waterlevel (ft)	Comment
BACKW1.OUT	4,500	1,179.00	Water surface profile at various reservoir levels
BACKW2.OUT	4,500	1,175.00	Water surface profile at various reservoir levels
BACKW3.OUT	4,500	1,170.00	Water surface profile at various reservoir levels
BACKW4.OUT	4,500	1,165.00	Water surface profile at various reservoir levels
BACK5.OUT	4,500	1,160.00	Water surface profile at various reservoir levels
BACK6.OUT	4,500	1,155.00	Water surface profile at various reservoir levels
BACKEX.OUT	4,500	1,165.00	Simulation of BACK4.OUT with excavation from 5,000 to 6,750
BACKEX2.OUT	4,500	1,170.00	Simulation of BACK3.OUT with excavation from 5,000 to 6,750
HOPE.2	4,500	1,154.00	Simulation if dam filled with sediment to ogee (1149)

as input to the model. The 100-year floodplain was delineated on detailed topographic maps, based on the results of the hydraulic modeling. Review of the floodplain maps reveals that all of the large bars in the study area would be inundated during a 100-year event.

2.2 SEDIMENT TRANSPORT AND ACCUMULATION

Sedimentation behind the Ralston Afterbay Dam is causing operational problems in two areas; first, the accumulation of fine sediments in the main body of the reservoir threatens the Oxbow intake, and second, recently deposited sediments in the upper parts of the reservoir and along the Rubicon River are raising channel bed elevations and tailwaters at the Ralston Powerhouse. The result of the sedimentation in both areas has been increasingly restricted operations during medium to large floods and progressive loss of power production.

2.2.1 Reservoir Sedimentation

A reservoir creates an imbalance between sediment supplied from upstream and the capability of the flow to transport this sediment. Sediment carried by the fast moving river is quickly deposited when it reaches the quiet waters that are backed up behind the reservoir. The first sediment deposited is usually the largest because the greatest energy is required to move these coarse sediments. Finer sediment can be carried well into the reservoir before it is deposited. The finest sediment may bypass the reservoir and be spilled through the gates or pass through the Oxbow tunnel.

As a reservoir fills with sediment, the thickness of these sediments forms a wedge that tapers upstream. The upstream extent of sedimentation varies from dam to dam but can be expected to go beyond the point where the reservoir level intersects the old channel bed. Experience from a variety of dams suggests that this upstream extent and local magnitude of sedimentation can be estimated from the channel slope reduction that is observed. Research suggests that stable reservoirs, reservoirs no longer accumulating sediment, have bottom gradients that equilibrate at values 20-100 percent of the original channel bed slope (Borland 1971). A value of 50 percent is fairly representative. These scattered data come from 24 dams having slopes ranging from 0.0003 to 0.0500. Variations in discharge regime, grain size, valley geometry, and dam design probably explain the large scatter in residual slopes.

2.2.2 Annual Ralston Afterbay Sedimentation

Since operations began in 1966, the Ralston Afterbay Reservoir has been accumulating sediment at the average annual rate of 56,500 cubic yards. This value was calculated from the total amount of sediment accumulated from 1966 to 1989 plus the amount of sediment removed by excavation (Table 2-2). The total amount of sediment entering the reservoir each year is higher because an unknown amount of primarily finer sediment passes through during high flows.

TABLE 2-2

RALSTON & OXBOW POWERPLANTS

ESTIMATE OF SEDIMENT ACCUMULATION
IN RALSTON AFTERBAY 1966-1989

LOCATION	QUANTITY (cu. yd)	DATA SOURCE/YEAR
SEDIMENT ACCUMULATION		
Dam to 10+00 ft above dam	117,000	EA estimate from photo series
10+100 ft to 67+00 ft above dam	900,000	Surveys 1987
67+50 ft to powerhouse (81+00 ft +/-)	10,000	EA estimate
Subtotal	1,027,000	
SEDIMENT REMOVAL		
Tailrace	no data	1969
Tailrace & 800 ft downstream	10,000	1981
Tailrace and Bar A (66+00 ft)	13,000	1984
Bars B (58+00 ft) & C (55+00 ft)	12,000	1985
From 300 ft upstream of powerhouse to Bars A, B, C, and D (50+00 ft)	125,000	1986
Bars D & E (45+00 ft)	32,500	1989
Subtotal	192,500	
TOTAL ACCUMULATION	1,187,000 *	
PERIOD (yrs)	1966 to 1987	
AVERAGE ANNUAL ACCUMULATION	56,524	

Note: 1. *- Sediment Removed in 1989 excluded because it's accounted for in 1987 survey
2. Sediment removal estimated by PCWA from truck capability data.

2.2.3 Sediment Sizes

The grain size distribution of this deposited material varies by location in the reservoir. The finer material is deposited in the deeper, and/or more isolated parts of the reservoir, while the coarser material is found upstream near where the river enters the reservoir.

The grain size distribution of the sediments at various points in the reservoir have been documented (Alpha Consultants 1988) in previous studies. The mean size of bed surface materials decreases moving downstream. Grain sizes are near 70 mm at 6,800 feet upstream of the dam, 40 mm at 6,450 feet, 30 mm at 5,500 feet, and 20 mm at 4,200 feet. The bed is largely sand (<2mm) below 3,800 ft. The bed material size at the powerhouse (~8,500 feet above the dam) was not characterized as part of the Alpha Consultant's report.

2.2.4 Past and Future Sedimentation of the Reservoir

The history of sedimentation behind the Ralston Afterbay Dam upstream beyond the Ralston Powerhouse is shown in Figure 2-3, where bed profiles from 1962, 1966, and 1986 (measured in 1987) are presented. These profiles may provide some refinement to the estimates of stable channel slopes and channel bed elevations in the future. The 1962 profile predates the dam and the 21-24 December 1964 flood associated with the Hell Hole dam failure. The 1966 channel bed averages 9 feet higher than the 1962 bed. While part of this aggradation is attributable to deposition associated with the 1964 flood, an unknown portion of this deposition is associated with dam construction. Since the dam was closed in 1966, the channel bed has aggraded 7 additional feet. This sedimentary wedge is thicker closer to the reservoir and thins upstream. While the bed profiles from the survey of 1987 do not extend upstream to the powerhouse, observations made after the 1986 storm indicate 8 ft of accumulation to 1,178 feet (PCWA Memo - 1986). Consequently the bed elevation at the powerhouse prior to 1986 is estimated at 1,170 feet. Sediment removal operations have lowered the bed near the powerhouse to near pre-1986 levels, (i.e., ~1,170).

The 1987 channel bed has a slope of 0.0032, which is 50 percent of the original channel bed slope of 0.0064. If this present slope is indicative of the final channel slope, the long-term stable elevations can be computed. This new stable profile will be one that can transport the sediment supplied from upstream hence no further sedimentation would be expected. The stable elevation, or the amount of further sedimentation at any point, depends upon setting the elevation to which sediment will accumulate at the dam. This elevation forms the local base level, or point to pin the profile. Thus, the amount of aggradation is determined by the level at which the reservoir is operated during flows that are carrying and then depositing sediments. If the reservoir is operated with high water levels, sediment near the dam will accumulate to a higher level near the dam and projection of the stable slope of 0.0032 upstream will mean higher bed elevations farther upstream. Conversely, lower water levels will restrict the height of deposits and the amount and extent of upstream sedimentation.

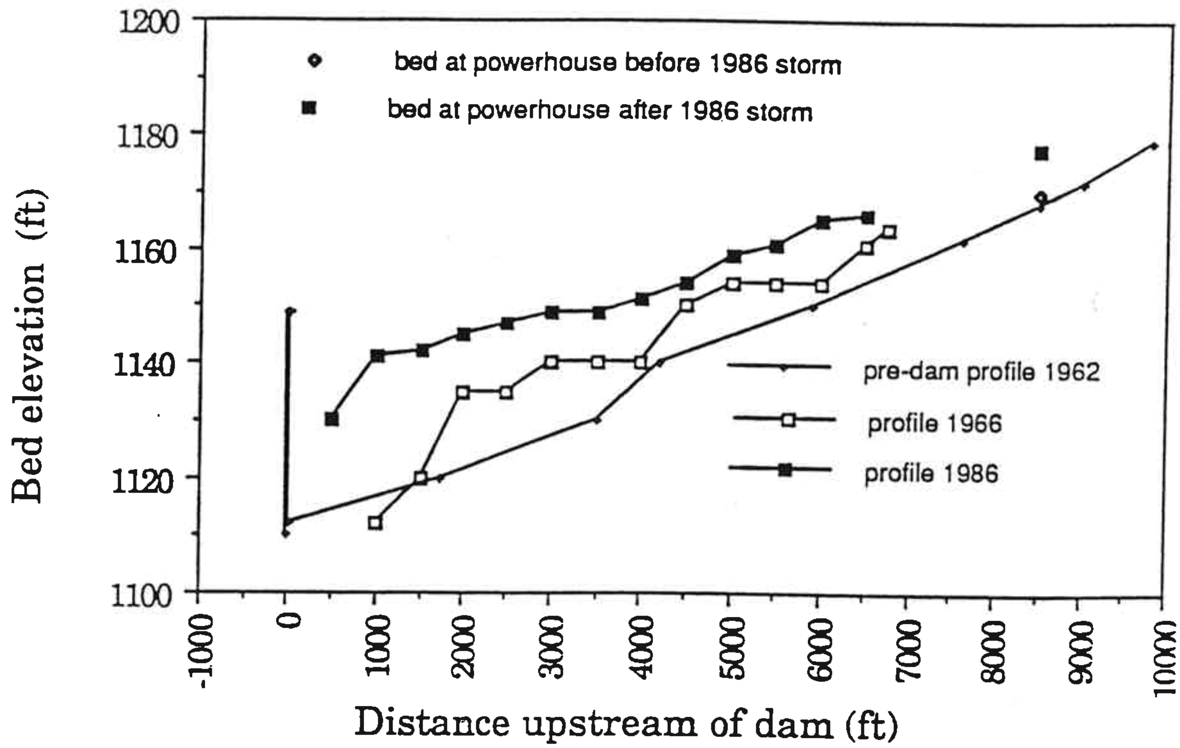

Figure 2-3. Historical bed profiles at Ralston Afterbay Reservoir.

In particular, if the water surface elevation of Ralston Afterbay is kept relatively low during flood events when the bed sediments are in motion, and if the bed is allowed to aggrade to the spillway crest level of 1,149, the stream bed in the vicinity of the powerhouse is expected to aggrade to an approximate elevation of 1,178 (Figure 2-4). The expression "relatively low" refers to an afterbay level which does not cause the deposition of sediments in areas which restrict the hydraulic capacity of the river. Based on HEC-2 modeling, this afterbay level is an approximate elevation of 1,170. However, as the sediment continues to fill the channel and reservoir, this elevation will correspondingly reduce to the point where the spilling gates must be fully opened during significant flood events.

If the reservoir is operated as it has been in the past with the water level kept at 1,175, without sediment removal, the bed at the powerhouse could rise to elevation 1,198 feet (Appendix C). Under the two operating scenarios 8 to 28 feet of additional sedimentation of the Ralston Powerhouse could be expected.

