

# **Matilija Dam Removal *Appraisal Report - April 2000***

**U.S. Department of the Interior  
Bureau of Reclamation**

*Prepared by*  
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Matilija Dam Removal  
Appraisal Report

TABLE OF CONTENTS

Executive Summary .....	ES-1
A. Project Objective .....	1
B. Introduction .....	1
C. Existing Project Features .....	2
D. Proposed Dam Removal Alternative .....	3
1. Concrete Excavation and Disposal .....	3
2. Sediment Excavation and Disposal/Stabilization .....	4
E. Proposed Plans for Dam Removal .....	4
1. Site Access and Mobilization .....	4
2. Dam Removal Alternative 1A - Mechanical Removal of Sediment Upstream ...	5
a. Streamflow Diversion .....	5
b. Structural Removal .....	6
c. Sediment Stabilization .....	8
d. Site Restoration. ....	8
e. Advantages and Disadvantages .....	8
3. Dam Removal Alternative 1B - Mechanical Removal of Sediment Downstream .	9
a. Streamflow Diversion .....	9
b. Structural Removal .....	9
c. Sediment Removal\Stabilization .....	9
d. Site Restoration. ....	10
e. Advantages and Disadvantages .....	10
4. Dam Removal Alternative 1BB - Remove Sediment Downstream by Slurry Pipeline .....	11
a. Streamflow Diversion .....	11
b. Structural Removal .....	11
c. Sediment Removal .....	11
d. Site Restoration and Mitigation. ....	11
e. Advantages and Disadvantages .....	12
5. Dam Removal Alternative 2 - Phased Natural Transport of Sediment .....	12
a. Streamflow Diversion .....	12
b. Structural Removal .....	12
c. Sediment Removal .....	12
d. Site Restoration. ....	12
e. Advantages and Disadvantages .....	12

Matilija Dam Removal  
Appraisal Report

TABLE OF CONTENTS - Continued

F. Environmental Considerations .....	13
1. Noise Abatement .....	13
2. Air Quality .....	13
3. Water Quality .....	13
4. Public Health and Safety .....	14
5. Traffic .....	14
6. Special Status Species .....	14
a. Listed Species .....	14
b. California Species of Special Concern .....	16
7. Wetlands .....	17
8. Cultural Resources .....	18
9. Socioeconomics .....	18
G. Streamflow Diversion Requirements and Construction Sequencing .....	18
H. Waste Disposal .....	19
1. Construction Debris .....	19
2. Hazardous Waste .....	19
I. Sediment Management .....	19
1. Hydrology of the Ventura River Basin .....	19
2. Sediment Transport of the Ventura River Basin .....	31
3. Sediment Deposition in Matilija Reservoir .....	38
a. Chemical Composition of Sediment .....	44
b. Potential Erosion of Sediment .....	45
4. Simulation of Dam Removal .....	47
5. Potential Impacts .....	50
a. Deposition of Release Sediment May Increase Flood Damage .....	50
b. Sediment Deposition at Robles Diversion Dam May Increase .....	51
c. Fine Sediment May Temporarily Degrade Fish Habitat .....	51

Matilija Dam Removal  
Appraisal Report

TABLE OF CONTENTS - Continued

d.	Turbidity May Rise in the Ventura River, Affecting Water Quality	51
e.	A Large Period of Time Before Benefits of Dam Removal are Realized	52
f.	Habitat Upstream of Reservoir Will be Converted	52
g.	Resupply of Beach Sand	53
h.	Increased Uncertainty of Impacts	53
6.	Summary	53
J.	Project Schedule and Estimated Cost	53
1.	Development of Construction Logic and Duration	53
2.	Field Cost Estimate for Dam Removal	53
a.	Alternative 1A - Mechanical Removal of Sediment Upstream	53
b.	Alternative 1B - Mechanical Removal of Sediment Downstream	55
c.	Alternative 2 - Phased Natural Transport of Sediment	56
3.	Design and Construction Management	56
K.	Project Benefits	58
L.	Conclusions	58
M.	Additional Investigations for Future Studies	59

References

Appendix A - Project Drawings

Appendix B - Project Photographs

Appendix C - Construction Schedule

Appendix D - Cost Estimates

Appendix E - Notes from November 22-23, 1999 Brainstorming Session

Appendix F - Reconnaissance-Level - Spillway Gate Modification - Robles Diversion Dam  
By: Borcalli and Associates, Inc. Sacramento, California.

Appendix G - Alternative 1BB by the United States Army Corp of Engineers

Appendix H - Project Plan for Future Work by United States Geological Survey

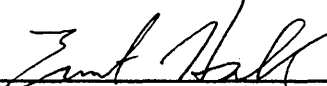
Appendix I - Planning Aid Memorandum by the Fish and Wildlife Service

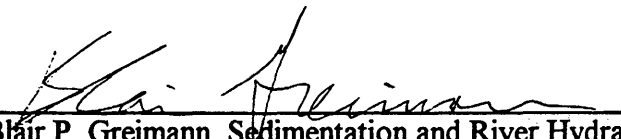




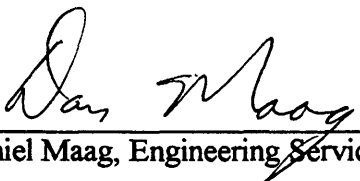
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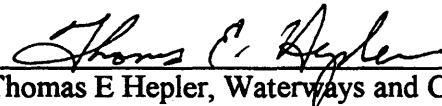
  
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# MATILIJA DAM REMOVAL PROJECT

## APRIL 2000

### EXECUTIVE SUMMARY

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The Bureau of Reclamation's (Reclamation) involvement in the Matilija Dam Removal Project (Project) is the result of a request by the Ventura County Board of Supervisors (Board). Upon the Board's request, Reclamation assumed the lead in creating the Matilija Dam Technical Task Force Committee (Committee), comprised of Federal, State and local entities, to expedite an appraisal-level study of the technical issues associated with the removal of Matilija Dam. Project tasks were defined and assigned to Committee members as appropriate. Reclamation assumed the lead throughout the appraisal-level effort including the preparation and completion of an appraisal report and the determination of the surface characterization and volume analysis of sediment located in Matilija Reservoir behind Matilija Dam. Concurrent with the appraisal-level process, the Ventura County Flood Control District (VCFCD) initiated planning for a Demonstration/Evaluation Project scheduled for October 2000; the United States Geological Survey (USGS) began work on items identified in their proposed workplan (survey studies) related to the Project; the United States Army Corps of Engineers (USACE) completed an Appraisal Report Supplement and preliminary Evaluation of Environmental Impacts; and the United States Fish and Wildlife Service (FWS) completed a Planning Aid Memorandum outlining potential environmental habitat concerns and benefits associated with the Project.



Figure 1 - Geographic View of Project Area

### Project Objectives

There are three main Project objectives: 1) to improve aquatic and terrestrial habitat to benefit fish and wildlife species (including endangered steelhead) along Matilija Creek and the Ventura River; 2) restore hydrologic and sediment transport regime in support of downstream coastal beach sand replenishment to pre-dam conditions; and 3) enhance recreational opportunities along Matilija Creek (including U.S. Forest Service land) and the downstream Ventura River system.

## Introduction

The Ventura River, a coastal stream in southern California, is located approximately 60 miles north of Los Angeles, California. The mainstem of the Ventura River spans roughly 31 miles from headwaters at upper Matilija Creek through the Ventura River proper to the Pacific Ocean. The Ventura River originates at the junction of North Fork Matilija Creek and Matilija Creek. Matilija Dam is located approximately 0.6 miles upstream of this junction and flows about 15.6 miles to the ocean. Approximately 89 miles of the river and tributaries within the Ventura River watershed are within areas designated as Wilderness including an additional 30 miles of the upper Matilija Creek and tributaries designated as a Wild and Scenic River under the U.S. Wild and Scenic Rivers Act.



Figure 1a - Location Map of Matilija Dam

Matilija Dam and reservoir was constructed by the VCFCO. A primary purpose of Matilija Dam was to remedy continuous water supply shortages that had plagued the Ventura River watershed since the 1920s. Construction began in 1947 -- initial storage began on March 14, 1948. Prior to Matilija Dam's completion, it became clear that

additional water supply facilities would be required to meet future demands. The VCFCO began a study resulting in the recommendation of a 90,000 acre-foot reservoir on Coyote Creek to include a canal for surplus flow diversion from the Ventura River. This study eventually resulted in the construction, by Reclamation, of Casitas Dam, Robles Diversion Dam and the Robles-Casitas Canal (Casitas Project, 1959). The Casitas Project was operated by the Ventura River Municipal Water District (VRMWD), now the Casitas Municipal Water District (CMWD). In 1959, the VRMWD assumed responsibility for operation and maintenance of Matilija Dam for the purpose of integrating the dam's storage and diversion capabilities with the Casitas Project.

### Existing Matilija Dam Features

Matilija Dam is a variable radius concrete arch dam with an average height of 190 feet and a crest length of 620 feet. The arch section varies in thickness from 8 feet at the original crest to 35 feet at the base of the dam.

Originally, the dam had a 276-foot-long ungated spillway located in the center of the structure with a crest elevation of 1125.0 feet National Geodetic Vertical Datum (NGVD). The original outlet works consisted of a 48-inch diameter sluice gate with an invert elevation of 1000.8 feet NGVD located in the center of the dam and a 36-inch diameter outlet gate with an invert elevation of 1025.0 feet NGVD located near the left abutment. The reservoir formed by Matilija Dam had an original storage capacity of 7,000 acre-feet at the spillway crest.



*Photo 1 - View Upstream of Matilija Dam and Reservoir After Completion in 1947*

Since its construction, Matilija Dam has experienced significant deterioration due to an alkali-aggregate reaction. In 1965 a 280-foot-long by 30-foot-deep notch, with its base at an elevation level of 1095 NGVD, was excavated in the center of the dam to remove damaged concrete, reduce the hydrostatic load, and improve the stability of the dam. The center notch was widened to 358 feet in 1977 and now functions as the spillway for flood releases. Lowering the spillway reduced the maximum reservoir capacity by 3,200 acre-feet.

Lake Matilija has been subject to substantial sedimentation build-up due to the highly erosive nature of the watershed. Studies performed by Reclamation in December 1999 resulted in an estimate of 6 million cubic yards of sediment stored in Lake Matilija. The reservoir was estimated to have approximately 500 acre-feet of storage in 1997. Floods in 1998 may have reduced the current capacity to as little as 400 acre-feet. Based on the current growth rate of sediment build-up, by 2010 the reservoir will be totally filled with sediment. Matilija Dam has trapped the majority of the coarse sediment normally transported downstream during large floods. The absence of this natural sediment supply is a beach erosion concern.

The Ventura River historically supported a substantial steelhead run estimated in 1946 at between 4,000 and 5,000 adult fish in an average year. The mid to upper reaches of Matilija Creek contain prime spawning habitat representing over half of the historical habitat. Currently, the population of anadromous steelhead in the Ventura River is greatly reduced to a level below 200 fish. This estimate, along with steelhead abundance estimates for additional drainages in southern California, was used by the National Marine Fisheries Service (NMFS) in their decision to list the Southern California Steelhead as endangered in 1997.

### Proposed Dam Removal Alternatives

The Committee developed several potential alternatives for the removal of Matilija Dam. Methods for removing and disposing of the concrete dam and sediment in the reservoir area were developed. Methods for excavating and disposing of the concrete are independent of methods for excavating and disposing of the sediment. However, the same concrete excavation and disposal option will be used for all sediment removal alternatives.



Photo 2 - Accumulated Sediment Behind Matilija Dam

**Sediment Excavation and Disposal/Stabilization** - The removal and disposition of an estimated 6 million cubic yards of sediment behind Matilija Dam is the most challenging issue associated with the Project.