Assuming the historic average annual sedimentation rate of 56,500 cubic yards per year, the time scale for this sedimentation can be estimated. For the low reservoir scenario, it will take approximately to the year 2013 for the bed to cease rising. For the high reservoir scenario, the bed would continue to rise until the year 2063. Of course, these numbers are based upon the average input of sediment. A series of large floods or a change in supply could drastically change the time frame for reaching a stable profile.

2.2.5 Potential Importance of Upstream Events

The assumption that past accumulation of sediment is a good indicator of future sedimentation is made somewhat tenuous by the potential effects of the Hell Hole Dam failure. The Rubicon River in the area of interest was affected by the passage of the flood surge associated with the failure of the Hell Hole Dam in 1964. This event, which occurred approximately 30 miles upstream of the Ralston Powerhouse, had an estimated discharge of 330,000 cfs, more than three times the 100-year flood. USGS Professional Paper 422-M by K.M. Scott and G.C. Gravelee documents 1-3 feet of aggradation in the main channel in the ten mile stretch centered at the powerhouse. Aggradation is linked to the destabilization of the adjacent valley sides by removal of the toe of the slopes during the flood surge. Landsliding occurred after the passage of the peak discharge and the waning flows were unable to transport all the supply, thereby causing the aggradation. The report describes a large (535 foot wide at its base) streamside landslide about 1 mile upstream of the Ralston Powerhouse. A photograph shows the input of large boulders and cobbles at this point.

Before decisions are made on mitigation for high tailwater at Ralston, it would be appropriate to examine the potential role of the upstream dam failure and, in particular, the nearby landslide. It is possible that a significant amount of the recorded aggradation at the powerhouse is associated with the effects of the Hell Hole Dam failure rather than the backwater caused by Ralston Afterbay Dam.

2.2.6 Discharge of Consequence for Sediment Transport and Deposition

The streambeds of gravel and cobble rivers tend to armor with coarse sediments that are immobile at low to moderate flow rates. When the discharge increases, the armor is broken and underlaying sediments are released and mobilized. Consequently, for flows below a "threshold flow," the bed materials are immobile. This threshold flow has been found to be approximately equal to a flood flow with a recurrence interval of 1.5 to 3 years. It has also been noted for many rivers that the floods of this recurrence interval are the most important to channel forming and sediment transport processes.

For the Middle Fork of the American River, near Foresthill, California, the 1.5 year flood is approximately 4,500 cfs. Thus, for river flows greater than 4,500 cfs, the river carries significant sediment load. The majority of the sediment that has been deposited in the river was probably placed there during flood events exceeding 4,500 cfs. This is important to any consideration for modifying reservoir operation to reduce deposition near the powerhouse.

2.3 POWER GENERATING FACILITIES AND OPERATIONS

This section describes the hydroelectric generating facilities associated with Ralston Afterbay and the operating problems related to high water and sedimentation.

2.3.1 Description of Project Facilities

Ralston Powerplant and Afterbay Reservoir and Oxbow Powerhouse are at the lower end of a complex of 2 water storage reservoirs, 4 diversion dams and 5 hydroelectric powerplants that comprise the Middle Fork American River Project. A perspective view and profile of the project are shown on Figures 2-5 and 2-6. The project has a total installed generating capacity of 210,780 kilowatts and an average annual energy generation of 1149.4 GWh. The average annual plant factor is 62 percent.

Ralston Powerplant -- Ralston Powerplant is located on the north bank of the Rubicon River just upstream of the confluence with the Middle Fork American River. The powerhouse is a reinforced concrete semi-outdoor type structure housing a single vertical multi-jet impulse turbine and synchronous generator. The plant's intake is located at the Interbay Dam on the Middle Fork American River at elevation 2,527 feet. Water flows through a 6.7-mile long tunnel and then descends through a 1,670-foot long steel penstock to the powerhouse. The water elevation in the Rubicon River at the powerhouse is about 1,175 feet.

The turbine has a rated capacity of 106,300 horsepower at a rated net head of 1,250 feet and flow of 836 cfs. The power plant has a rated generating capacity of 79,200 kW and has a maximum generating capacity of about 85,000 kW.

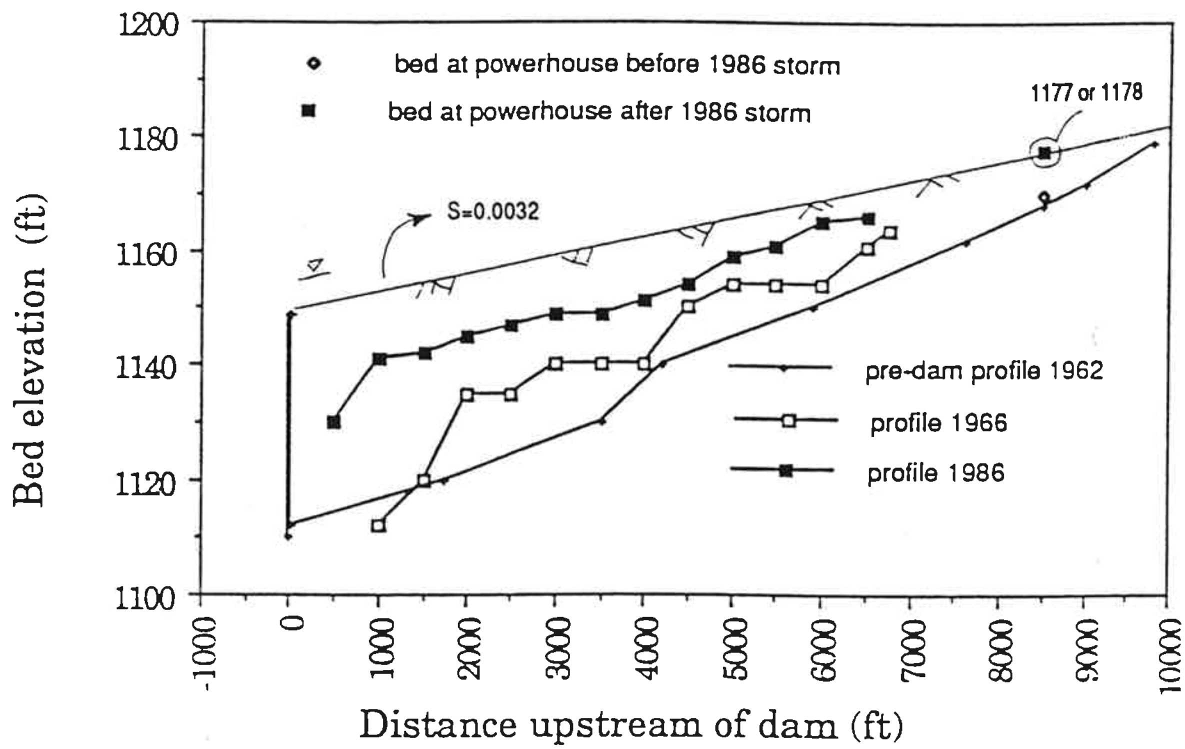

Figure 2-4. Profile of the estimated stable bed with the reservoir operated at 1170.

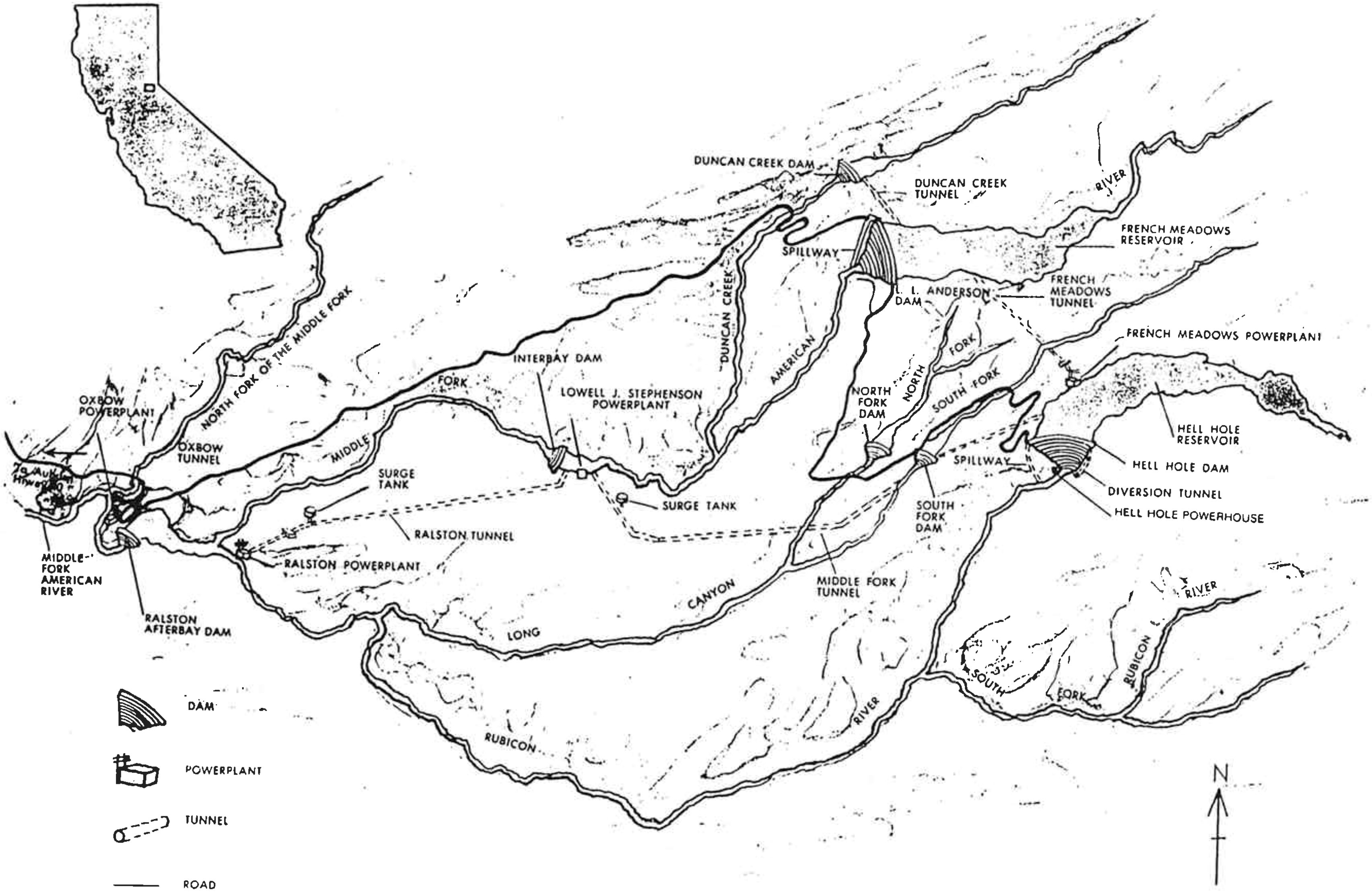

Figure 2-5. American River Project: Middle Fork American River Schematic. (Source: Placer County Water Agency Power Systems Division)

Western Division

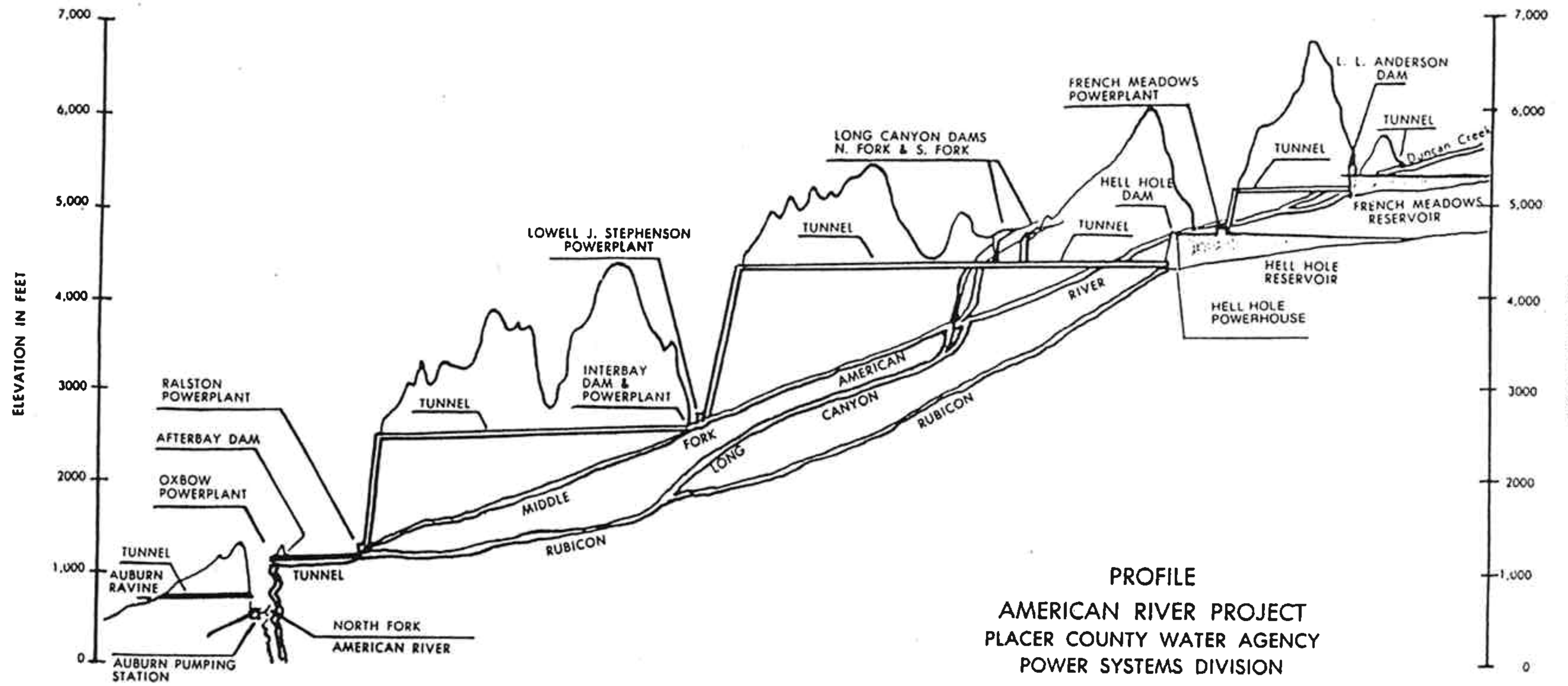

Figure 2-6. American River Project: Middle Fork American River Profile. (Source: Placer County Water Agency Power Systems Division)

Ralston Afterbay -- Ralston Afterbay regulates the outflow from Ralston Powerplant and creates a headpond for the Oxbow Powerplant. The impoundment has a total water storage capacity of 2,782 acre-feet and is about 1.7 miles long. The dam is a 560-foot long and 89-foot maximum structural height concrete gravity structure with a gated overflow spillway rated at 159,000 cfs. The maximum normal operating water level is 1,178 feet. The crest of the gated ogee section is at elevation 1,149 feet which is about 40 feet above original river bed level and 25 feet below normal operating level. Sediment levels in the reservoir are currently at about elevation 1,120 feet i.e., 30 feet below the ogee section.

Oxbow Powerplant -- Oxbow Powerplant utilizes the hydraulic head developed by the Ralston Afterbay Dam. The intake is located on the upstream side of a large oxbow in the river about 1,000 feet upstream of the dam. A 400-foot long tunnel through the oxbow carries up to 1,090 cfs to the powerplant located downstream of the dam. The powerhouse is an enclosed reinforced concrete structure housing a single vertical axis Francis turbine and generator which has an installed generating capacity of 6,570 kW.

2.3.2 System Operation

Ralston Powerplant is dispatched by Pacific Gas and Electric Company and is operated in tandem with the Lowell J. Stephenson Powerplant which discharges into Ralston's headpond at Interbay. Operation of the powerplants is governed by PG&E's power system load, dependable generating capacity requirements, and the amount of water stored in French Meadows and Hell Hole reservoirs.

Normally during summer the powerplant is operated for about 12 hours a day during daylight hours. In drought years the period of operation is reduced to conserve water for the mid-summer peak load months.

During winter the powerplant is normally operated at part load for about 8 hours per day, more during wet years. In periods of high or flood flows during winter and spring the powerplant is operated 24 hours a day to maximize energy production and minimize spills at the upstream reservoirs.

2.3.3 Operating Constraints During Winter Storms

High tailwater levels and movement of sediment into Ralston Afterbay during periods of high streamflow presently reduce generating capability at both Ralston and Oxbow powerplants.

Ralston Powerplant is located at the inlet to the afterbay. When water levels rise above 1,177 feet at Ralston backsplash within the turbine discharge chamber causes vibration of the turbine and a reduction in turbine efficiency due to increased drag forces. The peak load that the unit can sustain diminishes as the water level increases until at elevation 1,181 feet operation must completely cease.

At Oxbow Powerplant which is at the downstream end of the afterbay increased sediment load in the water causes problems in maintaining a clean cooling water supply to the generator. Strainers provided to filter sediment from the water become overloaded and require very frequent backflushing. During large flood events the turbine has been shut down. To keep the intake and tunnel free from deposition of sediment it is possible to run water through the conduit and the synchronous bypass valve at the unit while the turbine is out of service.

2.3.4 Estimate of Lost Generation Due to Curtailments

Operating records provided by Placer County Water Agency have been analyzed to determine the loss of energy at both Ralston and Oxbow powerplants during high tailwater and sediment accumulation events. Results of this analysis are shown on Table 2-3. The data show that about 92,812 MWh have been lost over the life of the facility with an average annual loss of 4,763 MWh. The loss is extremely variable with 58,020 MWh being lost in one year (1986).

2.4 COSTS OF GENERATION CURTAILMENTS AND SEDIMENT REMOVAL

The cost of the Ralston problem has two major components:

- PG&E's cost of replacing lost generation from the project during curtailment periods by generating more power at other powerplants or purchasing power from other producers.
- The cost of removing accumulated sediment to keep the project in operation. This cost is also presently bourne by PG&E under the operation and maintenance provisions of the agreement between PCWA and PG&E.

Estimates of these costs are presented in the following sections:

2.4.1 Cost of Lost Power Generation

During a period of curtailment the cost of lost generation from the project is equivalent to the cost of replacing the lost generation from another source. In a large electrical generating system it is usual to equate the value of a small increase or decrease of generation to the marginal cost of supplying more or less energy from the so called "Generating Facility at the Margin" which is the plant in the system that would be used to pick-up additional load. In PG&E's system marginal generating costs are currently based on the cost of additional generation at a natural gas fired thermal-electric generating facility.

Energy values used in the analysis are based on PG&E estimates of marginal generation costs. Two estimates are used to define a small range:

TABLE 2-3

RALSTON & OXBOW POWERPLANTS

ESTIMATE OF LOST GENERATION DURING CURTAILMENTS

YEAR	RALSTON (MWh)		OXBOW (MWh)	TOTAL (MWh)
1970	2528	*	n.d.	2528
1971	463	*	n.d.	463
1974	204	*	n.d.	204
1980	12723	*	n.d.	12723
1981	2284		0	2284
1982	7940		270	8210
1983	8288		91	8379
1986	56376		1644	58020
TOTAL	90807		2005	92812
PERIOD (Yrs)	1970 to 1989		1981 to 1989	
DURATION (Yrs)	20		9	
ANNUAL AVERAGE	4540		223	4763

Notes: 1. *- approximate estimate from operators logs
2. n.d.- No data

- The first is taken from PG&E's medium forecast of avoided costs developed in 1986 as part of their ECAC proceeding. The forecast marginal energy cost in 1990 is 26.3 mills per kWh. This data was supplied by PG&E in response to a letter request of July 31. (A copy of this correspondence is provided in Appendix D.)

- The second is extracted from PG&E's Cogeneration & Small Power Production Quarterly Report for the first quarter of 1990 also found in Appendix D. The corresponding energy purchase price for winter 1990 is 37.27 mills per kilowatt hour.

It is assumed that no capacity cost will be applied to the curtailments as they normally take place during high streamflow periods in winter or early spring when there is a plentiful supply of capacity available to PG&E from other sources. This assumption appears to be supported by PG&E's winter as-delivered capacity prices which are currently 0.06 mills/kWh during partial peak periods and 0 mills/kWh during off-peak periods. It is also unlikely that curtailments at Ralston will affect generation during critical summer drought periods which are normally used to define the dependable capacity of a hydroelectric powerplant.

Using an average annual energy loss of 4.76 GWh/yr and a 1990 energy value in the range of 26.3 to 37.3 mills per kilowatt hour, the estimated average annual value of energy lost in 1990 dollars (rounded) is $125,000 to $180,000 per year. In a very wet year such as the winter of 1986 the value of lost generation in 1990 dollars would be $1.5 million to $2.2 million.

2.4.2 Cost of Sediment Removal Operations

An estimate of the total accumulation of sediment in the afterbay since its commencement of operations in 1966 is shown on Table 2-2. At present the reservoir has about 1,027,000 cubic yards of sediment in it which occupies about 640 out of a total of 2,782 acre-feet of storage capacity (i.e., 23 percent). The average annual rate of accumulation of sediment is 56,500 cubic yards per year. The total amount entering the reservoir each year is likely to be higher because an unknown amount of finer material passes through during high flow events.

Sediment removal operations carried out in 1984, 1985, 1986, and 1989 were analyzed to determine the direct unit cost of excavating, hauling, and disposing of sediment. This analysis presented on Table 2-4 shows a considerable variation in sediment disposal costs depending primarily on whether excavation is carried out under wet or dry conditions and secondarily on the length of haul. The major cost item in 1986 was for a large crane which was used to excavate material from the river during early spring.