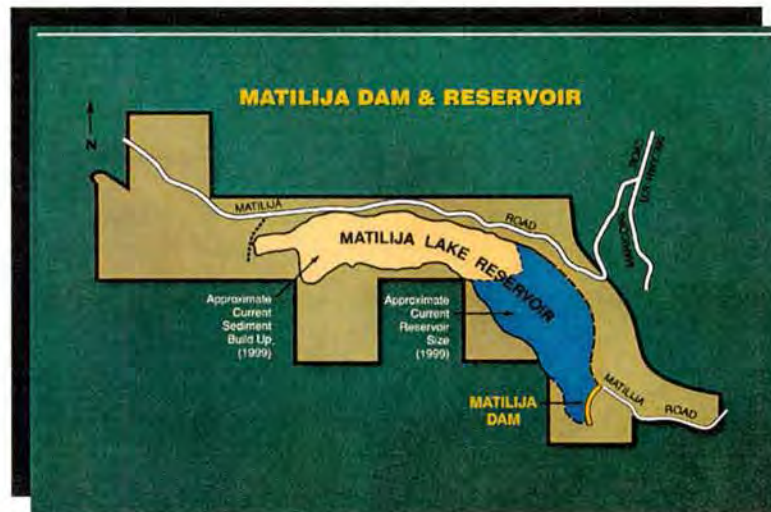


Figure 2 - Current Sediment Build Up (2000)



Several alternatives were addressed by the Committee as follows:

- ▶ Alternative 1A - Move the Sediment Upstream of the Dam and Stabilize
- ▶ Alternative 1B - Move Sediment to a Site or Sites Downstream by Trucking
- ▶ Alternative 1BB - Remove sediment to a downstream site or sites by slurry pipeline
- ▶ Alternative 2 - Phased Natural Transport of Sediment
- ▶ Alternative 3 - A Combination of Alternatives 1 and 2
- ▶ Alternative 4 - Complete Removal of the Dam in One Phase with Uncontrolled Natural Erosion of the Sediment
- ▶ Alternative 5 - Construction of a Fish Ladder or By-pass with No Dam Removal
- ▶ Alternative 6 - No Action

Cost estimates in the appraisal-level report for Alternatives 1A, 1B, 1BB, and 2 were carried forward as proposed by the Committee. Cost estimates for the remaining alternatives were not carried forward but were not excluded from potential consideration and future investigations. A brief description of each alternative is as follows:

**Alternative 1A - Move the Sediment Upstream of the Dam and Stabilize.** A sloped channel similar to the gradient of the pre-dam streambed would be constructed to route stream flows along the left side of the reservoir.

Sediment would be moved to the right side of the reservoir, shaped, and stabilized to adhere to the surrounding topography. Top soil would be placed on the top of the sediment for re-vegetation purposes. The slope on the right side would be stabilized with geogrid and gabion mats filled with riprap. This alternative would require stripping of the

existing vegetation at the disposal site. Time would be required for re-vegetation creating a negative visual impact during construction and for a period of time afterwards. The dam would be completely removed and the concrete hauled to commercial sites downstream for processing, and ultimately recycling. Metal work from the dam removal would be hauled to an appropriate disposal site. Construction of this alternative is estimated to require two years.



Photo 3 - Upstream Channel of Matilija Creek





**Concrete Excavation and Disposal** - Several options for excavating the concrete dam, and the advantages and disadvantages for each, were considered. These options include:

- ▶ Controlled Blasting
- ▶ Expandable Chemicals
- ▶ Diamond Wire Cutting
- ▶ Hoe-Ram

For the appraisal-level design, controlled blasting was used as the preferred option. The concrete would be hauled by highway trucking to a commercial concrete recycling plant. The concrete would be recycled to conform to Ventura County Ordinance #4155 which requires all commercial businesses located or operated in unincorporated portions of Ventura County to separate and divert from disposal items such as concrete. Two local recycling plants, Hanson Aggregate at 3555 Vineyard Avenue and CalMat at 6029 Vineyard Avenue, Oxnard, California, have been notified and are equally capable of managing the full volume of demolished concrete.

The defined concrete excavation and disposal options would be applied to subsequent sediment removal alternatives.

**Alternative 1B - Move Sediment to a Site or Sites Downstream by Trucking.** The dam would be completely removed. Metal work from the dam removal would be hauled to an appropriate disposal site. The sediment would be hauled downstream by truck. The reservoir area would be re-vegetated where side slopes permit upon Project completion. Time would be required for re-vegetation causing a negative visual impact during construction and for a period of time afterwards. Three options exist for this sediment removal alternative: haul the sediment directly to the ocean; haul the sediment to a permanent storage site downstream; or haul the sediment to a temporary storage site downstream. Delivering the sediment to the ocean would directly benefit beach restoration. Hauling the sediment to a beneficial permanent downstream storage site is expected to cost approximately the same as hauling the sediment to the ocean but would not benefit beach restoration. The third option, a combination of Alternatives 1A and 1B, would conceivably be most beneficial. The sediment would be hauled to a temporary downstream storage site for processing as the sediment is thought to consist largely of coarse material which may be a beneficial source of aggregate if processed. The coarse material would be removed for commercial resale -- the remaining material would be hauled to the ocean for beach restoration. The material would assumably be processed in the future at no additional Project cost. A temporary storage site for sediment to be dumped directly into the ocean and storage sites for beneficial permanent storage (fill dirt, golf course, etc.) have not been identified. Two possible temporary storage sites have been located downstream of Matilija Dam; S.P Milling site approximately two miles upstream of the intersection of Main Street and S.P. Milling Road, and the flood plane area approximately two miles downstream of the Robles Diversion Dam. The S.P. Milling site is roughly 28 miles downstream of Matilija Dam. Because temporary sites for future ocean disposal and/or permanent storage of sediment





have not been located, it would be assumed that all of the sediment would be hauled to a downstream temporary storage site (S.P. Milling site) for cost estimating purposes. The cost associated with hauling the sediment to the ocean for disposal is assumed comparable to the cost of hauling the sediment for temporary storage to the S.P. Milling site. Construction of this alternative is estimated to require four years.



Photo 4 - Pre-dam Channel of Matilija Creek (1900s)

During periods of no-construction, the dam and the sediment would be lowered to the same elevation. This would prevent large sediment discharges and sediment build-up during these periods. The majority of the sediment in the reservoir would be removed returning the reservoir area to near pre-dam conditions.

**Alternative 1BB - Remove Sediment to a Downstream Site or Sites by Slurry Pipeline.**

Carried forward to estimate costs by the USACE, this alternative consists of a slurry pipeline from Matilija Dam to transport fine grain material (1mm or less grain size) to the ocean and a conveyor belt and trucking system to transport large material (greater than 1mm grain size) downstream to the ocean or a temporary disposal site. The sediment excavated from the reservoir would be sorted -- water would be added to the fine sediment before being pumped through the pipeline as slurry. The sediment settling out after discharge from the slurry pipe could be used for beach restoration. The coarse sediment would be moved by conveyor to a temporary stockpiling area downstream of the Los Robles Diversion. The feasibility of this alternative depends largely on the water supply available for use in the slurry and the properties of the sediment stored in the reservoir.

**Alternative 2 - Phased Natural Transport of Sediment.** This alternative would require the dam be removed in stages. The dam would be lowered allowing the sediment in the reservoir to be removed by natural creek flow. When the sediment in the reservoir erodes to the new crest of the dam, the dam would again be lowered. This would be repeated in nine separate phases separated by intervals of two to three years until the dam is completely removed. During this dam removal process, concrete and metal would be hauled to the disposal sites listed in Alternative 1B. The sediment would eventually travel to the ocean supplying material for beach nourishment. The site would be re-vegetated naturally. Time would be required for re-vegetation creating a slight visual impact for a period of time. Completion of this alternative is estimated to require 25 years.

**Alternative 3 - A Combination of Alternatives 1 and 2.** A combination of alternatives may well produce a less costly more appealing final product than any one individual alternative. This combination alternative, however, will not be carried forward at this point in the removal process. The analysis performed for the individual alternatives will provide the necessary insight into potential combinations that can be further studied in the feasibility phase of the removal process.

**Alternative 4 - Complete Removal of the Dam in One Phase with Uncontrolled Natural Erosion of the Sediment.** Sediment directly upstream of the dam would be excavated and moved upstream to allow the concrete dam to be removed. After removal of the dam the sediment would be left to erode or re-vegetate in a natural manner. The sediment would likely erode slowly until large flood events occur carrying the sediment either fully or partially to the ocean. The sediment reaching the ocean would be a source for beach nourishment thus meeting the downstream coastal beach sand replenishment Project objective. Sediment which is not carried to the ocean would potentially cover existing spawning grounds raising the flood plane in localized areas. This alternative is considered to have a high risk potential for extreme social and environmental damage. This alternative will not be carried forward at this time.



Photo 5 - Upstream Matilija Dam-site (early 1900s)

**Alternative 5 - Construction of a Fish Ladder or Bypass with No Dam Removal.** For this alternative a fish ladder or fish by-pass would be constructed to allow passage of the steelhead upstream either around or over the dam leaving the dam in place. This alternative could possibly satisfy some portions of the Project objectives, but would not fulfill the overall objective of the Project. This alternative will not be carried forward at this time.

**Alternative 6 - No action.** The no action alternative would leave the dam in place. As the dam continues to fill with sediment it would eventually become a run of the river structure. Additional sediment would no longer be retained in the reservoir. This would provide material for beach nourishment but would not satisfy any other portion of the Project objectives. This alternative was not be carried forward at this time.

### Environmental Considerations

The basic design and construction philosophy behind the removal of Matilija Dam is to create a positive balance between temporary negative social and environmental construction impacts and long-term benefits consistent with overall efficiency of construction. These impacts fall in the general categories of local noise pollution, air quality, water quality, habitat, debris disposal, and increased traffic.





**Noise Abatement** - Noise would be produced by various dam removal activities including the operation of heavy construction equipment and controlled blasting. Noise levels may produce short-term adverse impacts close to the dam site, but should not be noticeable beyond about 1 mile. No special noise abatement procedures should be necessary.

**Air Quality** - Construction activities during dam removal would send large amounts of traffic related pollutants and particulate into the air in the immediate area and along many haul routes. Dust generated by construction traffic and drilling would be controlled by spraying with water. All construction activities associated with removal of the dam would require the use of fossil fuel thus air quality control would be required. Air quality mitigation costs would be included in the final dam removal cost estimate(s).

**Water Quality** - The dam removal process is expected to increase stream turbidity levels during construction and for some time afterwards. These small grain materials would be mobilized during the first wet season after completion of the Project. Turbidity is expected to increase during this first wet season to a level comparable to turbidity produced during normal high flows. Potential adverse impacts are expected to be minor. Water quality impacts associated with Alternative 2 would be a function of the basin hydrology and the properties of the sediment.

**Public Health and Safety** - Applicable construction safety standards would be enforced during all dam removal activities. Structures rising above the final grade of the reservoir floor would be removed. No public health and safety concerns associated with the dam structure would be affiliated with the dam site after the dam is removed.

**Traffic** - All public roads used to haul equipment to and from the dam, transport concrete to recycling plants, and relocate sediment downstream for Alternative 1B are highly traveled and congested. Special traffic control measures would be required for all travel on these roads. Road repair would be assumed necessary for Alternatives 1A and 1B and would be reflected in the cost estimates.

**Species of Special Concern** - At least 26 special status species are known from the aquatic, riparian, and wetland habitats in the study area including 13 listed species (endangered, threatened, or fully protected) and 13 California species of special concern. Taking into consideration all of the known special status species in the study area, the FWS is most interested in the potential impacts to the California red-legged frog and several riparian bird species. The National Marine Fisheries Service (NMFS) is primarily concerned with the endangered southern steelhead.

**Wetlands** - Several acres of land in the reservoir area upstream of Matilija Dam have developed into wetland-type environments. These areas support numerous species of plant and animal life. Removal of the sediment would result in a loss of these wetland areas. Wetlands mitigation costs would be included in each dam removal alternative.



**Cultural Resources** - Potential cultural resource impacts associated with dam removal would be addressed in subsequent investigations. The structure would also be evaluated for its historical significance. Construction activities would need to be planned to avoid effects on the nine-acre site located downstream of the dam (Matilija Hot Springs).

**Socioeconomics** - Dam removal could result in a loss to the CMWD of approximately 400 acre-feet of water per year if the dam is removed before the reservoir is completely silted in (projected to occur in 2010). Additionally, the reservoir has historically been used as a water supply to fight forest fires in the area. Removal of Matilija Dam would have significant impacts on the sediment accumulation at Robles Diversion Dam located downstream of the dam. To reduce the need for periodic cleaning of the stilling basin, a high-flow bypass facility to transport sediment through the structure was developed by CMWD. The cost of constructing this structure would be included in the total Project costs for each dam removal alternative.

Major restoration benefits of the dam removal may include the long-term restoration of anadromous steelhead in the mid and upper Matilija Creek and a natural supply of sediment for beach replenishment. Removal of the dam would improve public access to, and recreational opportunities in, Matilija Canyon. The high flow bypass facility would reduce the need for periodic cleaning of the Robles Diversion stilling basin. The removal of Matilija Dam would also eliminate ongoing maintenance and future dam safety liabilities for the VCFCO.

### **Streamflow Diversion Requirements and Construction Sequencing**

Construction activities in the reservoir would be sequenced to take place during historical low flow periods in April through December. For the mechanical excavation alternatives, low flows would be diverted around the construction site by placing cofferdams upstream and downstream of the construction area. Flow would be conveyed through pipelines around the construction area.

### **Waste Disposal**

All concrete would be removed from the site and hauled to commercial recycling plants. Mechanical items such as pipes, gates, valves, operators, and trashracks would be salvaged to aid in offsetting Project costs. The cost estimates are based on the salvageable items being hauled from the site as payment of the salvage value and, therefore, would not be an added cost to the Project. Miscellaneous embedded metal, such as reinforcement and grout tubing, would be disposed of at an appropriate landfill.