2.4.3 Annual Costs of Curtailment and Sediment Removal

The expected typical range of annual costs due to the sediment and elevated tailwater conditions at Ralston Afterbay are shown on Table 2-5. In round numbers costs are expected to fluctuate

TABLE 2-4

RALSTON AFTERBAY

HISTORIC DIRECT COST OF SEDIMENT REMOVAL

YEAR	SEDIMENT REMOVED	PERIOD From	PERIOD To	DIRECT COST	COST INDEX	DIRECT COST	Unit Cost
	cu. yd			$actual		$ 1990	1990 $/yd
1984	13,000	1-Oct	26-Oct	$58,627	105.0	$72,818	$5.60
1985	12,000	14-Oct	25-Oct	$39,956	109.0	$47,806	$3.98
1986	45,000	Spring		$460,000	112.7	$532,310	$11.83
1986	80,000	Fall		$255,000	112.7	$295,085	$3.69
1989	32,500	18-Sep	17-Oct	$199,990	130.4	$199,990	$6.15
TOTAL	182,500			$1,013,573		$1,148,010	
WEIGHTED AVERAGE							$6.29

TYPICAL HISTORIC DIRECT REMOVAL COSTS	
Removal of sediment under dry conditions (short haul)	$3.75
Removal of sediment under dry conditions (3 mile haul up grade)	$6.15
Removal of wet sediment under flood conditions (short haul)	$11.83

TABLE 2-5

RALSTON AFTERBAY

ESTIMATED CURRENT ANNUAL COSTS OF CURTAILMENT AND SEDIMENT REMOVAL

1990 Dollars

	UNITS	AVERAGE WINTER	DRY WINTER	WET WINTER
1. GENERATION				
Lost Generation	MWh	4,763	0	58,020
2. VALUE OF LOST ENERGY DUE TO CURTAILMENT				
PG&E Projected Avoided Cost	1990 $/MWh	$26.30	$26.30	$26.30
Corresponding Value of Lost Energy		$125,267	$0	$1,525,926
PG&E QF Energy Purchase Price	1990 $/MWh	$37.27	$37.27	$37.27
Corresponding Value of Lost Energy		$177,517	$0	$2,162,405
3. SEDIMENT REMOVAL				
Quantity	cubic yards	56,524	0	125,000
4. COST OF SEDIMENT REMOVAL				
Dry excavation-Long haul	1990 $/cu. yd	$6.15	$6.15	$6.15
Quantity	cubic yards	42393	56524	80000
Direct Cost		$260,717	$347,623	$492,000
Indirect Cost		$65,179	$86,906	$123,000
Annual Cost		$325,896	$434,528	$615,000
Flood conditions-Long haul	1990 $/cu. yd	$14.29	$14.29	$14.29
Quantity	cubic yards	14131	?	45000
Direct Cost		$201,932	$0	$643,050
Indirect Cost		$50,483	$0	$160,763
Annual Cost		$252,415	$0	$803,813
5. TOTAL ANNUAL COST OF CURTAILMENT AND SEDIMENT REMOVAL				
Using PG&E Projected Avoided Cost	1990 dollars	$703,578	$434,528	$2,944,739
Using PG&E QF Energy Purchase Price	1990 dollars	$755,828	$434,528	$3,581,218

between $0.4 million and $3 million dollars per year and average about $0.75 million per year. In a very wet year or one with successive large storms, costs could well exceed this range.

The largest curtailment event since the commencement of operations in 1967 occurred in February 1986 and was due to a flood which reached 78,400 cfs at the Middle Fork gage near Foresthill. This flood has an average recurrence interval of only about 30 years so it was not an extreme event. Substantially higher flows and larger inflows of sediment can be expected within the operating life of the project.

2.5 LAND USE

Major management activities in the project area are power generation and timber production. The less steep, upper canyon slopes have been heavily logged in the past, although current logging consists only of salvaging operations from the "Big Trees" forest fire. Canyon walls surrounding the reservoir have not been logged due to extremely steep terrain. Other typical uses of low elevation forest, such as recreation and grazing, also are restricted by the topography. Access into the project area is from the north via USFS Route 96 (Mosquito Ridge Road) and Ralston Afterbay Road, or from the south via the Wentworth Springs Road out of Georgetown.

There are three land management agencies in the project vicinity that control various areas. The American River and Ralston Afterbay Reservoir form the dividing line between Placer and Eldorado counties as well as between the Tahoe National Forest (to the north) and the Eldorado National Forest to the south. Directly downstream of the Ralston Afterbay Dam lands are owned by the Bureau of Reclamation with some private inholdings.

Both National Forests have recently released Land and Resource Management Plans which will provide direction for Forest management for the next 10 to 15 years. The Tahoe National Forest Land and Resource Management Plan (LRMP) divides the Forest into Management Units which are based on physiographic areas. Ralston Afterbay Reservoir is located in the Little Oak Management Unit - 108 of the Tahoe National Forest. The Little Oak Management Unit encompasses most of the south-facing slope of Foresthill Ridge.

In the Eldorado National Forest LRMP the Forest is divided into predominant resource emphasis areas called Management Areas. In the project vicinity there is a General Forest Management Area which covers a majority of the Forest, and a Streamside Management Zone (SMZs) Management Area which addresses riparian areas along streams and lakes. There are several other Management Areas in the Forest such as Wilderness, but they do not occur in the project vicinity. For each Management Area in the Eldorado National Forest there are Forest-wide and individual practices which are defined in the Standards and Guidelines for the Forest.

Table 2-6 summarizes and compares the Standards and Guidelines applicable to management of various resources of the two Forests which could be affected by sediment removal and disposal activities at Ralston Afterbay. The Standards and Guidelines are based on the PRF (Preferred)

LAND AND RESOURCE MANAGEMENT PLANS

ELDORADO NATIONAL FOREST

ALTERNATIVE A — PRF (PREFERRED)

MANAGEMENT AREA NUMBER 20 (GENERAL FOREST) Apply an uneven-aged selection system of timber management where individual or small groups of trees are removed. Maintain a high level of visual quality. Provide opportunities for water, wildlife, enhancement, grazing, mineral exploration and development, and dispersed recreation.

For northfacing slope above the immediate reservoir area -- MANAGEMENT AREA NUMBER 23 (GENERAL FOREST). Maintain the natural character of Middleground Partial Retention where high site even-aged timber harvest practices are applied to the landscape. Provide opportunities for compatible wildlife enhancement, grazing, minerals exploration and development, and dispersed recreation.

TAHOE NATIONAL FOREST

ALTERNATIVE PRF (PREFERRED)

This alternative provides for increased recreation emphasis. It will increase the level of environmental protection over the current program while maintaining grazing outputs near existing levels. This alternative . . . establishes a high level of protection for wildlife, riparian areas, soil productivity, water quality, and visual quality.

PRESCRIPTION — 7. The theme is to improve fish and wildlife harvest species habitat while producing other commodities. Allow grazing if not conflicting with wildlife. Restrict transportation use to meet wildlife objectives. Harvest timber on a regulated basis.

LAND USE

ELDORADO NATIONAL FOREST — STANDARDS AND GUIDELINES

POWER-RELATED LICENSES AND PERMITS

MANAGEMENT PRACTICE 98 Power Related Licenses and Permits — Do not allow major power projects that are incompatible with Foreground Retention Visual Quality Objectives. Minimize impacts on visual quality, water quality, timber, and wildlife habitat objectives.

TAHOE NATIONAL FOREST — STANDARDS AND GUIDELINES

FACILITIES

During relicensing of hydroelectric projects, require flows and habitat conditions more favorable to fish and wildlife if the existing project has degraded these resources. Coordinate relicensing projects with the California Department of Fish and Game.

Special Use permits will only be issued for activities that serve public needs and cannot reasonably be conducted on private lands. Priority will be given to special uses that maximize public benefits, including energy-related uses.

If the reservoir is drawn down during all times when the streambed is mobile, it may be possible to at least temporarily minimize further sedimentation near the Ralston Powerhouse by taking advantage of sediment storage areas further downstream. The past operations of the reservoir have led to a pattern of deposition that has a characteristic slope that is 50 percent of the original, but with a greater than expected amount of deposition in the upstream parts of the valley. These sediments are near where the river slows when it enters the reservoir held at 1,175 and dramatically loses its capacity to transport sediment. Lowering the reservoir level during flows carrying sediment, flows greater than 4,500 cfs, will concentrate the sedimentation in the area 4,500 feet below the powerhouse where substantial storage is available. Thus, with this operational change, sediment input can be managed for a period of time to prevent bed aggradation at the powerhouse. The present operating level necessary to transport the sediments to unused storage in the reservoir is approximately elevation 1,160. The storage available, 550,000 cubic yards, before general aggradation resumes, translates to approximately 10 years of input. We would suggest maintaining some local storage for sediments delivered in large floods; perhaps 275,000 cubic yards.

The lowered reservoir levels may have additional benefits. Calculations using HEC-2 have shown that sediment that has accumulated in the region from 5,000 feet to 6,700 feet above the dam (1,800 to 3,900 feet below the powerhouse) restricts flow passage, which in turn raises tailwaters at the powerhouse and reduces the amount of sediment the channel can carry. Operating the dam at this lower level for a period of years may allow the river to cut through this restriction thus improving hydraulic efficiency and lowering tailwater. Alternatively, sediment removal operations totaling 40,000 cubic yards could speed the downcutting to increase hydraulic and transport efficiency.

Effect on Resources

Implementation of Alternative 4 would result in much the same resource conditions and impacts as Alternative 3, except that sediment disposal would be delayed for several years.

Costs and Economics

This alternative may reduce annual costs of sediment removal by providing additional storage capacity in the reservoir. It is assumed that over the long term the average annual amount of sediment removed from the reservoir will be the same but that an initial 10 year reprieve during the next 23 years will reduce average annual costs of sediment removal to 40 percent of present costs.

It is assumed that some emergency removal of sediment will still be required with this alternative and that the quantities of dredging and excavating will be the same as what occurs now. It is also assumed that the average generation lost at the Ralston and Oxbow powerplants will remain the same as at present. The small decrease in generation at Oxbow during the brief drawdown period would not be significant. The analysis on Table 3-5 shows that average annual costs are estimated to be $370,000 to $420,000, which is about one-half of the present costs.

3.1.5 Alternative 5 -- Keep Reservoir Free of Sediment

Another approach to reservoir management would be to entirely remove the sediment accumulated to date, and to continue removing materials that are added in the future. Even this approach might not entirely eliminate operational curtailments during flood events, but the need for emergency work would be minimized.

Implementation, Maintenance, and Effectiveness

Implementation of this alternative would require removal of roughly a million cubic yards of sediment from the reservoir, plus ongoing operations to remove an average of at least 56,500 cubic yards per year in the future. Although the removal work could be planned in advance and conducted under dry conditions, there are serious problems with handling the finer sediments that occupy the downstream portions of the storage reservoir. Lengthy restrictions on operations would be needed to progressively reduce the pool elevation while sediments were excavated. The finer material drains poorly and releases methane, constraining working conditions and requiring several weeks of settling after the pool is emptied of water. Alternatively, fine sediments might be dredged while the pool was full, deposited at temporary sites to drain, and then hauled to permanent disposal sites.

Maintenance of the cleared pool would not be much easier than the initial clearing except that less material would have accumulated between excavations. Maintenance would still require emptying the pool or wet dredging and handling fine sediments. By increasing residence time, the large storage capacity of a cleared pool might result in more rapid accumulation of fine material than with the storage volume partially occupied. This might mean that more than the average annualized accumulation of 56,500 cubic yards would need to be removed in future operations.

Although this alternative would help to reduce power production curtailment due to storm events and sediment accumulation, complete clearing of the reservoir is unnecessary and would be costly. The major operations required might also have adverse effects on existing resources and uses of the area.