Hazardous materials possibly encountered as a result of the dam removal include a small amount of lead-based paint, oil, and grease. A minimal amount of sediment contaminated by septic system waste may be present in the reservoir. A site assessment would be performed to establish all potential environmental hazards existing at the dam site prior to final design. For the purpose of the appraisal level study, no hazardous waste is assumed to be present -- this would significantly affect the costs for the dam removal.



### Project Schedules and Estimated Costs

Construction cost estimates prepared for this Project are summarized as follows: For appraisal-level estimates and comparison purposes, non-contract costs (costs incurred in addition to the field costs) are assumed. Non-contract costs include an additional allowance for construction management, design, air quality and wetland mitigation. Another non-contract cost that will effect the total Project costs includes the acquisition of the 9-acre parcel of land directly downstream of the dam for Project staging and future recreational access.



Figure 2a - Major Land Holdings

In addition, removal of Matilija Dam would have significant impacts on the accumulated sediment at Robles Diversion Dam located downstream of Matilija Dam. An estimated cost for modifications to Robles Diversion Dam to include a high flow by-pass facility would be added to the total Project costs to lessen the impacts of the removal of Matilija Dam on Robles Diversion Dam.

An additional cost estimate was completed for the possible initial removal of the dam to elevation 1095.0 NGVD. This estimate resulted in a field cost of \$2,600,000. If this initial phase is accomplished under a separate contract, this cost should be subtracted from the costs indicated in Table 1 below.

Table 1 - Total Cost Estimates for Matilija Dam Removal Project

Alternative	Field Cost (Million \$)	Non-Contract Cost (Million \$)	Total Project Cost (Million \$)
1A - Mechanical Removal of Sediment Upstream	\$57	\$12.2	\$69.2
1B - Mechanical Removal of Sediment Downstream	\$130	\$14.4	\$144.4
1BB - Mechanical Removal of Sediment Downstream by Slurry Pipeline - USACE	\$160.7	\$18.7	\$179.4
2 - Phase Natural Transport of Sediment	\$14	\$7.6	\$21.6

### Project Benefits

Removal of Matilija Dam would improve the aquatic and terrestrial habitat benefitting a variety of fish and wildlife species – including the restoration of anadromous steelhead and other Federal and State listed endangered or threatened species. Historically a prime spawning habitat for the steelhead population, removal of the dam would open up sections of the mid-to-upper Matilija Creek, acting as a first step in steelhead restoration. Dam

removal would also release the trapped sediment, and future eroded sediment, allowing the material to move naturally down the Ventura River for beach replenishment. In addition, removal of the dam would re-establish public access to the area, increasing recreational and outdoor education opportunities. Finally, Matilija Dam has experienced deterioration due to alkali- aggregate reaction since its construction. Dam removal would further prevent deterioration that might result in future safety concerns from catastrophic failure.

## Conclusions

Removal of Matilija Dam is technically feasible, and would require an estimated period of 2 to 25 years to accomplish depending on the alternative selected. Total Project costs are between \$21,600,000 and \$179,400,000 (including contingencies and non-contract costs) depending on the selected final removal alternative.

A single alternative cannot be recommended at this time due to various unknowns associated with each alternative. The unknowns do not affect the technical feasibility of the individual alternatives. However, they do affect the overall desirability of the alternatives to fulfill the stated Project objectives.

Because of the multiple constraints on the Project and the various potential impacts, it is likely that a combination of alternatives would provide the best overall removal option as illustrated in Table 2 below:

Table 2 - Comparison of Removal Alternatives

Alternative	Total Project Cost (Million \$)	Risk of Flood Damage	Traffic Impacts	Air Quality Impacts	Completion Time (years)	Supply Existing Sediment to Beach
1A	69.2	low	low	low	2	low
1B	144.4	low	high	high	4-5	low to high**
1BB	179.4	low	moderate	moderate	4*	moderate
2	21.6	high	low	low	25	high

\* Alternative assumes 31,000 acre-feet of water is available for sluicing fine grain sediment to the ocean to meet this schedule.

\*\* The final disposal site(s) will dictate the amount of existing sediment available to the beach. The final disposal site(s) have not been determined.

## Future Investigations

Additional studies are necessary to refine and quantify impacts and to choose the optimal dam removal scenario. Future investigation in the implementation of this ecosystem restoration should include: public outreach; environmental compliance; sediment management; engineering and constructibility review; evaluation of alternatives; final designs; implementation plan and Project implementation/construction. A detailed estimate for such investigations is being prepared in coordination with Ventura County.



## A. Project Objective

There are three main Project objectives: 1) to improve aquatic and terrestrial habitat, to benefit fish and wildlife species (including endangered steelhead), along Matilija Creek and the Ventura River; 2) restoration of hydrologic and sediment transport regime in support of downstream coastal beach sand replenishment to pre-dam conditions; and 3) enhancement of recreational opportunities along Matilija Creek (including U.S. Forest Service land) and the downstream Ventura River system.

## B. Introduction

The Ventura River, a coastal stream in southern California, is located approximately 60 miles north of Los Angeles, California. The mainstem of the Ventura River spans about 31 miles from headwaters at upper Matilija Creek through the Ventura River proper to the Pacific Ocean. The Ventura River proper originates at the junction of the North Fork Matilija Creek and Matilija Creek and flows about 15.6 miles to the ocean. Above the junction with North Fork Matilija Creek, Upper North Fork Matilija Creek and Murietta Creek flow into the mainstem of Matilija Creek. Matilija Dam is located approximately 0.6 miles upstream of the junction of North Fork Matilija Creek and Matilija Creek. See Project Location Map, Appendix A.

The drainage area of the Ventura River is about 226 square miles with about 55 square miles above Matilija Dam. Approximately half of the basin is Forest Service land and half is privately owned land. Approximately 89 miles of the river and its tributaries are within areas designated as Wilderness with an additional 30 miles of the upper Matilija Creek and tributaries designated as Wild and Scenic Rivers [1]. The basin topography is characterized by rugged mountains in the upper basins becoming to relatively flat valleys in the lower downstream areas. Both areas support abundant vegetation especially during the wetter winter and spring months. The basin is frequently subjected to fires which clear the normally dense vegetation resulting in increased erosion. The soil in the basin is easily eroded [2] and consists of colluvial soils on steep basin slopes.

In 1944 the Ventura County Flood Control District (VCFCD) was formed. The VCFCD proposed a water conservation and flood control project involving Matilija Dam. One primary objective of the project was to alleviate persistent water supply shortages that had plagued the Ventura River watershed since the 1920's. Construction began in 1947 with initial storage beginning on March 14, 1948. Due to drought conditions Matilija Dam did not fill until the winter of 1951-1952 during a large flood. Subsequently, the reservoir produced approximately 1,000 acre-feet of water per year spanning 1952 to 1958.

Prior to the completion of Matilija Dam, a requirement for additional water supply facilities was established to meet future demands. The VCFCD initiated a study resulting in the recommendation of a 90,000 acre-foot reservoir on Coyote Creek to include a canal diverting surplus flow from the Ventura River. This study eventually resulted in the construction by the Bureau of Reclamation (Reclamation) of Casitas Dam, Robles Diversion Dam and the Robles-Casitas Canal (Casitas Project) in 1959. The Casitas Project was operated by the Ventura River Municipal Water District (VRMWD, now the Casitas Municipal Water District, CMWD). In 1959, the VRMWD assumed responsibility for operation and maintenance of Matilija Dam for the purpose of integrating its capabilities with that of the Casitas Project. As payment for rental of

Matilija Dam for an agreed upon 50-year operating period (1959 to 2009), VRMWD agreed to pay the remaining bond indebtedness on the dam.

Since the construction of Casitas Dam, Lake Matilija has been used to increase yield of Lake Casitas by temporarily storing winter runoff for release and diversion at Robles Diversion Dam. Matilija Dam was initially estimated to increase the yield from Lake Casitas by about 1,900 acre-feet per year. Due to sediment infilling of the reservoir it was estimated in 1997 that the yield was approximately 400 acre-feet per year. The current yield may be as low as 300 acre-feet due to additional loss of storage caused by floods in 1998.

Lake Matilija has been subject to large sedimentation due to the erosive nature of the watershed. Approximately 6,000,000 cubic yards of sediment is estimated to be stored in Lake Matilija based on exploration performed by the Reclamation in December 1999 [3]. The sediment volume was calculated by comparing a 1999 survey to pre-dam topography. Based on the current rate of sediment build-up, the reservoir is expected to be completely full of sediment by 2010 under a dry weather cycle sooner if the weather cycle is wetter than normal.

Matilija Dam has trapped the majority of coarse (mostly sand gravel, and cobbles) sediment normally transported downstream during large floods. The coarser sediment, which under natural conditions would be deposited at the mouth of the coastal rivers, are reworked by wave action and transported by littoral current to provide material for beach replenishment. The absence of this natural supply of sediment is a beach erosion concern [4].

Historically, the Ventura River supported a substantial steelhead run of at least 4,000 to 5,000 spawning fish, of which approximately half (2,000 to 2,500) spawned in Matilija Creek above Matilija Dam [1]. Flows in the mainstem of the Ventura River were seemingly large enough to support both resident and anadromous fish. Sections of the mid to upper Matilija Creek are thought to have been prime spawning habitat and may represent over half of the historically used habitat. Currently, the population of anadromous steelhead in the Ventura River is greatly reduced and may be below 200 fish [1]. This estimate along with steelhead abundance estimates for additional drainages in southern California, was used by the National Marine Fisheries Service (NMFS) in their determination to list the Southern California Steelhead as endangered. The steelhead has the ability to adapt to unpredictable climates and retain the flexibility to remain landlocked for many years, or even generations, before returning to the ocean when conditions allow. This flexibility may be an important factor in the possible restoration of steelhead in the Ventura River.

### C. Existing Project Features

Matilija Dam is a variable radius concrete arch dam with an average height of 190 feet and a crest length of 620 feet. The arch section varies in thickness from 8 feet at the original crest to 35 feet at the base of the dam. Originally the dam had a 276-foot-long ogee spillway located in the center of the structure with a crest elevation of 1125.0 feet. On both sides of the spillway the dam was raised with two 3-foot steps. The first stepped section on both sides of the spillway was 46-feet long and had a crest elevation of 1128.0 feet. The dam was further raised an additional 3 feet on both sides of these sections. The left side had a 125-foot long section at elevation 1131.0 feet. The right side had a 42-foot



long section at elevation 1131.0. On either side of these sections the dam was stepped up to the abutment crest elevation of 1138.0 feet. The original outlet works consisted of a 48-inch-diameter sluice gate with an invert elevation of 1000.8 feet located in the center of the dam and a 36-inch-diameter outlet gate with an invert elevation of 1025.0 feet located near the left abutment. The reservoir formed by Matilija Dam had an original storage capacity of 7,000 acre-feet at the spillway crest. For drawings of the structure see Appendix A; for photographs of the site see Appendix B.

Since its construction, the dam has experienced significant deterioration due to an alkali-aggregate reaction. In 1965 a 280-foot-long by 30-foot-deep notch was excavated in the center of the dam to remove the most damaged concrete. The center notch was widened to 358 feet in 1977 and functions as the spillway. Lowering the spillway reduced the reservoir capacity by 3,200 acre-feet.

In January and February 1969 large storms resulted in deposits of over 1,000 acre-feet (approximately 1.6 million cubic yards) of debris and sediment in the reservoir. This reduced the reservoir storage capacity to approximately 2,500 acre-feet. A large amount of sediment was also deposited in the reservoir after the 1985 Wheeler fire. Continued sedimentation has reduced the reservoir capacity to an estimated 500 acre-feet. Due to sedimentation the original 48-inch diameter sluice gate in the center of the dam was abandoned. The 42-inch diameter regulating valve at the sluice gate was relocated to the 36-inch diameter outlet and the intake was raised. Controlled releases are now discharged from this outlet.

#### D. Proposed Dam Removal Alternatives

In November 1999, during the appraisal-level process, the Committee examined several possible alternatives for the removal of Matilija Dam. Further methods for excavation and disposition of the concrete dam and the sediment in the reservoir were discussed and considered. Methods for excavating and disposing of the concrete are independent of methods for excavating and disposing of the sediment. A complete set of notes from this meeting can be found in Appendix E.

1. Concrete Excavation and Disposal - Several alternative methods of excavating the concrete dam were discussed as well as advantages and disadvantages for each. These methods include:

- ◆ Controlled Blasting
- ◆ Expandable Chemicals
- ◆ Diamond Wire Cutting
- ◆ Hoe-Ram

For the appraisal-level design estimates, controlled blasting will be used as the concrete excavation technique. The concrete will be hauled by highway trucking to commercial concrete recycling plants to be recycled and reused. The concrete will then be recycled to conform to Ventura County Ordinance #4155 which requires all commercial businesses located or operated in unincorporated portions of Ventura County to separate and divert from disposal items such as concrete [5]. This ordinance is intended to reduce solid waste in the county. Two local recycling plants, Hanson Aggregate at 3555 Vineyard Avenue and CalMat at 6029 Vineyard Avenue, Oxnard, California, were contacted to see if they had the capacity to house

concrete from the dam removal. At the time of contact both plant managers felt confident in their ability(s) to manage the full volume of demolished concrete. For proposed haul routes from the dam to the recycling plants see Haul Routes, Appendix A. The volume of concrete to be removed is approximately 48,000 cubic yards.

2. Sediment Excavation and Disposal/Stabilization -The removal and disposition of an estimated 6,000,000 cubic yards of sediment behind Matilija Dam is the most perplexing issue associated with the dam removal. Sediment handling and dam removal alternatives discussed include the following:

- ◆ Alternative 1A - Move the sediment upstream and stabilize
- ◆ Alternative 1B - Remove sediment to a site or sites downstream by trucking
- ◆ Alternative 1BB - Remove sediment to a downstream site or sites by slurry pipeline
- ◆ Alternative 2 - Phased excavation of the dam allowing time between phases for natural erosion of the sediment
- ◆ Alternative 3 - A combination of alternatives 1 and 2
- ◆ Alternative 4 - Complete removal of the dam in one phase with uncontrolled natural erosion of the sediment
- ◆ Alternative 5 - Construction of a fish ladder or by-pass with no dam removal
- ◆ Alternative 6 - No action

A brief description with advantages and disadvantages of each alternative is located in Appendix E. Alternatives 1A, 1B, 1BB, and 2 have been carried forward as cost estimates in the appraisal-level report. A study of alternative 1BB has been provided by the USACE and is included as Appendix G.

#### E. Proposed Plans for Dam Removal

1. Site Access and Mobilization - Site access to Matilija Dam is provided by traveling approximately 3.2 miles northwest from Meiners Oaks, California, on the Maricopa Highway (State Highway 33) to Matilija Road South then traveling west approximately 0.6 miles to the dam site. The reservoir area can be accessed by a similar route using Matilija Road North. These roads are paved public roads but are narrow and winding and not conducive to frequent heavy equipment travel. Power is available at the dam site from overhead transmission lines.

It is assumed that a contractor would establish a work area directly upstream of the dam and this area will be used for removal of the concrete dam for all proposed alternatives. Equipment would be transported to the dam site by truck along the aforementioned route. Large equipment has been hauled to the dam site in the past for the notching activities in 1965 and 1977. A dam removal demonstration activity will be conducted in the fall of 2000. As part of this demonstration, movement of heavy equipment will be studied. A crane will likely be required to access the dam face for excavation of the concrete. It is assumed the concrete will be excavated by controlled demolition, for the appraisal-level design, using explosives. This concrete excavation alternative was selected based on Reclamation's experience in the rehabilitation of existing concrete dams, such as Theodore Roosevelt Dam, Buffalo Bill Dam, and Folsom Dam, where controlled blasting was used. Alternate methods

of concrete removal will be studied during the dam removal demonstration. The results of this demonstration will be incorporated into the feasibility phase of the removal project. It will be assumed that controlled blasting will remove the concrete in small enough pieces to void extensive processing. Some processing will be required to ensure excavated concrete is reasonable enough in size (maximum 2-foot diameter) for transport to recycling plants. A hoe-ram is assumed to be required following blasting for this processing. Existing transmission lines will need to be relocated near the dam to allow room for crane usage. This activity may take place as part of the dam removal demonstration. Large earthmoving equipment will be required for movement of sediment.

A nine-acre parcel of privately owned land is located approximately 1,000 feet downstream of the dam (see Appendix A, Area of Matilija Dam and Property Proposed for Purchase). This property should not be inhabited during construction/blasting operations due to safety concerns. To prevent injury, it was suggested, during the November 22-23, 1999 meeting of the Technical Task Force Committee, that this land be purchased prior to the onset of construction activities. It was widely agreed that this property should be purchased regardless of which dam removal alternative is ultimately selected. Therefore, for estimating purposes the cost estimate for the purchase of this property will be added to all dam removal alternatives. This area (Parcel No. 010-0-180-430) is zoned O-S/160 ac/160 which is Open Space, 160-acre minimum lot size, Sensitive Resource Protection Overlay. It is also registered as County Historical Landmark #25. This site was originally purchased by Ventura County as a staging area for the construction of Matilija Dam. Its re-acquisition would allow it to be used again as a staging area for dam removal activities.

Prior to mobilization for removal of the dam an extensive eradication program will be required to remove non-native vegetation from the area upstream of Matilija Dam. This is required to prevent the non-native invasive vegetation such as arundo, which is located in the wetlands area and upstream on Matilija Creek, from moving downstream and replacing the native vegetation along the Ventura River. This effort may be a multi-year project. Future coordination with the existing Ventura County Arundo Task Force will be required to ensure the non-native vegetation is removed before mobilization for dam removal begins.

## 2. Dam Removal Alternative 1A - Mechanical Removal of Sediment Upstream

- a. Streamflow Diversion - The reservoir can be drained down to the existing sediment level using the 36-inch diameter outlet located on the left (north) abutment of the dam. This outlet was used in 1997 to drain the reservoir for inspection of the dam and can be used as the sediment is lowered, if needed, until the reservoir reaches an elevation of 1025.5. Modifications to the existing outlet riser will be required as the sediment is lowered. As the reservoir is being drained a fish rescue operation to capture and transport game fish to appropriate sites from the reservoir will be assumed.

Concurrent to the reservoir draining and fish rescue activities an upstream cofferdam will be constructed. Streamflows will be captured at this cofferdam and piped around the construction area on the left reservoir rim. The streamflow

will piped approximately 1 mile from the upstream cofferdam over the dam and past a downstream cofferdam.

In addition to the diversion of the inflows into Lake Matilija, drainage from the sediment must also be diverted, treated, and discharged into Matilija Creek. This is considered key to economically hauling the upstream sediment. A downstream cofferdam will be constructed to form a settling pond to prevent sediment laden discharge from entering Matilija Creek. Sediment near the dam will be excavated to form a collection pool. Trenches will be excavated into the upstream sediment to allow them to drain freely. The trenches will be sloped towards the dam. However, local sump pumps will likely be required to assist the unwatering. Wells will also be drilled into the sediment near the dam to further dewatering efforts. Drainage from the sediment will be collected near the dam and conveyed downstream to the stilling pool by pipelines. An average drainage discharge of 5 ft<sup>3</sup>/s will be assumed for the appraisal-level cost estimates.

b. Structural Removal - The entire concrete dam structure above the original streambed will be removed. Concrete at the abutments will be trimmed to the extent necessary to limit the visibility of the concrete. All concrete above the original streambed elevation will be removed along with all existing mechanical and electrical equipment. Concrete in the key trench below the original streambed and all dental concrete placed within rock depressions and trenches will be left in place. This concrete will be shaped to ensure fish passage and to simulate the natural stream configuration. The abandoned fish ladder and all control structures will be removed.

It will be assumed the concrete dam excavation will be performed by controlled blasting for the appraisal-level design. The concrete in the dam was originally placed in lifts approximately 5 feet high. The liftlines will have less bond strength than the monolithically placed concrete on either side of the liftline. The lower bond strength will allow the concrete to break along the liftline and form a clean horizontal surface. One of these liftlines will be used as the lower limit during each phase of concrete excavation. The concrete will be excavated in approximately 15-foot vertical lifts. A single line of horizontal drill holes will be placed 18-inches apart along the bottom liftline of the excavation (cross-canyon). Additional rows of horizontal holes will be drilled 3-feet apart across the dam between each set of higher liftlines. Horizontal holes will be drilled approximately 75 percent of the thickness of the dam at the location of the hole. Vertical holes will be located approximately every 3 feet in both the cross-canyon and upstream/downstream direction. The vertical holes will be placed a minimum of 2 feet from either face of the dam and drilled the full depth of the excavation. This will result in the concrete being broken into small blocks with a maximum dimension of approximately 2 to 3 feet. Blasting will be performed in a manner which will result in the excavated concrete falling upstream. The concrete will be processed after blasting as required for transportation to a commercial concrete recycling plant. For estimating purposes, the concrete will be assumed to be processed to a maximum diameter of two feet and all reinforcement, or other embedded metal will be cut flush with the concrete, by torch, as required by the aforementioned recycling plants. The processing of any

concrete which remains too large after blasting will be assumed to be performed by a hoe-ram. The plant is located approximately 30 miles from Matilija Dam.

There is an alternate disposition method for concrete removed from the dam for this sediment removal plan. The concrete excavated from the dam could be used to stabilize the sediment in the place of some of the riprap. This alternative will provide a reduction in cost as well as a reduction in the amount of travel over public roads. Reducing the travel on public roads will reduce road damage, air quality, and public safety concerns. The concrete could be placed in large blocks or used as fill for gabions along the new stream channel to prevent sediment erosion. The concrete blasting program would require some modification if large blocks were required. This could reduce the cost of blasting and the need for additional processing of the concrete after blasting. The disadvantages of this alternative is esthetics. The concrete will not have the natural appearance of rock riprap. Future studies will be conducted to determine if using the concrete to stabilize the sediment will conflict with future designation of the area as a Wilderness Area or a Wild and Scenic River.

An additional disposition method for concrete removed from the dam exists for all dam removal alternatives. This alternative would consist of hauling the concrete to the ocean for construction of artificial reefs in the nearshore marine area. This would require some modifications to the blasting program to produce larger blocks. This could reduce the cost of blasting and the need for additional processing of the concrete after blasting. Additional cost would be incurred to transport the concrete offshore. This alternative will not change the amount of travel over public roads or reduce road damage, air quality, or public safety concerns. The reefs could, however, enhance nearshore fishing habitat and improve fishing opportunities.

During excavation of the concrete dam a small amount of metal work will be removed. This metal work consists of miscellaneous piping, valves, and trashracks from the outlet works as well as reinforcement and grout piping cut from the concrete. All pipes, valves, and trashrack structures will be assumed to be removed and salvaged. The cost estimates will assume that these items will be hauled from the site as payment of the salvage value resulting no additional cost to the Project. All reinforcement and grout tubing will be assumed to be hauled to the Toland Road Landfill located approximately 24 miles from the dam on Toland Road between Santa Paula and Fillmore California for disposal. At the completion of the concrete removal the downstream cofferdam will be removed and all construction debris will be removed from the existing stilling pool.

A large portion of the dam is above the excavated notch at an elevation of 1095.0 feet. Excavation of this portion of the dam, as well as the abandoned fish ladder, can be completed without impact to the remaining structure or sediment control process. These items can be removed during mobilization of equipment for the removal of the sediment and as the sediment is being dried. The items could also be removed as a first phase of the overall dam removal to expedite completion of the Project as a whole. Removal of this concrete will provide a test section for a contractor to refine excavation and concrete transportation

methods. A cost estimate for this first phase activity will be included in this report.

c. **Sediment Stabilization** - The area upstream of Matilija Dam appears to be sufficiently wide to store sediment along one reservoir rim while maintaining a channel along the other. For this alternative the reservoir sediment will be assumed to be excavated and placed upstream on the right (south) reservoir rim. This will require the deposit areas to be stripped of all vegetation prior to deposition. The reservoir area is owned by Ventura County, however, the area above and around the reservoir is Forest Service property which will require approval for use of the land. For limits of the reservoir area see Appendix A, Area of Matilija Dam and Property Proposed for Purchase. A channel will be formed on the left side of the reservoir with a slope near that of the pre-dam streambed. This channel will be sized to pass the peak discharge from approximately the 50-year recurrence level flood (see Section I.1. Hydrology of the Ventura River Basin), which closely corresponds to the largest flood on record, without overtopping Matilija Road North near the reservoir. The channel will be approximately 30 feet wide at the invert. The right channel side slope will be 4:1 and will be stabilized with geogrid and gabion mats. A key will be excavated at the toe of the right channel side slope to tie the stabilization to bedrock and prevent undercutting of the slope. The left channel side slope will be excavated to near pre-dam condition where possible. Localized stabilization and armoring will likely be required. The riprap for the key trench and gabion mats will be processed from material found in the reservoir and from the Schmidt Rock Quarry located approximately 900 feet north of Matilija Road, approximately 5 miles from the dam. Using riprap from the immediate area will result in a more natural appearing channel and minimize haul distance. Well graded riprap will be used to prevent boulders from blocking fish passage during lower flows. The sediment mound will be tied to the right reservoir rim with keys to rock both upstream and downstream. The channel invert will be configured to match the dam excavation and the stream downstream of the dam.

As part of future studies on alternative 1A a partial dam removal with a fish ladder over the lowered dam will be addressed. This would allow for upstream stabilization of a portion of the sediment and possibly allow for disposal of the excavated concrete in the immediate area. The advantages and disadvantages would be similar to those addressed later in this report for alternative 1A.

d. **Site Restoration**. - The dam will be completely removed above the original streambed. All control structures and construction debris will be removed from the site for disposal or recycling. The sediment mound will be shaped to be as natural appearing as possible. Top soil will be placed over the sediment mound for re-vegetation. Only locally native stock or sterile annual grasses will be used for re-vegetation. A final site inspection should be performed following the winter and spring rain season to confirm the adequacy of the dam removal and sediment stabilization.

e. **Advantages and Disadvantages**. - This alternative has several advantages which include less cost than alternative 1B and less heavy traffic on public roadways. Less traffic will reduce both air quality and public health concerns. The cost is, however, more than alternative 2 and traffic concerns are the same.