Effect on Resources

Large amounts of sediment would be removed from the reservoir under Alternative 5. Sediment removal would occur on an intensive bases for several years in order to remove all sediments from the reservoir and then annually to keep up with deposition. Hauling of spoil, and draw-down of the reservoir would occur in most years, probably in the fall. During the remainder of the year the reservoir pool would be deep and scoured. Little if any riparian vegetation would

TABLE 3-5

RALSTON AFTERBAY SEDIMENT STUDY

IMPROVE SEDIMENT TRANSPORT AND STORAGE

ANALYSIS OF ANNUAL COSTS

				Energy Value	ANNUAL COST ($1990) PG&E ECAC ($million)	PG&E QF ($million)
REPLACEMENT GENERATION						
Energy	4.7 GWh @	26.3	mills/kWh		$0.12	
	4.7 GWh @	37.27	mills/kWh			$0.18
Dependable Capacity						
	0 MW @	56	$/kW-yr			
SEDIMENT REMOVAL						
Dredging and removal of wet sediment during winter and spring. Three mile haul to disposal area.						
	14100 cu. yd @	20	$/yd		$0.28	$0.28
Excavation and removal of dry sediment during late fall. Three mile haul to disposal area.						
	42400 cu. yd @	8	$/yd		$0.34	$0.34
SEDIMENT STORAGE						
Gain of ten years of sediment storage capacity						
Present Worth in 1990 $million				($4.53)		
Equivalent annual value (1990 to 2013)					($0.37)	($0.37)
TOTAL ANNUAL COST IN MILLIONS OF 1990 DOLLARS					**$0.37**	**$0.42**

become established or mature along the reservoir shoreline. Road improvements in and out of the reservoir would be necessary in order to accommodate the large volumes of sediment being removed. Long-term planning of sediment disposal would become a major activity of PCWA.

Land Use Under this alternative huge volumes of sediments would be removed from the reservoir. Special Use Permits might be difficult to obtain for placement of large volumes without serious consideration of alternatives to disposal. Close supervision and extensive monitoring of reclamation plans could be expected.

Fisheries Complete drawdown of the reservoir on a regular basis would result in adverse impacts to the fisheries resources of the reservoir. Draining the reservoir would temporarily eliminate all fish and their habitat from the reservoir and would have long-term effects on any self-sustaining population.

Riparian Vegetation/Wildlife Regular removal of sediments from the entire reservoir would probably eliminate the limited riparian growth on the reservoir shoreline that currently exists. Regular drawdown and excavation of the reservoir would probably prevent the future establishment of riparian vegetation at the reservoir.

The elimination of fish, fish habitat, and riparian vegetation would result in an adverse effect on wildlife by degrading habitat.

Recreation This alternative would have adverse effects on recreation opportunities at Ralston Afterbay. Regular drawdown of the reservoir would most likely eliminate fishing opportunities. Although the deep scoured reservoir would be attractive to recreationists, boating opportunities would be severely curtailed due to constant sediment removal and disposal operations. Heavy truck traffic associated with sediment disposal would also reduce the attractiveness of the reservoir for recreating.

Public Health and Safety Regular removal of all sediments from the reservoir would minimize the public safety concern for dam safety resulting from sedimentation. Trucking of large amounts of material out of the reservoir would intensify traffic safety problems mentioned in Alternatives 2 and 3.

Aesthetics Because large volumes of sediment would be removed on an almost annual basis, operations could extend into the summer recreation season when most visitors view the area. If such operations dominated the activity at the reservoir this would significantly reduce the visual quality of the reservoir viewshed. Although the deep water pool resulting from sediment removal could be attractive, the residual from such activity (disturbed shoreline, removal of vegetation) would reduce the visual quality.

Finding sites for disposal of large volumes of material where VQOs could be met might be difficult. It could be expected that stringent guidelines and restrictions may be imposed by the land managing agency.

Other Resources Impacts to historical and cultural resources would need to be avoided as in alternative 2 and 3.

Costs and Benefits

Removal of all accumulated sediment from the reservoir will require excavation and disposal of over one million cubic yards of material. In estimating the annual costs of this alternative it is assumed that this material would be removed in the dry by draining the reservoir. If an average of 2,000 cubic yards were removed per day this process would take 500 days, requiring extensive scheduled outages. It is assumed that this would be carried out in September, October, and November of many years and would result in no loss of dependable capacity but the loss of the equivalent of one year's generation over the 23 year operation period.

The estimated annual cost shown on Table 3-6 is in the range of $1.84 to $2.13 million dollars and is therefore unattractive as compared to the present management practices or other alternatives.

3.2 ALTERNATIVES INVOLVING STRUCTURAL MODIFICATIONS

Some of the operational problems that occur at the Ralston and Oxbow powerplants might be reduced or corrected by structural modifications. This section describes the nature of existing problems and discusses several potential options for improving operations during high flows.

3.2.1 Potential Modification at Ralston Powerplant

There are two problems that occur at Ralston Powerplant during periods of high flow in the Rubicon River. The high flows cause increased tailwater elevations which curtail or prevent operation of the powerplant. Sediment and bedload moving downriver past the powerplant deposit in the tailrace and on occasion flow into the discharge chamber beneath the turbine runner. Conceptually there are several options for dealing with these problems:

- Cease or curtail operation of the powerplant during flood events
- Raise the powerplant higher above tailwater level
- Depress tailwater levels
- Modify the tailrace to avoid deposition of sediment.

These options are discussed in the following paragraphs:

Cease or Curtail Operations -- This is the operating approach which is presently used because there is no alternative. As tailwater elevations rise above 1,177 feet the output of the powerplant

TABLE 3-6

RALSTON AFTERBAY SEDIMENT STUDY

KEEP RESERVOIR FREE OF SEDIMENT

ANALYSIS OF ANNUAL COSTS

				ANNUAL COST ($1990)	
			Energy Value	PG&E ECAC ($million)	PG&E QF ($million)
REPLACEMENT GENERATION					
Energy	26.8 GWh @	26.3	mills/kWh	$0.71	
	26.8 GWh @	37.27	mills/kWh		$1.00
Dependable Capacity					
	0 MW @	56	$/kW-yr		
INITIAL SEDIMENT REMOVAL					
Removal of accumulated sediment during fall and early winter Three Mile haul to disposal area					
1,027,000 cu. yd @ 8 $/yd =		$8.22	million		
Equivalent annual value (1990 to 2013)				$0.68	$0.68
ANNUAL SEDIMENT REMOVAL					
Dredging and removal of wet sediment during winter and spring. Three mile haul to disposal area.					
	0 cu. yd @	20	$/yd	$0.00	$0.00
Excavation and removal of dry sediment during late fall. Three mile haul to disposal area.					
	56500 cu. yd @	8	$/yd	$0.45	$0.45
TOTAL ANNUAL COST IN MILLIONS OF 1990 DOLLARS				**$1.84**	**$2.13**

is steadily reduced until it must be entirely shut down at elevation 1,181. A rough analysis of water surface profiles indicates that this curtailment will start when the flow at the afterbay dam is about 7,000 cfs and that generation must entirely cease when flows reach about 20,000 cfs.

This operating mode causes a loss of generation at the powerplant during periods of curtailment and also requires careful monitoring of the turbine load to prevent excessive vibration. It is not known whether or not the vibration is causing damage to the turbine or the powerhouse structure. A further complication with this approach is that sediment can flow into the tailrace and discharge chamber and prevent restarting of the unit without first dredging out the tailrace and turbine discharge chamber. In 1986 this process required expensive and time consuming sediment removal and clean up work inside both the powerhouse and tailrace under very difficult winter conditions.

Closing the tailrace bulkhead gate under high flow conditions would help reduce the amount of sediment entering the powerhouse. Under present conditions this is difficult to do quickly because there is no permanent hoist on the tailrace gates and an outside crane must be brought in to service the gates. Installation of a permanent hoist would enable the plant operator to quickly close the gate and prevent sediment from building up inside the powerhouse. Build up of large accumulations of sediment against the outside of the gate may make it difficult to raise after the storm has passed. However, large storms will continue to require drag line operations, as in 1986, and the sediment can be removed from in front of the gate as part of that work. The cost of adding a permanent hoist would almost certainly be justified by the time and effort saved following major storms.

Raise the Powerplant higher above Tailwater Level -- Raising the powerplant further above tailwater level would require reconstruction of the existing powerhouse structure at a higher elevation. It is very unlikely that this would be an economically attractive option due to the following:

- The high cost of reconstruction work which would probably be in the range of 4 to 6 million dollars.
- The continuous 1 to 2 percent loss in energy due to the small decrease of hydraulic head on the unit.
- The loss of generation when the plant would be out of service for major reconstruction work.

This option is therefore not recommended for further consideration at this time.

Depress Tailwater Levels -- Tailwater depression with compressed air is a proven method for reducing tailwater elevation in the discharge chamber of impulse turbine units. During periods of elevated tailwater levels, compressed air is pumped into the discharge chamber increasing the air pressure from near atmospheric to several pounds per square inch which pushes the tailwater level down and away from the turbine runner. Normally these systems are only operated for brief periods when tailwater is elevated due to high streamflow conditions.

Assuming a turbine design flow of 836 cfs, a turbine runner elevation of 1,186 feet, a desired minimum clearance to tailwater of 9 feet and a design maximum tailwater elevation of 1,190 feet a total of 13 feet of depression will be needed which will require an air pressure of 5.6 pounds per square inch in the discharge chamber. Assuming a 20 percent ratio of air flow to water flow a total air supply capacity of about 10,000 cubic feet per minute will be required at the design pressure.

In retrofitting tailwater depression systems to a semi-outdoor powerplant, it is usual to mount the air blowers outside on the top deck of the powerplant and use the existing discharge chamber air vent pipe as a conduit for carrying compressed air down to the discharge chamber. A series of valves and controls are installed to isolate the air blower from the vent under normal operating conditions and to close off the vent intake when the depression system is in operation. Depending on the design of the lower turbine bearing and shaft seals it may also be necessary to install an additional shaft seal below the bearing to avoid air flow through the bearing and loss of oil.

For planning purposes the cost of retrofitting a tailwater depression system is estimated to be approximately $300,000. This would cover purchase and installation of two positive displacement air blowers each rated at 5,000 cfm at 6.0 psi, new piping work, controls, and a turbine shaft seal. The actual cost would largely depend on the amount of custom piping, valves and electrical installation work that would be required. Final selection of the blower system to be used would also need to take into consideration such things as the amount of station service power available for starting large 150 to 200 hp electric motors, piping and isolation requirements and structural capacity of the powerhouse deck.

Installation of a tailwater depression system at Oroville Wyandotte Irrigation District's Woodleaf Powerplant in 1984 is reported to have cost $80,000. This is equivalent to about $95,000 in 1990 dollars. This system was smaller than that required at Ralston Powerplant and comprised two electric blowers each rated at 2,500 cfm at 2.5 psi, piping, controls and a turbine shaft seal. Much of the installation work was carried out by OWID's maintenance staff which also kept the overall cost down.

The estimated capital cost of retrofitting a tailwater depression system to Ralston Powerplant is $300,000. Additional annual costs will be incurred operating and maintaining the equipment and providing energy to run the air blowers.

In the cost analysis shown on Table 3-7 the annualized cost of installing and operating the system is estimated to be about $34,000 in 1990 dollars. It is assumed that the system will eliminate curtailments at Ralston Powerplant but require a small amount of energy annually to operate for an average of 4 to 5 days per year. It is also assumed that operation of the unit will eliminate the need for emergency sediment removal from Ralston tailrace and that all sediment removal can be scheduled for late summer when the reservoir can be lowered. The tailwater depression system would not change curtailments at Oxbow Powerplant; therefore the associated energy losses would continue.

TABLE 3-7

RALSTON AFTERBAY SEDIMENT STUDY

INSTALL TAILWATER DEPRESSION SYSTEM AT RALSTON POWERPLANT

ANALYSIS OF ANNUAL COSTS

				Energy Value	ANNUAL COST ($1990) PG&E-ECAC ($million)	PG&E-QF ($million)
TAILWATER DEPRESSION SYSTEM						
Capital Cost	$0.30	million				
Equivalent Annual Cost (1990-2013)					$0.025	$0.025
O & M Cost					$0.009	$0.009
REPLACEMENT GENERATION						
Energy	0.3 GWh @	26.3	mills/kWh		$0.007	
	0.3 GWh @	37.27	mills/kWh			$0.010
Dependable Capacity						
	0 MW @	56	$/kW-yr			
SEDIMENT REMOVAL						
Dredging and removal of wet sediment during winter and spring. Three mile haul to disposal area.						
	0 cu. yd @	20	$/yd		$0.00	$0.00
Excavation and removal of dry sediment during late fall. Three mile haul to disposal area.						
	56500 cu. yd @	8	$/yd		$0.45	$0.45
TOTAL ANNUAL COST IN MILLIONS OF 1990 DOLLARS					**$0.49**	**$0.50**

The estimated annual cost of operations with the system is shown on Table 3-7 and is $490,000 per year or about 60 to 65 percent of current costs. This alternative appears to be attractive and should be pursued further.

Even with a tailwater depression system installed at Ralston Powerplant, there will still be aggradation of the river bed outside the exit of the discharge chamber and the possibility of sediment entering or partially blocking the discharge chamber. If the unit were shut down for any reason a repeat of the 1986 problem in which the discharge chamber was choked with sediment might occur. Possible changes to the discharge from the powerplant are discussed in the next subsection. A permanent hoist on the gates is also needed with this alternative

Modification of the Tailrace to Avoid Blockage with Sediment -- As previously discussed, addition of a permanent tailrace gate hoist would help to avoid blockage of the turbine discharge chamber with sediment when the turbine is shut down. Outages are likely to occur during storms for reasons other than just high tailwater (such as transmission outages or intake problems) so it would be useful to have the capability to quickly isolate the powerhouse from the river.

Ralston Powerhouse is in the narrow channel of the Rubicon River and the exit of the turbine discharge chamber is in the deepest part of the river's channel. The opening of the powerhouse is about 30 feet wide and 16 feet high and is angled at 90 degrees to the centerline of the river. Hydraulic analyses indicate that the river will aggrade about 8 to 28 feet depending on the way the dam is operated during flood events.

One way the tailrace could be modified to reduce or eliminate sedimentation of the turbine discharge chamber would be to construct a training wall to divert bedload rich bottom-flow away from the powerhouse and a movable partition so that under flood conditions when the tailwater depression system was working water discharged from the turbine could flow over the partition and prevent sediment from entering the powerhouse. During normal operation the partition would be removed to allow the powerplant to operate without tailwater depression. Hydraulic model studies would be required to develop a practical design for such a system.

3.2.2 Potential Modifications at Oxbow Powerplant

At present there are three problems that occur at Oxbow Powerplant during periods of high flow in the Rubicon River.

- The high flows cause high sediment concentrations which overload the cooling water strainers.
- Sediment and bedload moving downriver below the afterbay dam deposit in the tailrace and reduce the overall operating efficiency of the powerplant.
- Sediment flow through the turbine or bypass valve probably is causing accelerated wear of hydraulic and sealing surfaces.

If the plant is shut down there is a risk that the intake and tunnel will become choked with fine sediment. Conceptually there are several options for dealing with these problems:

- Cease or curtail operation of the powerplant during flood events
- Relocate the cooling water intake to a location where there is a lower sediment concentration
- Retrofit larger automatic backflushing strainers on the cooling water supply
- Redesign the intake to avoid inundation by sediment.

These options are discussed in the following paragraphs:

Cease or Curtail Operations -- This is the operating approach which is presently used because there is no alternative. When the cooling water strainers become overloaded the turbine and generator are shut down. At times the synchronous bypass valve adjacent to the turbine has been left open to keep water flowing through the intake and tunnel and thus avoid deposition of sediment.

It is likely that future deposition of fine sediment at the downstream end of Ralston Afterbay will increase the amount of fine sediment drawn into the intake during flood events. Operation of the turbine under such conditions will probably increase the rate of wear on hydraulic and sealing surfaces.

Relocate the Cooling Water Intake -- It is understood that at present the cooling water intake is tapped in to the penstock and therefore accepts water drawn in at depth from the afterbay. During flood conditions the water near the bottom of the afterbay entering the intake is likely to be heavily laden with sediment. Water nearer the surface will have a lower sediment load so a separate small floating intake in a stilling basin would draw in less sediment. An inexpensive solution which has been successfully used at small hydroelectric plants in New Zealand is to use water from the turbine headcover drain for generator cooling. A check would have to be made of the Oxbow turbine to determine if there is sufficient water for this purpose.

Retrofit Larger Automatic Backflushing Strainers -- The present problems with frequent manual cleaning of the cooling water strainers could be alleviated by retrofitting a pair of larger automatic backflushing strainers.

Redesign the Intake to Avoid Inflow and Blockage by Sediment -- The present intake is a conventional horizontal axis reinforced concrete intake structure with a trashrack structure and a 12-foot high by 8-foot wide bulkhead closure gate. The gate sill is at elevation 1,140 feet and the entrance to the intake is 17 feet wide by 17 feet high. Under normal operating conditions the afterbay water level is at 1,175 feet and the submergence to the crown of the intake gate at elevation 1,152 feet is about 23 feet. Preliminary calculations indicate that the minimum submergence to avoid vortices at the intake would be about 11 feet. The present intake configuration could be raised 12 feet without adversely affecting operation under normal reservoir operating levels. However, operation at lower reservoir water levels could be affected. Raising the whole intake structure and the entrance to the Oxbow tunnel would be a difficult and costly solution.

It may be possible to effectively raise the intake in place by extending the mouth of the existing intake closer to the surface. This could be achieved by constructing a short 45 degree elbow in the intake on the upstream side of the gate, extending the walls of the intake out 8 feet and raising the bottom lip of the intake to elevation 1,154 feet. Extensive modifications to the trashrack structure would be required to provide sufficient screening area at a higher elevation. Further detailed investigation of this alternative appears to be a promising improvement for Oxbow assuming that sediment levels in front of the intake will continue to rise. Raising the intake will reduce the amount of moving bedload sediment from entering the intake but it will not eliminate ingestion of fine suspended sediment during flood events, therefore, improvements to the cooling water filtration system would still be necessary.

3.2.3 Potential Modifications to the Ralston Afterbay Dam

Sediment levels in Ralston Afterbay are largely controlled by the Afterbay Dam. The effect of the dam on sediment and water levels is greater at the lower end of the afterbay and diminishes further upstream.

Conceptually one way of changing the present effect of the dam would be to remove or reduce the effect of the dam during high flow events by adding sluices at a low elevation. New sluices would probably need to be about 30 feet lower and have a discharge capability in the order of about 25,000 to 50,000 cfs. They would need to be quite large to provide this discharge capability without a substantial increase in head upstream to push the water through. For example if the mean water velocity through the sluices as open channel flow were 10 feet per second, the area required would be 2,500 to 5,000 square feet. The total area of the existing 5 gates is 6,000 square feet so the increase in gate capacity required would be considerable. Retrofitting such sluices to the dam would require reconstruction of the dam and it is unlikely that this would be a cost effective solution to the sediment problem unless the dam were to be replaced for other reasons.

Increased sediment elevations on the upstream face of the dam will increase horizontal loading on the structure and may affect the stability of the dam. It is not known whether the dam is designed to safely withstand such additional loading and it is understood that this is being evaluated by Harlan Tait Consultants as part of the FERC and State of California dam safety inspection program. If substantial modifications to the dam are proposed as a result of their study then the need for additional low-level outlet capacity should be considered.

From an environmental standpoint any reconstruction of the dam would be constrained by the build-up of existing sediment in the reservoir, because removal of the existing structure would possibly allow a large volume of sediment to move downstream if a flood event occurred during the construction process. The normal approach to this problem would be to construct a new dam downstream and leave the old structure in place, however at Ralston Afterbay, the old structure would have to be breached to reduce water and sediment levels during flood events.

In summary, this appears to be an expensive solution which could be considered further if it ever becomes necessary to reconstruct or replace the Ralston Afterbay Dam or increase the capacity of its spillway.

3.3 SEDIMENT DISPOSAL OPTIONS

Half of Ralston Afterbay Reservoir lies within the Eldorado National Forest (south) and half is in the Tahoe National Forest (north). Both Forests have Land and Resource Management Plans that call for the protection of Forest resources such as water quality, riparian corridors, wildlife habitat, threatened and endangered wildlife and plant species, historical sites, visual quality and recreational opportunities. On National Forest lands protection of resources can conflict with plans to dispose of sediment. EA Engineering, Science, and Technology contacted Resource Officers from both the Foresthill (Tahoe) and Georgetown (Eldorado) Ranger Districts which have jurisdiction over the project area. Procedures and guidelines (formal and informal) that the Ranger Districts would like to see when applying for a Special Use Permit (SUP) for sediment disposal were discussed. The preferred procedure consists of:

- Preliminary consultation with the Ranger District to identify issues;
- Consult with other agencies (State Water Resource Control Board; California Department of Fish and Game) and conduct engineering and environmental studies;
- Submit Special Use Application with an environmental assessment to Ranger District for review, public notification, and Forest Service approval.

Preliminary consultation would entail disclosure of the total amount of material to be removed from the reservoir and scheduling of operations. There would be discussion of potential sites including the applicant's and Forest Service's proposals, including alternatives to not use federal lands. The Foresthill Resource Officer said "They have to realize not every flat spot is available (for sediment disposal) in the Forest." The Eldorado Resource Officer said they would like to see sediment placed in a location and manner in which it would be available for future use. Both Officers expressed an interest in seeing PCWA explore other ways to dispose of the material. Suggestions included selling the materials for road surfacing, advertising the materials in local papers, and researching opportunities to "recycle" the sediment.

Typically Special Use Permits are issued for a 10 year period. If sediment removal were to occur on a regular basis, and sediments were to be placed on National Forest lands it would be preferable to develop ten year plans for sediment disposal.

Other agencies to contact regarding the protection of such resources as water quality, fish, and wildlife would be identified and the scope of the Environmental Assessment defined. The assessment should address the engineering, economic and all the environmental issues associated with the proposed activity. The Forest Service is responsible for archaeological, and Threatened and Endangered plant and animal species clearance of sites, but where mitigation is necessary, the proponent would carry the cost. If mitigation of a site is not possible it would be dropped. The Forest will give priority to certain resources. For example protection of key wildlife habitat could be more important than obtaining Visual Quality Objectives in certain areas. Refer to Table 2-6 for resource priorities that could affect sediment disposal plans.

Sometimes environmental information is inadequate and Forest Service staff will supplement the document with additional information, or return it to the applicant for more work if necessary. Finally, the Forest Service notifies the public of the proposed activity and submits the Special Use Application to the Forest Supervisor for approval.