This alternative can likely be accomplished over two construction seasons which is considerably less than any other alternative. There are several disadvantages associated with the alternative. The canyon upstream of Matilija Dam is known to be formed of highly erosive material. The erosive nature of the canyon will make stabilization of the sediment difficult. Placing the sediment upstream in the reservoir area will result in some erosion and additional sediment in the Ventura River for a period of time after removal of the dam. The reservoir area will be restored to appear as natural as possible, but will not be returned to a pre-dam condition. Stabilizing the sediment upstream of the dam will not supply the sediment stored behind the dam to the ocean for beach replenishment. Several unknowns also exist for upstream stabilization of the sediment, namely the type and gradation of the sediment and the surrounding reservoir walls. Placing the sediment upstream may affect the future ability to designate the area as a Wilderness Area or a Wild and Scenic River. Future studies will be required to relieve the uncertainty resulting from the listed unknowns.

3. Dam Removal Alternative 1B - Mechanical Removal of Sediment Downstream

a. Streamflow Diversion - Streamflow diversion will be accomplished in the same manner as stated for alternative 1A - mechanical removal of sediment upstream.

b. Structural Removal - Structural removal of the dam will be accomplished by controlled blasting as described for alternative 1A - mechanical removal of sediment upstream.

c. Sediment Removal/Stabilization - Sediment will be removed and hauled to a downstream disposal site by highway trucking. The reservoir will be cleared to near pre-dam contours. A low flow channel will be constructed and armored with rock processed from the sediment material. Upper reservoir areas will be re-vegetated where possible. Some steeper side slopes may not be conducive to re-vegetation and may require some stabilization. Large rock found in the sediment will be left in the reservoir area to provide a more natural appearance.

Three alternatives exist for the removal of the sediment downstream; haul the sediment directly to the ocean; haul the sediment to a beneficial permanent storage site downstream; or haul the sediment to a temporary storage site downstream. Delivering the sediment to the ocean will directly benefit beach restoration. It will, however, result in increased dredging costs at Ventura Harbor [7]. Only a portion of the sediment held behind Matilija Dam is estimated to be suitable for beach restoration [8]. Hauling the sediment to a beneficial permanent downstream storage site would be expected to cost approximately the same as hauling it to the ocean but will not directly benefit beach restoration. The final alternative, which is more or less a combination of the first two, would likely be the most beneficial. The sediment would be hauled to a downstream storage site for temporary storage and processing. The sediment is expected to have a large volume of coarse material. The coarse material may be a beneficial source of aggregate if processed and removed for resale on the commercial market. The remaining material would be hauled to the ocean for beach restoration. This would allow the sediment to enter the ocean at a slower rate resulting in less dredging costs at the Ventura Harbor and

supply a needed source of coarse aggregate to the area. It is assumed the material will be processed in the future at no additional Project cost. A study performed by the USACE to determine beneficial uses for the sediment is located in Appendix G.

No sites for dumping the sediment directly into the ocean or beneficial permanent storage (fill dirt, golf course, etc.) have been located. Possible ocean disposal sites and beneficial permanent storage sites should be studied as part of the next phase of the Project. Two possible temporary storage sites have been located downstream of Matilija Dam. These sites are the old S.P Milling site about ½ mile upstream of the intersection of Main Street and SP Milling Road and the flood plain area about ½ mile downstream of the Robles Diversion Dam. The SP Milling site is approximately 28 roadway miles downstream of Matilija Dam. Robles Diversion Dam is approximately 2.5 river miles downstream of Matilija Dam. Both sites should be further evaluated for their actual suitability in the next phase of the Project. The haul route to the S.P. Milling site will be essentially the same as that to the concrete recycling plants (see Appendix A).

As no sites for ocean disposal or permanent storage have not been located, it will be assumed the sediment will be hauled to a downstream temporary storage site. For the appraisal level cost estimates it will be assumed that all sediment will be hauled downstream to the S.P. Milling site. The Robles site is closer and hauling costs would be less, but would not provide a realistic cost estimate if a final decision is made to haul sediment directly to the ocean. The cost associated with hauling the sediment to the ocean for disposal would be relatively close to the cost of hauling the sediment for deposits at the S.P. Milling site. It is likely that the haul distance and cost of handling would also be similar for both alternatives. For this study it will be assumed the sediment will be placed and stabilized at the S.P. Milling site. The topsoil in the area will be stripped prior to stockpiling of the sediment. The sediment will then be placed, graded, and stabilized. Erosion protection will be placed to protect the toe of the stockpile, a drainage system will be installed, and silt fencing will be erected. If the sediment is processed in the future it is assumed that a portion of the profits from the sale of the coarse aggregate will be used to pay for the transport of the remaining sediment to the ocean. The estimated cost of this alternative does not account for movement of the sediment from the temporary storage area. The cost estimate should be adequate for all downstream disposal alternatives.

d. Site Restoration - The dam will be completely removed above the original streambed. All control structures and construction debris will be removed from the site for disposal or recycling. The sediment will be removed to provide a stream channel that is near to that of the pre-dam stream bed. Where side slopes permit the reservoir area will be re-vegetated. Only locally native stock or sterile annual grasses will be used for re-vegetation. Large rock will be left in the reservoir area and along the reservoir rim to provide a natural appearance and help stabilize the side slopes. A final site inspection should be performed following the winter and spring rain season to confirm the adequacy of the dam removal and sediment stabilization.

e. Advantages and Disadvantages - There are three major advantages to this alternative. The sediment will be moved downstream and will not pose any



future adverse impacts to the canyon or the Ventura River. There are fewer unknowns with this alternative than any of the other alternatives and this alternative could directly provide the existing sediment to benefit beach replenishment. Additional benefits could include a source of aggregate to the area. The two major disadvantages are cost and the large increase of heavy truck traffic on public roadways. An additional disadvantage is the length of time required for removal. If the sediment is placed in temporary storage, processed, and removed from the site at a latter date, additional negative impacts to traffic, air quality, and public health and safety will occur. Placing the sediment in temporary storage for latter processing or placing the sediment in permanent storage on land will deny sediment to the ocean for beach replenishment. This alternative is estimated to take four construction seasons for completion which is two years longer than alternative 1A.

4. Dam Removal Alternative 1BB - Remove Sediment Downstream by Slurry Pipeline

This alternative consists of a slurry pipeline from Matilija Dam to transport fine grain material (1mm or less grain size) to the ocean and a conveyor belt and trucking system to transport larger material (greater than 1 mm grain size) downstream to the ocean or a temporary disposal site. A study of this alternative is provided by the USACE and included as Appendix G. As part of this study it was assumed that approximately 31,000 acre-feet of water would be available for purchase in the area. The feasibility of this alternative depends largely on the water supply available for use in the slurry and the properties of the sediment stored in the reservoir.

a. Streamflow Diversion - Streamflow diversion will be accomplished in the same manner as the mechanical removal alternatives 1A and 1B

b. Structural Removal - This alternative utilizes the structural removal process outlined in Alternative 1A: removing the dam in phases concurrent with the sediment removal. If the dam is left in place during sediment removal, demolition could occur in one step at the end of the project. For the appraisal-level design estimates, controlled blasting will be used as the concrete excavation technique. The concrete will be hauled by highway trucking to commercial concrete recycling plants to be recycled. For proposed haul routes from the dam to the recycling plants see Haul Routes, Appendix A-4.

c. Sediment Removal - This alternative examines mechanical removal of the sediment downstream by slurry or conveyor. Two primary variables that affect the pipeline and conveyor design are the sediment composition within the reservoir and the available water supply. See Appendix G for more details on this variables.

d. Site Restoration and Mitigation - The new streambed and surrounding area at the reservoir will be restored to pre-dam conditions wherever feasible. The project will also likely require compensatory mitigation for such project elements as the pipeline and conveyor corridor(s), and wetland mitigation for loss of the reservoir. Costs cannot be calculated for these mitigation elements at this time because of limited information.

e. Advantages and Disadvantages - Advantages to this approach could include: The storage capacity would increase as sediments are removed, allowing more flood water to be captured. In addition, excavation from the barge could continue through the winter months when stormwater is most available. The disadvantages to this approach could include: The trapping efficiency of the dam would increase, so the reservoir could potentially capture an increasing amount of the incoming sediment from the watershed each year. Major floods could deposit large amounts of debris in the reservoir, which might have been passed through had the dam been notched to the same elevation as the sediment. In addition, dredging could be significantly reduced during drought years.

## 5. Dam Removal Alternative 2 - Phased Natural Transport of Sediment

a. Streamflow Diversion - Streamflow diversion will be accomplished in the same manner as the mechanical removal of sediment but on a much smaller scale. Unwatering is assumed to be required for approximately three months during each dam removal phase.

b. Structural Removal - Structural removal of the dam will be accomplished by controlled blasting as described for the mechanical removal of sediment upstream. This method may be changed if blasting cannot provide a clean horizontal break which can withstand overflow from the reservoir. A clean horizontal surface is particularly important for this alternative because of the long period of time that the surface will be subject to outflow from the reservoir. All downstream structures, except the outlet works, will be removed during the first construction season. The outlet works will be closed after each phase of dam excavation and will remain closed until the reservoir drainage is required for the next phase of dam excavation.

c. Sediment Removal - Sediment removal will be from natural stream flow. The rate of dam removal in this alternative is largely controlled by the rate at which the river is able to transport the sediment downstream with acceptable impacts. If the dam is removed too quickly, the input of sediment may be too large and the downstream impacts could cause economic loss, ecological destruction, and even loss of human life. If the dam is removed too slowly, the benefits of dam removal will not be realized in an acceptable amount of time. Therefore, it is important to accurately predict the transport of sediment in the river system so that the dam removal can proceed in the most efficient manner possible. To this end, the sediment management portion (Section I) of this document will summarize previous studies relating to the sediment transport of this river basin and provide initial quantitative analysis of the sediment management for the Phased Natural Transport Alternative.

d. Site Restoration - The dam will eventually be completely removed above the original streambed. All control structures and construction debris will be removed from the site for disposal or recycling. No restoration will be performed in the reservoir area other than that by natural forces.

e. Advantages and Disadvantages. - The major advantage of this alternative is cost which is much lower than the other two alternatives. This alternative will also provide the existing sediment to the ocean for beach replenishment. In

addition the sediment will be delivered to the ocean slowly reducing dredging cost at the Ventura Harbor. This alternative is estimated to take approximately 25 years to complete. The major disadvantage would be possible adverse effects on the Ventura River system and the steelhead trout population. Sedimentation build-up in the downstream channel could also raise flood levels and threaten health and safety on public and private property.

#### F. Environmental Considerations

The basic design and construction philosophy necessary to remove Matilija Dam is to create a positive balance between the temporary negative social and environmental construction impacts and overall construction efficiency. These impacts will be prominent in the general categories of local noise pollution, air quality, water quality, habitat, debris disposal, and increased traffic.

1. Noise Abatement - Noise would be produced by various dam removal activities including the operation of heavy construction equipment such as excavators, hoe-rams, dozers, hauling equipment (including trucks), drills, jackhammers, air compressors, and controlled blasting. Noise levels may produce short-term adverse impacts near the dam site, but should not be noticeable beyond about 1 mile. Natural attenuation of noise levels would be provided by the existing terrain. No special noise abatement procedures should be necessary.

2. Air Quality - Construction activities during dam removal send large amounts of traffic related pollutants and particulates into the air in the immediate area and along any haul route. Construction-related sources of particulates would include the use of unimproved haul roads, loading and dumping, hoe-ramming, drilling and blasting. Dust generated by construction traffic and drilling will be sprayed with water for dust abatement.

All construction activities associated with removal of the dam will require the use of fossil fuel. Air quality mitigation will be required. The extent of mitigation will depend upon the alternative assumed for sediment removal. Alternative 1B will require the most extensive mitigation due to the pollutant emitted from the trucks hauling the sediment downstream. Alternative 1A would require less mitigation, but would still likely be substantial. Alternative 2 will require the least consumption of fossil fuel and therefore require the least mitigation. Air quality mitigation costs will be included in the final dam removal cost estimates.

3. Water Quality - The dam removal process is expected to increase stream turbidity levels during construction and for some time afterwards. During the removal of the dam and the sediment for alternatives 1A and 1B a stilling pool or pools will be required downstream of the dam to trap and settle sediment suspended in both the diverted streamflows and the drainage water from the sediment. Silt fencing will be required to control movement of sediment in the work area. The contractor will be required to take special care to avoid discharging sediment laden flow into Matilija Creek. After dam removal by either of these alternatives a some fine grained material will unavoidably be left in the reservoir/channel area. This material will be mobilized during the first few wet season after completion of the project. Turbidity would be expected to increase during this first wet season.