3.3.1 Sediment Disposal Within the Reservoir

Sediment disposal options within the reservoir include both retention of existing sediments and accumulation of new sediment at or below the normal water surface elevation of the reservoir. Over a million cubic yards of material now occupy the reservoir, and an average of 56,500 cubic yards is added each year.

Reservoir management Alternative 1 describes a scenario of continuing storage of sediment in the reservoir with no removal operations. Aggradation would be expected to continue until a stable bed profile is reached sloping up from the dam to the Ralston Powerhouse. The bed elevation at the powerhouse would be somewhere between 1,178 and 1,200 feet depending on how the water surface elevation of the pool is managed during storms that carry the bulk of the sediments. This process of filling the reservoir with sediment would take from 25 to 75 years. The consequences of this alternative are described in Section 3.1.1.

If the pool elevation is dropped during storm events, then water velocities in the upstream end of the pool will be sufficient to carry sediment farther downstream. This is a form of disposing of sediments within the existing reservoir. Reservoir management Alternative 4 explains that this type of sediment storage could be expected to occur for about 10 years at the average annual rates of sediment accumulation.

Reservoir management Alternatives 2, 3, and 4 include retention of some, but not all, existing sediment in the reservoir. Sediment removal operations would concentrate on the upper end of the reservoir where aggradation interferes with operations at Ralston Powerhouse. Continuing storage of the finer sediments in the lower end of the reservoir probably will not interfere with power production if structural modifications are employed to keep the Oxbow Intake operational. A small water storage volume is needed to meet ramping requirements downstream of the dam, but this already exists and would be maintained by excavation of sediments in the upstream part of the reservoir, plus the storage volume that would be retained immediately behind the dam.

As fine sediments accumulate in the lower part of the reservoir, riparian vegetation will begin to colonize the sands and muds in shallow water. Changes in stream channel morphology and flood events will often remove riparian growth, but large patches of willow and other invasive species will eventually persist over large areas. This new wetland habitat will be considered a valuable natural resource and might be managed to offset losses of wetlands at other Agency or County projects.

If a wetlands management approach is pursued in portions of the reservoir, it may be desirable to partition off these areas and stabilize them using some of the larger sediments excavated from the upper end of the reservoir. This would provide a convenient disposal area for some of the excavation work that will be needed to maintain an appropriate storage volume in the upper reaches of the reservoir. It might also be possible to dredge fine material from in front of the Oxbow Intake into a nearby isolated shallow area that would act as a settling pond and become wetland habitat.

Preparation of a wetland enhancement plan is a project that could be pursued during implementation of any of the first four reservoir management alternatives. It is possible that state or federal grant money could support such an effort, and it is even possible that the resulting habitat could produce economic benefits for PCWA. However, it is not likely to be easy to convince regulatory agencies that any active sediment disposal within the reservoir is acceptable. A long lead time would be required, the planning effort would be substantial, and the outcome would be uncertain.

3.3.2 Sediment Disposal Adjacent to the Reservoir

Sediment disposal adjacent to the reservoir has been sought whenever and wherever feasible. Disposal at these locations has been and probably will continue to be limited to small areas or to emergency situations. Regulations governing use of these sites are likely to become more restrictive. If emergency actions are needed with increasing frequency or if they result in any adverse impacts to water quality or fisheries, then regulatory pressures may also be applied to require approved plans for dealing with the emergencies.

In general, sites adjacent to the reservoir are unlikely to be suitable for sediment disposal due to very steep slopes, high visibility, and the potential for adverse effects on water quality and fish and wildlife habitat. A possible disposal area might be constructed in and adjacent to the road alignment between the bridge over the Middle Fork and the Ralston Powerhouse. This would require relocating the road and pole lines, as well as compacting the fill and stabilizing the slope along the shoreline. Disposal would probably occur in increments and it is not clear that access could be maintained inexpensively while disposal operations were in progress. Nevertheless, this site might accommodate up to a half million cubic yards of material, and the short haul distance makes it an attractive option.

Compaction and stabilization of the material would probably add one to two dollars per yard to the cost of disposal. Reconstruction of about a mile of road, relocation of power lines, traffic control, detours, and other complications would result in this alternative probably reaching a cost comparable to the uphill haul discussed in Section 3.3.4.

3.3.3 Sediment Disposal at Downstream Sites

The possibility of disposing of sediment at nearby sites downstream of the Ralston Afterbay Dam is attractive due to the short distance and small elevation change from the reservoir. However, access problems and regulatory constraints are formidable and probably offset the potential advantages of these sites.

In July of 1989, Forest Service responded to a PCWA request for preliminary consideration of developing a disposal site at Stoney Bar on the North Fork of the Middle Fork of the American River. Negative findings included construction of the haul road in the riparian zone and floodplain, disturbance of riparian vegetation, impacts to cultural resources, potential for adverse effects on water quality, and failure to meet visual quality objectives.

The Alpha Consultants report on the 100-year floodplain indicated that gravel bars along the Middle Fork American River that were included in the study would be covered by 20 to 30 feet of water during a 100-year event. Their report of 16 August 1988 estimated that as much as $2,000,000 worth of erosion protection might be required to stabilize 500,000 cubic yards of sediments placed at Indian Bar, Willow Bar, or American Bar. This requirement alone would add $4 per yard to the cost of disposal. This exceeds the historical difference of $2.40 per yard in the cost of short-haul disposal versus the 3-mile haul to upland disposal sites.

Possible disposal sites on terraces above the floodplain are likely to be constrained by the presence of both archaeological and historical resources, by riparian and wildlife values, by incompatibility with visual resource management, and by potential interference with recreational uses of the river. Land management agencies maintain jurisdiction over sites whether or not they are in the floodplain. The Forest Service's evaluation of any proposed disposal options would include review of impacts on all potential resource values. The Bureau of Reclamation does not allow disposal of material on their lands. Road construction or any other activity proposed within the floodplain would require numerous approvals and permits that are unlikely to be issued for a project having any viable alternatives.

Alpha Consultants suggested further evaluation of the Horseshoe Bar area. Although a detailed evaluation of this site is beyond the scope of this report, it appears that there is only a remote chance of this being a feasible disposal location. Favoring the concept is the possibility that public ownership and restoration of the site could be offered as part of the project. This might involve development of a recreation or interpretive facility and restoration of wetland habitat. In order to be economically attractive to PCWA, site development probably would need to be covered by state grand funds or other sources of financing. PCWA would also want to monitor the proposed Auburn Dam Project which could eliminate the possibility of development of this area.

There are several obstacles to use of Horseshoe Bar even if costs could be shared. First, access for sediment disposal would require construction of one to two miles of difficult road that would need to either cross the North Fork, or cross the Middle Fork twice. Road crossings generally are expensive and trigger complicated permitting and controversy. Second, hauling activities would probably be needed intermittently over many years. This would be likely to disrupt recreational use of the river, and would mean that the site restoration work would be in progress for a long time. These drawbacks would probably prevent the plan from being attractive to permitting agencies. Finally, the acquisition of private property would not necessarily be easy or inexpensive, and condemnation might not be desirable or feasible.

The following is a brief summary of the more significant regulatory constraints to the use of stream-side disposal sites:

- Forest Service Use Permit requirements apply if National Forest land is involved. Negative responses to the Stoney Bar proposal are likely to be applicable to other possibilities.

- If the American River Recreation Area is designated as a National Recreation Area a federal agency such as the Bureau of Land Management will be responsible for planning. Sediment disposal is very unlikely to be considered a suitable use of lands within one quarter mile of the river. This could restrict use of private as well as public land, and might require discontinuing use of a site even if expensive improvements such as road access were complete.

- CDFG has permitting authority within the streambed and an advisory role elsewhere. They probably could not be convinced that sediment disposal near the river could be mitigated to avoid adverse impacts. The studies and monitoring that would be required would be very expensive.

- RWQCB would review water quality issues. Jurisdiction and responses would likely be similar to CDFG's.

- U.S. Army Corps of Engineers would need to issue both a Dredge and Fill Permit and a Wetlands Alteration Permit for disposal sites within the floodplain. Wetlands regulations, in particular, probably would preclude use of the riparian zone unless it could be presented as a restoration or enhancement project. The measures needed to promote this concept would probably not be cost-effective.

- U.S. Environmental Protection Agency has veto authority over Wetlands Alteration Permits. They would share in determining mitigation and enhancement requirements for a restoration project.

In summary, it is highly unlikely that any downstream disposal sites within reach of Ralston Afterbay would be suitable or cost-effective for sediment disposal.

3.3.4 Sediment Disposal at Upland Sites

One upland site has been used for disposal of sediment excavated from the Ralston Afterbay Reservoir. This site is located at about elevation 2,400 feet, adjacent to the access road to the upper end of the Ralston Powerhouse penstocks and surge tank. Shortly after sediments were placed at this approved location in September and October of 1989, PCWA filed an application for use of a nearby site expected to accommodate 75,000 to 100,000 cubic yards of material. In both of these cases, a very simple application was filed with minimal supporting documentation of site conditions and visibility. The use permit that was issued included standard provisions for fire prevention, resource protection, assignment of liability, notifications and the like. Both of these disposal sites are in the Eldorado National Forest at locations closely associated with existing project facilities.

Another disposal site was used by PCWA for the disposal of material excavated from the Interbay Reservoir. This site, accommodating 35,000 cubic yards of material, is in the Tahoe National Forest and has required environmental studies in support of permitting, revegetation planning and implementation, and remedial follow-up work to meet objectives.

PCWA's experience with obtaining a use permit in the Tahoe National Forest for the Interbay Project is likely to be representative of all future situations involving sediment disposal on federal lands. Depending on which reservoir management alternative is selected, PCWA should probably seek a use permit for one large upland disposal area that would be used over many years in increments that would be dictated by need. Provision could be made for progressive revegetation of portions of filled areas that were considered complete, while maintaining an active area available for disposal operations as needed.

Forest Service probably will want an Environmental Assessment that considers the use of private lands as an alternative. Possible commercial uses of the material may also need to be documented. These kinds of considerations will affect the selection of upland disposal alternatives. However, both the proposed site and the Old Log Deck alternative that were presented in the 1989 use permit application (17 October 1989) are good possibilities.

Proposed Placement Site -- The area proposed by PCWA adjacent to the existing disposal area could be expanded to accommodate future needs for many years. The fact that the site has been logged probably means that there are no sensitive cultural or botanical resource values that would preclude use as a disposal site. Aesthetic and wildlife concerns could be mitigated by a revegetation program. Water quality, traffic, and other potential impacts could be mitigated by measures to be implemented largely during the hauling operations. Creative treatment of runoff and drainage in the small basin where the fill would occur might result in opportunities for development of riparian or other wetland habitat at completed portions of the filled area.

Costs associated with use of this site for sediment disposal would include minor use permit fees, environmental studies and documentation covering both planning and monitoring, and hauling material approximately 3 miles and 1,300 vertical feet. The cost of this has been estimated at roughly $8 per cubic yard in 1990 dollars, which is about 30 percent more than past operations using the adjacent existing disposal site. Mitigation requirements attached to a use permit could affect the cost more or less than has been estimated.

Old Log Deck Site -- The Old Log Deck site described as an alternative in the use permit application is on private land and would require the cooperation of the land owner to either sell or lease the property. Because of historical mining and other uses on or near the property, PCWA should approach any possibility of using this site cautiously in case there is a potential issue regarding liability for possible hazardous waste residue. If the site were found to be suitable for sediment disposal, it is likely that revegetation would be appropriate even though the Forest Service would not be a controlling force. If commercial uses of the material were foreseen, then the disposal site might be considered a temporary storage location and require only drainage and water quality protection measures.