Water quality impacts associated with alternative 2 will be a function of the basin hydrology and the properties of the sediment. For a detailed discussion of this alternative refer to Section G of this report.

4. Public Health and Safety - Applicable construction safety standards will be enforced during all dam removal activities; No structures will remain that rise above the final grade of the reservoir floor; No public health and safety concerns will be associated with the dam site after the dam is removed; and during dam removal with alternative 2, appropriate fencing and signs will be required to prevent public access to the dam.

5. Traffic - All public roads used to haul equipment to and from the dam, concrete to recycling plants, and sediment downstream for alternative 1B are highly traveled and congested. Special traffic control measures will be required for all travel on these roads. A comprehensive traffic study will be required prior to any construction activities if these haul roads are to be subjected to heavy truck traffic resulting in roadway damage. Road repair will be assumed necessary for alternatives 1A and 1B and will be reflected in the cost estimates. Due to the phased dam removal of alternative 2 the haul route used to transport concrete for recycling will not be assumed to need repair. For the proposed haul routes see Appendix A, Haul Routes.

6. Special Status Species - The following listing of special concern species was provided to Reclamation by the Fish and Wildlife Service (FWS). For details and a complete list of references for this section see Appendix I - Planning Aid Memorandum (PAM) by the Fish and Wildlife Service.

At least 26 special status species are known from the aquatic, riparian, and wetland habitats from the study area, and include 13 listed species (endangered, threatened, or fully protected) and 13 California species of special concern.

a. Listed Species - The 13 listed species known from the study area include 9 endangered species, 2 threatened species, and 2 fully protected species, as follows:

- ◆ Southern steelhead (*Oncorhynchus mykiss*), federally endangered; known to occur throughout the Ventura River watershed below Matilija Dam and Casitas Dam (Hunt and Lehman 1992).
- ◆ Tidewater goby (*Eucyclogobius newberryi*), federally endangered; known from the Ventura River mouth to about 2.0 miles upstream (Hunt and Lehman 1992).
- ◆ Least Bell's vireo (*Vireo bellii pusillus*), federally endangered and state endangered; known from riparian habitats of the lower Ventura River from the river mouth to about two miles upstream; breeding pairs known from this area (Hunt and Lehman 1992, Hunt 1994); suspected to use the Matilija Creek drainage as a migration corridor (Freel 2000).

- ◆ Southwestern willow flycatcher (*Empidonax traillii extimus*), federally endangered, state endangered; suspected to use the Matilija Creek drainage as a migration corridor (Freel 2000).
- ◆ Brown pelican (*Pelecanus occidentalis californicus*), federally endangered, state endangered; known from observations of roosting and feeding activities from the Ventura River estuary and adjacent beach and near shore marine areas (Hunt and Lehman 1992).
- ◆ California least tern (*Sterna antillarum browni*), federally endangered, state endangered; known from numerous sightings in the Ventura River Estuary area; no nesting activities have been observed, but feeding activities have been observed (Hunt and Lehman 1992).
- ◆ Peregrine falcon (*Falco peregrinus*), state endangered; known from a few sightings in the Ventura River Estuary area (Hunt and Lehman 1992).
- ◆ Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), state endangered; known from coastal salt marsh areas of the Ventura River Estuary (Hunt and Lehman 1992).
- ◆ Ringtail (*Bassariscus astutus*); state fully protected; known from riparian areas near Matilija Reservoir and Ventura River mainstem (Hunt 1994, Wehtje 2000).
- ◆ Black-shouldered kite (*Elanus caeruleus*), state fully protected; known from the Ventura River Estuary area, particularly in adjacent uplands (Hunt and Lehman 1992).
- ◆ Western snowy plover (*Charadrius alexandrinus nivosus*), federally threatened (nesting); known from beach and dune habitats of Ventura River mouth and adjacent areas; foraging activity, but no nesting activity has been observed (Hunt and Lehman 1992).
- ◆ California red-legged frog (*Rana aurora draytonii*), federally threatened; reported in the Matilija Creek area (Freel 2000, Sweet 2000).
- ◆ California condor (*Gymnogyps californianus*), federally and state endangered species; historic habitat in the Matilija Creek drainage, last reported soaring and roosting in the Matilija Valley in 1998 (Austin 2000); although not an aquatic, riparian, or wetland species, the California condor is mentioned here because of its wide-ranging travel habits, inquisitive nature, and recent episodes of contact with humans.

Additionally, suitable habitat for the state endangered yellow-billed cuckoo (*Coccyzus americanus*) exists along the Ventura River near the confluence with San Antonio Creek (Wehtje 2000). This species is known from the adjacent Santa Clara River (Wehtje 2000), but has not been reported in any of the references cited in this PAM.

b. California Species of Special Concern - The following 13 species are known to occur in the Matilija Reservoir area, tributaries upstream of Matilija Dam, or downstream of Matilija Dam, and are considered to be species of special concern by California Department of Fish and Game (CDFG):

- ◆ Arroyo chub (*Gila orcutti*); known to be widespread in distribution in most of the Ventura River watershed (Hunt and Lehman 1992). They have been identified in the Upper North Fork of Matilija Creek, upstream of Matilija Dam, and should be expected within the footprint of the proposed project site during the summer and early fall months.
- ◆ Southwestern pond turtle (*Clemmys marmorata pallida*); known to be widespread in distribution in the Ventura River, including the estuary, Matilija Creek, Matilija Reservoir, Lake Casitas, and San Antonio Creek (USFS unpublished data, Hunt and Lehman 1992, Entrix and Woodward-Clyde Consultants 1997).
- ◆ Silvery legless lizard (*Anniella pulchra pulchra*); known from coastal dunes near the mouth of the Ventura River (Hunt and Lehman 1992).
- ◆ Two-striped garter snake (*Thamnophis hammondi*); known from the Ventura River mainstem in the Casitas Springs area, and from 1.5 miles upstream of the mouth (Hunt and Lehman 1992).
- ◆ Tricolored blackbird (*Agelaius tricolor*), when in nesting colonies are considered a state species of special concern; known in riparian habitats from 1 mile upstream from Highway 101 (Natural Diversity Data Base 1999).
- ◆ White-faced ibis (*Plegadis chihi*); known from one sighting in 1989 on the beach adjacent to the eastern portion of the Ventura River mouth (Hunt and Lehman 1992).
- ◆ Osprey (*Pandion haliaetus*); known from several sightings of individuals feeding in the lower Ventura River, from the estuary to about 0.5 miles upstream (Hunt and Lehman 1992).
- ◆ Black swift (*Cypseloides niger*); known from one sighting at the Ventura River mouth in 1981 (Hunt and Lehman 1992).
- ◆ Cooper's hawk (*Accipiter cooperi*); known from sightings between Main Street Bridge and Foster Park (Hunt 1991, 1994).
- ◆ Yellow warbler (*Dendroica petechia brewsteri*); known from riparian woodland in the Ventura River Estuary area (Hunt and Lehman 1992).
- ◆ Blue grosbeak (*Guiraca caerulea*); known from unspecified areas of the Ventura River watershed (Mertes *et al.* 1995), expected in the Ventura River mainstem as a common spring and fall migrant, and as an uncommon breeder (Holmgren 2000).

- ◆ Yellow-breasted chat (*Icteria virens*); known from willow forest in the Ventura River Estuary area (Hunt and Lehman 1992).
- ◆ Pallid bat (*Antrozous pallidus*); known to roost under the Main Street Bridge over the lower Ventura River (Hunt and Lehman 1992).

Suitable habitat for the western spadefoot toad (*Scaphiopus hammondi*), a state species of special concern, occurs along the Ventura River in the Oak View area (Wehtje 2000), but this species has not been reported in any of the references cited in this PAM. Threespine stickleback (*Gasterosteus aculeatus*) have been identified approximately 1000 yards upstream of Matilija Dam.

When considering all of the special status species in the study area, the FWS has the most concerns for the potential impacts to California red-legged frog, tidewater goby, and southern steelhead.

The FWS concerns for the California red-legged frog are based upon reports of their presence in the vicinity of Matilija Reservoir. If California red-legged frogs are actually present in this area, they would be subjected to construction activities from the dam removal, plus the loss and modification of wetland and riparian habitats upon which they depend for survival.

The FWS concerns for the tidewater goby are based upon the potential for downstream impacts from sediment transport from Matilija Reservoir into the Ventura River Estuary. This sedimentation may cause changes to water quality, substrate characteristics, and estuary depths which may adversely impact the tidewater goby.

The FWS concerns for the southern steelhead are based upon the high potential for downstream impacts from sediment transport from Matilija Reservoir. This sedimentation may seriously impact steelhead migration and cause the loss of steelhead spawning and rearing habitat. The FWS would like to emphasize that it defers to NMFS on steelhead issues, and encourage Reclamation to continue to coordinate with them on future steelhead issues.

Mitochondrial DNA of 36 rainbow trout sampled within the Upper North Fork of Matilija Creek will be analyzed within the near future. This analysis will provide some information as to the affect of hatchery trout plants on the native trout population of the of Matilija Creek.

7. Wetlands - Several acres of land in the delta at the upstream end of Matilija Reservoir have become a wetlands environment. These areas support numerous species of plant and animal life, some of which are non-native. The type and quantity of life within these areas need to be quantified and listed. For additional information on the wetlands see Appendix I and Appendix G. Removal of the sediment will result in a loss of these wetland areas. Restoration of the reservoir area will likely result in development of some wetlands in the floodplain and side channels of the new creek channel, but they will likely be much smaller and have different plant communities and functions. The existing wetlands area is estimated to be approximately 20 acres. Wetlands mitigation may be required to ensure no net

loss in wetlands habitat. A wetlands mitigation costs will be added to each dam removal alternative.

8. Cultural Resources - Potential cultural resource impacts associated with Dam removal will be addressed in subsequent investigations. The structure would also be evaluated for its historical significance. Construction activities will need to be planned to avoid effects on the nine acre site located downstream of the dam (Matilija Hot Springs).

9. Socioeconomics - Dam removal will result in the loss of approximately 400 acre-feet (1997 estimate) of water per year to the Casitas Municipal Water District. This loss of additional storage would, however, take place regardless of whether the dam was removed or not. As the reservoir continues to fill with sediment it would eventually (estimated within the next 10 years) no longer be able to store water. The reservoir has also been used in the past as a water supply to fight forest fires. This benefit will be lost with dam removal, but as stated before within the next few years this benefit will be lost due to sedimentation. The above mentioned benefits could be salvaged if the dam was left in place and sediment was dredged, or in some other manner, removed from the reservoir. A large cost would be associated with continuing these benefits.

The removal of Matilija Dam will have impacts on the sediment accumulation at Robles Diversion Dam located downstream of Matilija Dam. The stilling basin upstream of Robles Diversion Dam is currently cleared of sediment approximately every 5 years. With the removal of Matilija Dam this cycle will increase. To prevent the need for continual cleaning of the stilling basin, a facility to transport sediment through the structure was developed by Borcalli and Associates on behalf of the Casitas Municipal Water District (see Appendix F for details). This structure would allow sediment to be flushed through Robles Diversion Dam during large flows reducing the need to clean the stilling basin. Construction costs for this structure will be included in the total Project cost for each dam removal alternative.

Several socioeconomic benefits will result from the removal of Matilija Dam. Major benefits may include the long-term restoration of anadromous steelhead in the mid and upper Matilija Creek and a natural supply of sediment for coastal beach replenishment. Removal of the dam will improve public access to, and recreational opportunities in, Matilija Canyon. The removal will also eliminate ongoing maintenance and future dam safety liabilities for the VCFCD. A likely future public dam safety hazard will also be eliminated.

#### G. Streamflow Diversion Requirements and Construction Sequencing

Total streamflow on Matilija Creek has been recorded at the Matilija Creek at Matilija Hot Springs (USGS gauge station No. 11115500) since 1928. A graphical plot of average daily discharge values from 1928 to 1988 for the approximately 55 mi<sup>2</sup> drainage area, as well as a detailed description of the basin hydrology, can be found in Section I (Sediment Management) of this report. Peak flows for the period of data primarily occur in the winter months of January through March. The peak recorded discharge for the period of data is 20,000 ft<sup>3</sup>/s on January 25, 1969. Minimum flows during the summer months are shown to be only a few cubic feet per second. For diversion an average flow of 3 to 5 ft<sup>3</sup>/s will be assumed for the months April through December. A cofferdam will be



constructed upstream of the reservoir. The cofferdam can be sized to store slightly larger flows and reduce the peak diversion requirements.

Construction in the reservoir will be sequenced to take place during the historical low flow period of April through December. For the mechanical excavation alternatives, low flows will be diverted around the construction site by placing cofferdams both upstream and downstream of the construction area and conveying flow through pipelines around the construction area. Just prior to the beginning of the wet season the concrete dam will be removed to the same elevation as the sediment has been excavated. This will prevent large portions of the existing sediment from being carried downstream during winter storms which could damage existing steelhead habitat. It will also reduce additional sediment build-up which would need to be removed the next dry season. For the alternative that incorporates upstream storage of the sediment, the sediment will be stabilized to withstand winter flows during any non-construction period.