Costs associated with use of the Old Log Deck site as compared to the proposed site include obtaining property rights, investigating the potential for liability, and increasing the haul distance by 2 miles and 1,000 vertical feet. Possible savings might be realized by avoiding a formalized environmental review process if the County could expedite its own project. There is also a possibility that the County's mitigation requirements might be less costly than those required by Forest Service. In spite of a few opportunities for cost savings, it is unlikely that use of the Old Log Deck site could be competitive in cost to use of the proposed site.

Mosquito Ridge Alternatives -- There is a small chance that a suitable sediment disposal area could be found in the vicinity of Mosquito Ridge. This would involve a minimum haul distance comparable to use of the proposed site but possibly with less elevation change. Constraints in the area include restrictive Visual Quality Objectives on National Forest land and potential traffic problems with use of a more heavily traveled road. An advantage of depositing sediment in that direction might be the possibility of increasing the potential for some commercial value. Rapidly developing areas of Placer County are more accessible from Mosquito Ridge Road than from the proposed disposal area, and there may be a chance that the material could be put to use if PCWA hauled it to an accessible site. If a large upland disposal site is sought, further consideration should be given to potential commercial uses of sediment, and to potential location of a disposal or transfer site near Mosquito Ridge Road.

4. CONCLUSIONS

This study has addressed the feasibility, costs, and environmental consequences of a variety of alternative approaches to management of sedimentation problems at Ralston Afterbay Reservoir. The following paragraphs summarize the conclusions that may be drawn based on information presented in Section 3. It must be understood that the analyses presented in this report constitute a preliminary assessment of a broad variety of alternatives. The scope of the studies was not intended to be conclusive or to lead directly to design work, but rather to serve as a screening process based on the information available to date. In most cases, more detailed studies would be advisable prior to implementation phases for the measures recommended.

4.1 VIABLE SEDIMENT MANAGEMENT OPTIONS

Table 4-1 is an economic comparison of the different reservoir management options. The most reasonable alternatives for management of the reservoir are Alternative 3, Continuation of Small to Medium Scale Operations, and Alternative 4, Improve Sediment Transport and Storage.

Alternative 3 is a continuation of existing practices and is taken as the baseline condition. The annualized cost associated with Alternative 3 has been estimated at $750,000 to $800,000. Alternative 4 would improve utilization of existing storage capacity in the reservoir and delay the time at which sediment removal operations would need to approximately equal incremental additions of sediment. On an annualized basis, this could save up to $420,000 per year over the baseline condition. The effectiveness of this alternative can be tested by implementation and monitoring. Detailed sediment transport modeling also could be done to better define the optimal operating conditions and resultant changes that would be expected in sediment deposition.

If Alternative 4 is implemented it will utilize the reservoir storage volume for sediment disposal within approximately 10 years. After the available storage area is filled with sediment, there would no longer be the option of benefiting from this management approach and it would be necessary to remove material in volumes roughly equivalent to new deposition. However, if implementation of Alternative 4 is delayed, the benefit of the option may be reduced by ongoing deposition of fine material in the area that would accommodate the larger material if the pool were drawn down during high flows. Because of the sensitivity to timing, it may be important to recognize the relative cost implications and values of Alternative 3 versus 4 prior to the time existing contractual arrangements between PG&E and PCWA expire.

4.2 POTENTIALLY USEFUL STRUCTURAL MODIFICATIONS

The most obvious need for a structural modification is the addition of a permanent hoist on the tailrace gates. The need for this facility is clear to operations personnel, and it is probably advisable to proceed to the design phase for this fairly minor modification.

A tailwater depression system is likely to be cost-effective and should be pursued in more detail. Table 4-1 provides an economic ranking of alternatives and summarizes the economic costs and

TABLE 4-1

RALSTON AFTERBAY SEDIMENT STUDY

ECONOMIC RANKING
OF
HIGH TAILWATER AND SEDIMENT
MANAGEMENT ALTERNATIVES

ECONOMIC RANKING	HIGH TAILWATER AND SEDIMENT MANAGEMENT ALTERNATIVE	RANGE OF ESTIMATED AVERAGE ANNUAL COST (millions of 1990 dollars)			RANGE OF ESTIMATED AVERAGE ANNUAL SAVINGS OR (COST) RELATIVE TO CURRENT PRACTICE (millions of 1990 dollars)		
1	*Improve sediment transport and install Ralston tailwater depression system*	$0.22	to	$0.22	$0.53	to	$0.57
2	*Improve sediment transport & storage*	$0.37	to	$0.42	$0.37	to	$0.37
3	*Install Ralston tailwater depression system*	$0.49	to	$0.50	$0.25	to	$0.30
4	*Continue small to medium scale operations CURRENT PRACTICE*	$0.75	to	$0.80	$0.00	to	$0.00
5	*Emergency removal only*	$1.25	to	$1.31	($0.51)	to	($0.51)
6	*Keep reservoir free of sediment*	$1.84	to	$2.13	($1.09)	to	($1.33)
7	*Cease sediment semoval*	$17.10	to	$22.67	($16.35)	to	($21.87)

benefits that might be expected to result from implementation of this structural modification. An annualized savings of $250,000 to $300,000 has been estimated.

Some of the other structural modifications discussed in Section 3.3 might be cost-effective, but more detailed design studies and careful examination of construction scenarios are needed prior to a determination. The options most likely to warrant further consideration are partitioning sediment away from the Ralston Powerplant tailrace (Section 3.2.1) and raising the sill of the Oxbow Intake (Section 3.2.2). If the sill at Oxbow is changed, preliminary studies should include a close examination of the compatibility of this with Alternative 4.

4.3 LIKELY SEDIMENT DISPOSAL OPTIONS

The sediment disposal option most likely to be feasible and cost-effective is the one most recently pursued by PCWA. This is the site that was proposed by PCWA in its special use permit application to Forest Service in October 1989. In the future, a larger site could be requested at approximately the same location, and it is likely that full environmental documentation will be required both for obtaining a permit and for implementing and monitoring the operations. Even with reasonable levels of additional environmental mitigation, use of this site is likely to be less costly than use of private land located farther away.

One upland disposal option meriting further consideration is the potential use of sites along Mosquito Ridge. It is possible that some additional cost of hauling material might be justified if it increased the probability of the sediment having some commercial value.

If a single large reservoir clearing operation is anticipated, it may be worthwhile to give further consideration to using the road alignment area near the powerhouse. It might be advisable to plan and cost this option and, if desirable, seek approval for implementation in response to sedimentation from a major storm.

In each situation where PCWA may be transporting and disposing of sediment, it is probably worthwhile to run some routine tests of the material. Testing of sediment composition would determine whether or not any toxic conditions might result from disposal. Any potential for problems could be dealt with at the planning phase, and if there were no potential for problems then that fact would be well documented.

4.4 COMBINATIONS OF ALTERNATIVES

Table 4-1 shows that substantial savings probably would be realized by implementation of the Alternative 4 reservoir management option combined with the tailwater depression system for the Ralston Powerplant. Reservoir management with Alternative 4 would use increased velocities at the upper end of the reservoir during storms to move sediment deposition areas farther downstream. In the short term, this would reduce the need for sediment removal operations. The tailwater depression system would reduce energy losses and decrease the unit cost of sediment removal by avoiding emergency dredging.

The estimated annual cost of this combination of alternatives is $220,000 (Table 4-2) which is about 30 percent of estimated current costs (baseline conditions). On an average annual basis the savings could amount to a little more than half a million dollars a year. However, the long-term implications of Alternative 4 should be recognized, along with the fact that annualized costs are based on long-term averages, whereas actual costs result from the conditions that occur in real time. A short-term series of conditions differing from their long-term probabilities could substantially change the economics of any of the alternatives presented.

4.5 UNCERTAINTIES ASSOCIATED WITH ANNUALIZED COSTS

Annualized costs and savings have been used in this study as a way of comparing the long-term economics of various alternatives if applied over the future years. There are several uncertainties inherent in any method used to predict future costs and benefits, especially when applying the study results to any given year or relatively short period of years. Some of the important uncertainties associated with this study are discussed in this section.

The annualized cost concept depends on probabilities for future events being similar to those measured in past years. No single year is expected to be "average," and no given future year can be predicted with any certainty at all. Even short sequences of years may have an average that is far from the long-term average. The variability in water years, for example, is extreme, and a single large flood event could have maintenance costs equivalent to many times the annualized average. Furthermore, there is no guarantee that past probabilities for certain flow events will be repeated, even on a long-term basis.

The average annual amount of sediment deposited in the reservoir has been calculated at approximately 56,500 cubic yards. This is a rough evaluation dependent on only observational information for the upper and lower portions of the reservoir and on reported volumes of materials excavated. No direct measurements were available for these volumes. Even more important is the fact that deposition has occurred for only about 23 years. This is a relatively short period of time and most of the sedimentation probably occurred during one or two major storms. Although EA made a quick check to determine that the 23-year period of record was reasonably representative of the long-term record, it would be improper to place much certainty on the average annual number for sediment deposition when extended to future years. Section 2.2.5 also describes the fact that land slides triggered by an accident (non-probable event) may have contributed abnormally to sedimentation.

The amount of sediment that passes through the reservoir over the long term may differ from what has occurred in the past. This cannot be predicted accurately without detailed sediment transport modeling studies that were not included in the scope of this project. It is likely that as the reservoir fills with sediment, more material will remain in suspension during high flows and

TABLE 4-2

RALSTON AFTERBAY SEDIMENT STUDY

IMPROVE SEDIMENT TRANSPORT AND STORAGE AND INSTALL TAILWATER DEPRESSION SYSTEM AT RALSTON POWERPLANT

ANALYSIS OF ANNUAL COSTS

				Energy Value	ANNUAL COST ($1990) PG&E-ECAC ($million)	PG&E-QF ($million)
TAILWATER DEPRESSION SYSTEM						
Capital Cost	$0.30	million				
Equivalent Annual Cost (1990-2013)					$0.025	$0.025
O & M Cost					$0.009	$0.009
REPLACEMENT GENERATION						
Energy	0.3 GWh @	26.3	mills/kWh		$0.007	
	0.3 GWh @	37.27	mills/kWh			$0.010
Dependable Capacity						
	0 MW @	56	$/kW-yr			
SEDIMENT REMOVAL						
Dredging and removal of wet sediment during winter and spring. Three mile haul to disposal area.						
	0 cu. yd @	20	$/yd		$0.00	$0.00
Excavation and removal of dry sediment during late fall. Three mile haul to disposal area.						
	56500 cu. yd @	8	$/yd		$0.45	$0.45
SEDIMENT STORAGE						
Gain of ten years of sediment storage capacity						
Present Worth in 1990 $million				($3.30)		
Equivalent annual value (1990 to 2013)					($0.27)	($0.27)
TOTAL ANNUAL COST IN MILLIONS OF 1990 DOLLARS					**$0.22**	**$0.22**

pass downstream. This is particularly likely with Alternative 4 but the magnitude of the effect has not been quantified.

Interpretation of the study results should recognize the limitations of both the information available for the study, and particularly the failure of probabilities and averages to predict events in any given year or short series of years.

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