#### H. Waste Disposal

1. Construction Debris - All concrete will be removed from the site and hauled to commercial recycling plants. Recycling of the concrete is mandated by Ventura County Ordinance # 4155 which requires all commercial businesses located or operated in unincorporated portions of Ventura County to separate and divert from disposal items such as concrete. Two commercial concrete recycling plants are located in Oxnard, California, approximately 30 miles from the dam site. This study assumes the concrete will be hauled to one, or both, of these sites for recycling. Neither site requires payment for concrete recycling.

Mechanical items such as pipes, gates, valves, operators, and trashracks should be salvaged to help offset the cost of the Project, as well as for environmental considerations, if practicable. The cost estimates will assume that the salvageable items will be hauled from the site as payment of the salvage value and therefore will be no additional cost to the Project. Miscellaneous embedded metal, such as reinforcement and grout tubing, should be disposed of in an appropriate landfill. The nearest landfill is the Toland Road Landfill located approximately 24 miles from the dam on Toland Road between Santa Paula and Fillmore California. For the assumed haul route, see Appendix A, Haul Routes.

2. Hazardous Waste - Hazardous materials anticipated as a result of the dam removal includes a small amount of lead-based paint, oil and grease. A small amount of sediment contaminated by septic system waste may be located in the reservoir. A site assessment should be performed to establish all potential environmental hazards existing at the dam site prior to final design. A visual inspection and literature search should first be performed to establish the possible presence of hazardous materials. A more detailed evaluation to confirm the presence and extent of the hazardous materials and determine appropriate action for removal [6] should follow. For the purpose of the appraisal level study, no hazardous waste is assumed present which would significantly impact the cost for the dam removal.

#### I. Sediment Management

1. Hydrology of the Ventura River Basin - Matilija Dam is in the Ventura River basin. In addition to Matilija Creek, there are several other important tributaries to

the Ventura River (Figure 1). N. Fork Matilija Creek joins with Matilija Creek to form the Ventura River at river mile 15.6. San Antonio Creek joins the Ventura River at river mile 7.83, Coyote Creek at 5.93, and Canada Larga at 4.54 (Table 1). Table 1 also gives the location of other important structures located along the Ventura River.

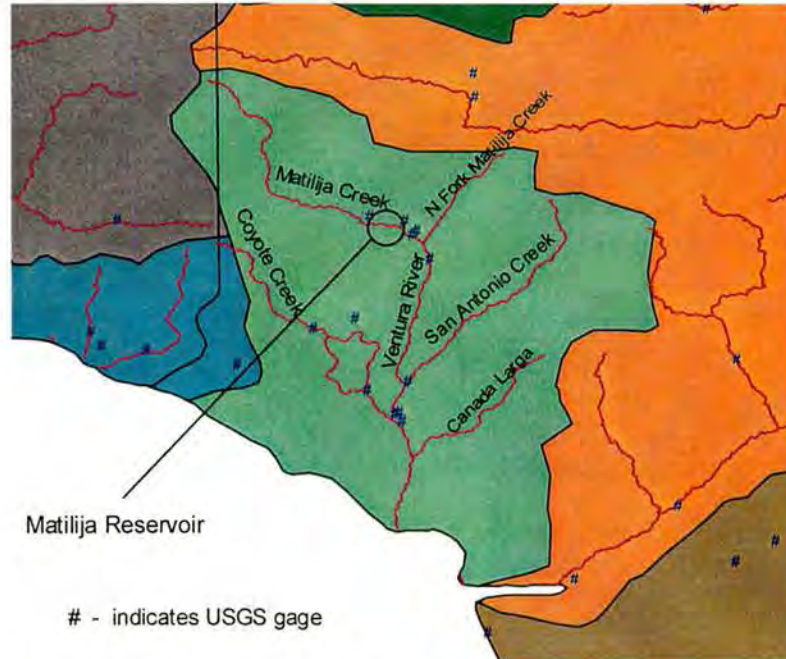


Figure 1. Map Showing the Ventura River Basin.

Table 1. Location in Terms of River Mile (from [2]).

Landmark	river mile
Mouth of Ventura River	0.0
Southern Pacific Railroad	0.2
Ventura Freeway (Highway 101)	0.41
Main Street	0.55
Shell Road	3.1
Confluence of Ventura River and Canada Larga	4.54
Foster Memorial Park and Casitas Vistas Road	5.86
Confluence of Ventura River and Coyote Creek	5.92
San Antonio Creek Confluence	7.83
Santa Ana Boulevard	9.25
Baldwin Road	11.09
Los Robles Diversion	14.0
Matilija Creek confluence with N. Fork Matilija Creek	15.6
Matilija Dam	16.23

The drainage area of the Ventura River is approximately 226 mi<sup>2</sup> at its mouth (Table 2). Matilija Creek is one of the largest tributaries to the Ventura River with a drainage area of about 55 mi<sup>2</sup>. San Antonio Creek is another major contributor of flow with a drainage area of 51.2 mi<sup>2</sup>. The drainage area of Coyote Creek is also large, but the flows in Coyote Creek downstream of Casitas Dam are significantly impaired.

Table 2. Drainage Areas of Rivers in the Ventura River Basin.

river and location	drainage area (mi <sup>2</sup> )
North Fork Matilija Creek At Matilija Hot Springs	15.6
Matilija Creek at confluence with N Fork	54.7
Coyote Creek Nr Ventura Ca	41.2
San Antonio Creek At Casitas Springs	51.2
Canada del Diablo at confluence with Ventura River	5
Canada Larga at confluence with Ventura River	19
Ventura River at Baldwin Rd	81
Ventura R below confluence with San Antonio Creek	143
Ventura R below confluence with Coyote Creek	184
Ventura R at mouth	226

There are several stream gages in the Ventura River basin with a period of record extending as far back as 1927. Originally, the United States Geological Survey (USGS) operated them all but starting in the 1980s, Ventura County (County) and CMWD operates several of the gages. The operation of some gages has been discontinued for various reasons. The gage above Matilija Dam (11114500) was destroyed in the 1969 flood. The records for gages above Casitas Lake (11117600 and 11117800) are not considered reliable for high flows after 1988 because CMWD, who took over their operation at that time, is not concerned with recording high flows in this area.

There are several structures that impact the flow in the Ventura Basin. Matilija Reservoir was built in 1947 with a capacity of 7018 acre-ft and dams Matilija Creek. Casitas Dam, which dams the Santa Ana Creek and Coyote Creek, was built in 1958 with a capacity of 250,000 acre-ft. Prior to Casitas Dam, Coyote Creek contributed 18 percent of the flow in the Ventura River. After construction, significant flow downstream of Casitas Dam in Coyote Creek only occurred during wet years when the spillway was passing water. As a result Coyote Creek contributed approximately 5 percent of the flow in the Ventura River during the period 1971-1980.

Robles Diversion Dam was built in 1958 and diverts water from the Ventura River into Casitas Reservoir. During the period 1991-1999, the average diversion into Robles Canal was 23.0 ft<sup>3</sup>/s, approximately 31 percent of the flow in Matilija Creek during this time period. Most of the diversion at Robles occurs from December through March and is highly variable. The maximum diversion rate at Robles is approximately 500 ft<sup>3</sup>/s (Chris Morgan, CMWD). In dry years, there is often almost no diversion because the diversion is subject to the following operating criteria (CMWD):

Table 3. Stream gages in the Ventura basin.

Description	USGS Gage Number	Drainage Area in sq mi	Period of Record (reason of no record)	Data Source
Matilija Creek Ab Res Nr Matilija Hot Springs Ca	11114500	50.7	1948 - 1969 (destroyed)	USGS
Matilija Creek At Matilija Hot Springs	11115500	54.7	1927 - present	USGS and CMWD
North Fork Matilija Creek At Matilija Hot Springs	11116000	15.6	1928 - present	USGS and County
San Antonio Creek Nr Ojai Ca	11117000	33.7	1927 - 1932 (???)	USGS
San Antonio Creek At Casitas Springs	11117500	51.2	1949 - present	USGS and County
Ventura R Nr Ojai Ca	11116500	70.7	1911 - 1984 (not maintained)	USGS
Ventura River Near Meiners Oaks Ca	11116550	76.4	1959 - present	USGS and CMWD
Robles Diversion Canal	--	--	1958 - present	CMWD
Coyote Creek Near Oak View	11117600	13.2	1958 - 1988 (not reliable)	USGS
Santa Ana Creek Near Oak View	11117800	9.11	1958 - 1988 (not reliable)	USGS
Coyote Creek Nr Ventura Ca	11118000	41.2	1927 - present	USGS and CMWD
Ventura R Div Nr Ventura Ca	11118400	--	1969 - present	USGS
Ventura R Nr Ventura	11118500	188	1929 - present	USGS
Ventura R Nr Ventura+ Div. Ca	11118501	188	1932 - present	USGS

Commencing with 1959-1960 water year, the following criteria will govern the operation of Robles Diversion Dam:

In general, when the natural flow of the Ventura River at the Robles Diversion Dam is less than 20 ft<sup>3</sup>/s, the entire flow will be passed down river and when the natural flow is greater than 20 ft<sup>3</sup>/s, no less than 20 ft<sup>3</sup>/s will be passed down river; provided that such release down river shall be increased or decreased under the following circumstances:

- ◆ If the water level in the river gravels fails to rise to the extent that would be expected under natural conditions for the time of year and type of year as evidenced by periodic measurements of wells along the river, the release shall be increased to correct this condition.

- ◆ If surface flow occurs at Santa Ana Boulevard, river releases shall be decreased appropriately.
- ◆ If rising water above the mouth of San Antonio Creek occurs in such amounts that it is apparent that water will waste to the ocean, the river release shall be decreased so that such waste shall not occur.

Under integrated project operation, flood flows temporarily stored in Matilija will be released down river for diversion to Casitas Reservoir at the Robles Diversion Dam. Such operational releases will be deducted from the total flow at Robles in order to determine the amount of natural flow available for release at the Robles Diversion Dam.

There is no written operating criteria for Matilija Reservoir, other than CMWD's criteria stated above. The general operating criteria for the reservoir is to maintain outflow equal to inflow when diversions are not taking place at Robles. When diversions are being performed at Robles, the reservoir level is cycled to produce larger flows in the Ventura River to optimize the amount of diversion at Robles. There is a 36-inch, a 12-inch, and a 6-inch release valve at Matilija Reservoir with the potential to release a maximum of 250 ft<sup>3</sup>/s.

There is also a Ventura City diversion structure located at Foster Memorial Park. The record of diversion at Foster Memorial Park can be obtained from USGS gage 11118400. The diversions at Foster Memorial Park are 7.0 ft<sup>3</sup>/s on average with a maximum of 24 ft<sup>3</sup>/s. No surface water is diverted if large suspended sediment concentrations are present in the river. The waste treatment plant, operated by the Ojai Valley Sanitary District (OVSD), releases tertiary treated water at an average flow rate of 3.2 ft<sup>3</sup>/s into the Ventura River below Foster Park.

Robles Diversion and the diversion at Foster Memorial Park do not significantly impact the sediment transport in Ventura River because large floods are responsible for the majority of the sediment transport in the river and these diversions are not significant to the flow during the large floods. However, Casitas Reservoir and Matilija Reservoir do significantly impact the sediment transport in the Ventura River basin due to their ability to trap sediment and attenuate flood peaks. Matilija Reservoir has only 500 acre-ft of capacity remaining and its ability to trap sediment and attenuate floods is significantly decreased. For example, the 10-year flood of 9900 ft<sup>3</sup>/s in Matilija Creek (see Table 4) would completely fill a dry reservoir in 0.6 hours. Therefore, it can be assumed that it provides no attenuation of the peak flow for large flood events. It may slightly lengthen the arrival time of the peak flow because of the decreased slopes in the reservoir area, but this extension of the arrival time would be less than 0.6 hours.

The average daily flows in Matilija Creek are shown in Figure 2a (a compilation of USGS gages 11114500 and 11115500). To estimate the average daily flow in Matilija Creek near the dam, the record at the stream gage downstream of Matilija Reservoir at Matilija Hot Springs (USGS gage 11115500) was used from 1927 to 1947 and from 1969 to present. During the period 1948-1969, the record at the gage upstream of the reservoir (USGS gage 11114500) was used. The average daily flows for the Ventura River near Ventura (USGS gage 11118500) are shown in Figure 2b. The flows in both rivers show clear seasonal variation. The maximum

average daily flow at Matilija Dam during the months of July through October never exceeded 300 ft<sup>3</sup>/s over the period of record and the mean is less than 10 ft<sup>3</sup>/s. The minimum for the Ventura gage does not show on the figure because it is below 0.1 ft<sup>3</sup>/s for all days of the year.

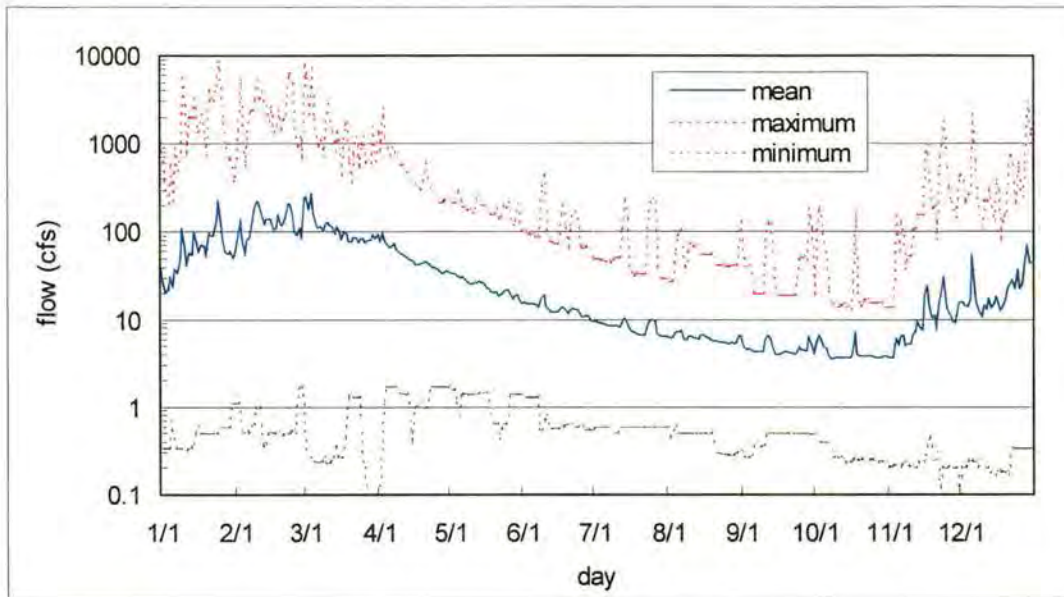


Figure 2a. Average daily flow at Matilija Gage (compilation of 11114500 and 11115500).

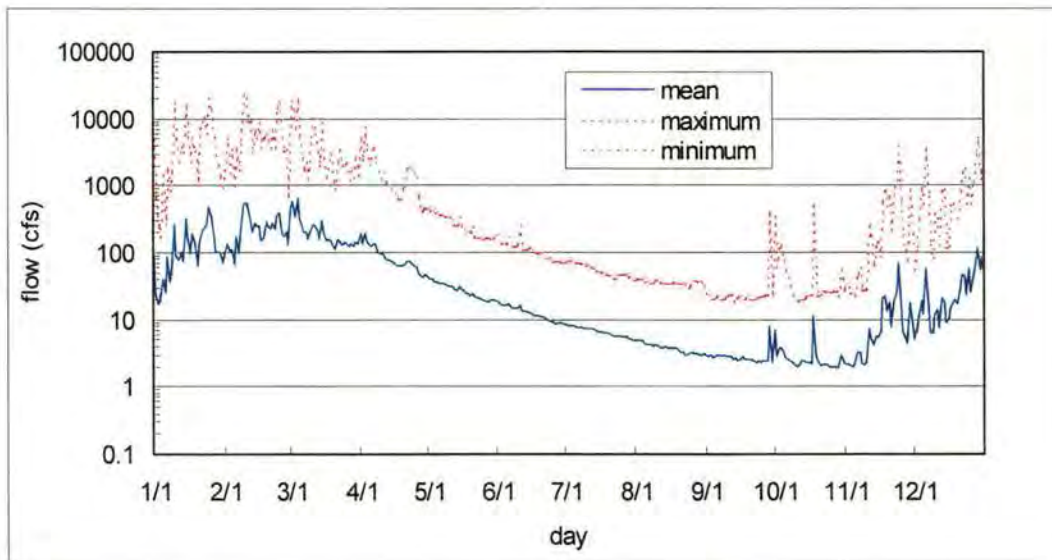


Figure 2b. Average daily flow at Ventura gage (11118500).

In general, the precipitation is greater in the upstream reaches of Matilija Creek and the Ventura River. The increase is shown in Figure 3, where the precipitation at Ojai (elevation approximately 250 ft) is approximately 50 percent greater than the precipitation at Ventura (elevation approximately 50 ft). Appendix A contains the spatial distribution of rainfall for January, 1995 in Ventura County. Substantially higher rainfalls were experienced in the upper reaches of the Matilija Creek than near the mouth of the Ventura River. The higher rainfalls in the upper reaches of Matilija Creek explain the fact that even though Matilija Creek accounts for only 30 percent of the drainage area of the Ventura River at USGS gage 11118500, Matilija Creek contributes approximately 50 percent of the flow if the effect of Robles diversion is removed.

Approximately 90 percent of the precipitation in the region falls during the months of November through April ([10] and Figure 3). The seasonal variation in stream flow is directly related to the seasonal variation in rainfall, but there is a lag time at the start of the rainy season before the river flows respond significantly to rainfall. This is due to the storage of water in the groundwater (both the saturated and unsaturated zones). The first precipitation of the rainy seasons may predominantly infiltrate into the soil and recharge the groundwater.

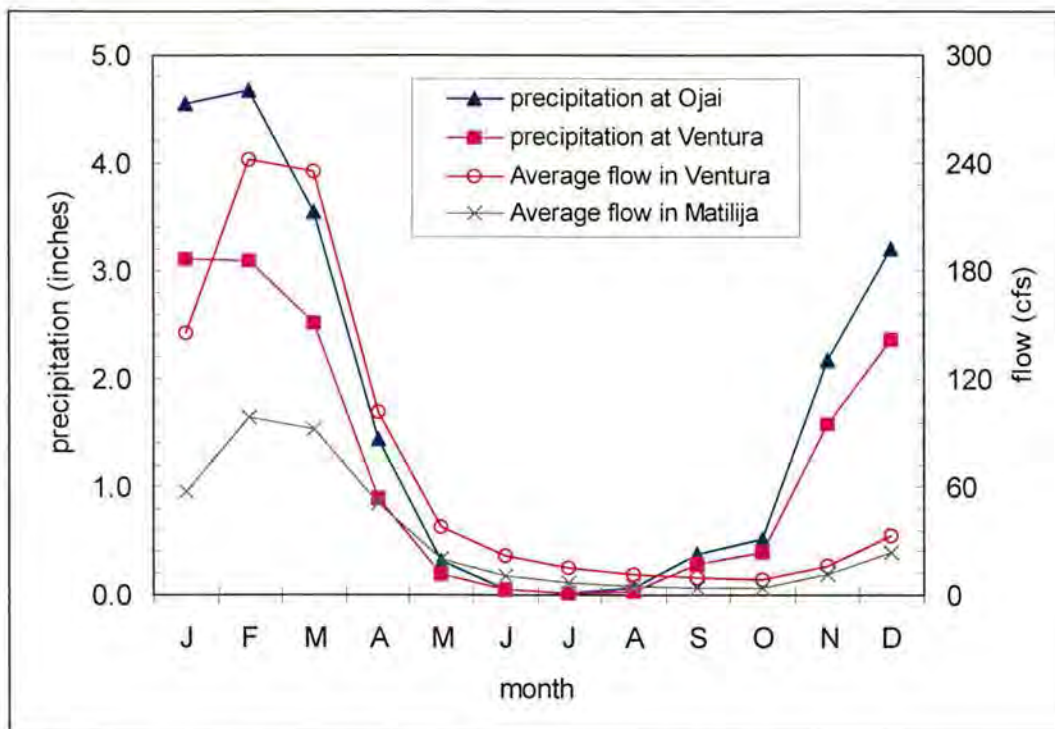


Figure 3. Monthly average precipitation for Ojai and Ventura (average of 3 rain gage stations). Flow for Ventura River near Ventura and Matilija Creek stream gages.

The river flows in the area are extremely variable from year to year (Figure 4a and 4b). The average daily flow in the Ventura River for each year was computed for the entire period of record. In Matilija Creek the average daily flow for the year varies from 174 ft<sup>3</sup>/s to 0.9 ft<sup>3</sup>/s. The average daily flow for the year in the Ventura River

varies between 356 ft<sup>3</sup>/s and 0.5 ft<sup>3</sup>/s. There is also some evidence of a long term trend in the average flow as shown by the 15 year moving average. There was a reduction in flows in the 1950s and the average flow has gradually increased since then. There is no guarantee that this trend will continue and it is possible that the wet cycle is ending and will be followed by another dry cycle.

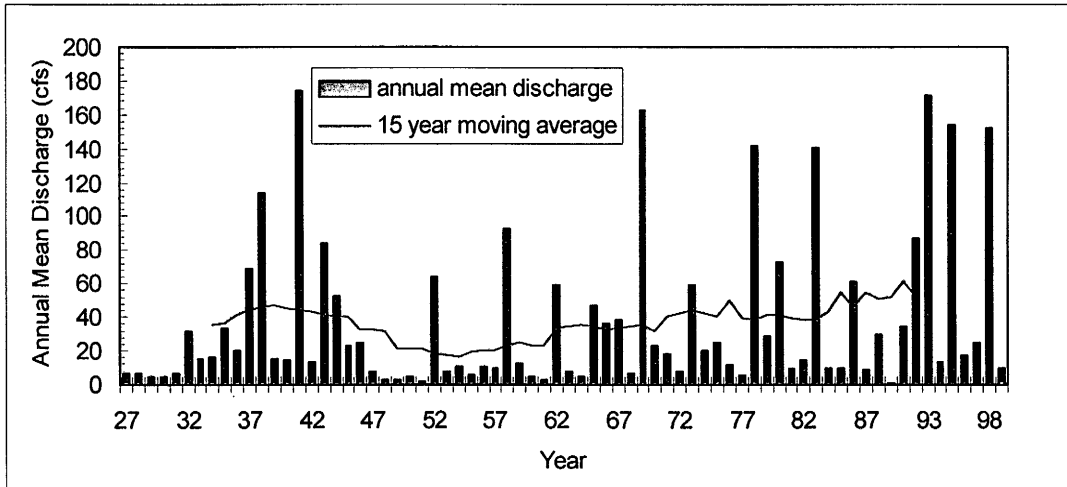


Figure 4a. Time Series of annual mean discharge in Matilija Creek.

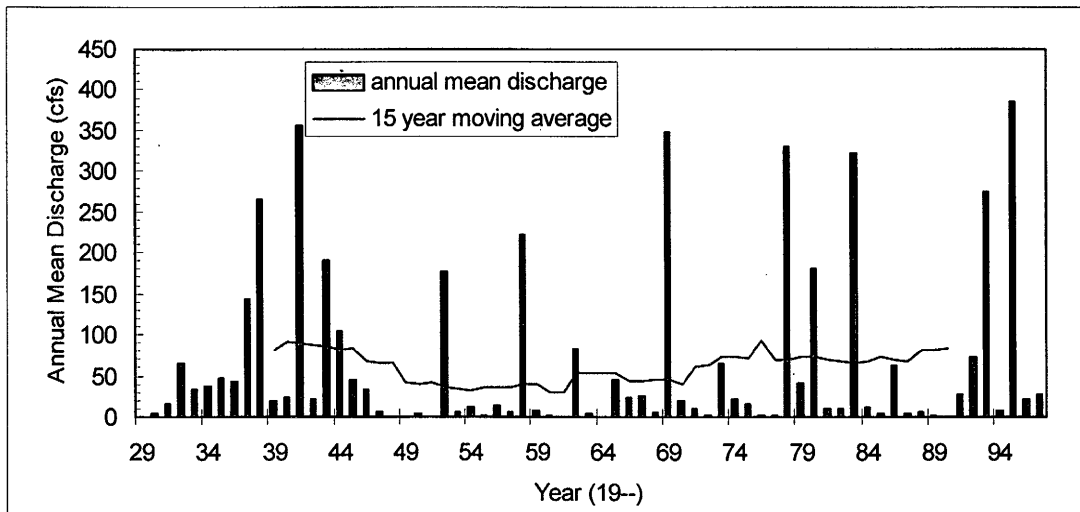


Figure 4b. Time Series of annual mean discharge in the Ventura River near Ventura.

A flow duration curve is the fraction of time a certain flow is exceeded. Flow duration curves for the Matilija Creek and Ventura River were constructed for the entire year and for the months of January through March (Figure 5). For a large portion of the year, the flow in the Ventura basin is quite small. The flow in Matilija Creek and Ventura River is less than 100 ft<sup>3</sup>/s for 93 percent of the time. The flow is greater than 1000 ft<sup>3</sup>/s 0.46 percent of the time in Matilija Creek and 1.2 percent of the time in the Ventura River. The flow duration curve is actually greater at Matilija



for flows under 10 ft<sup>3</sup>/s due to diversion at Foster Memorial Park, which is 7 ft<sup>3</sup>/s on average, depleting low flows. In addition, significant portions of the surface water seep into the groundwater downstream of the dam during low flows.

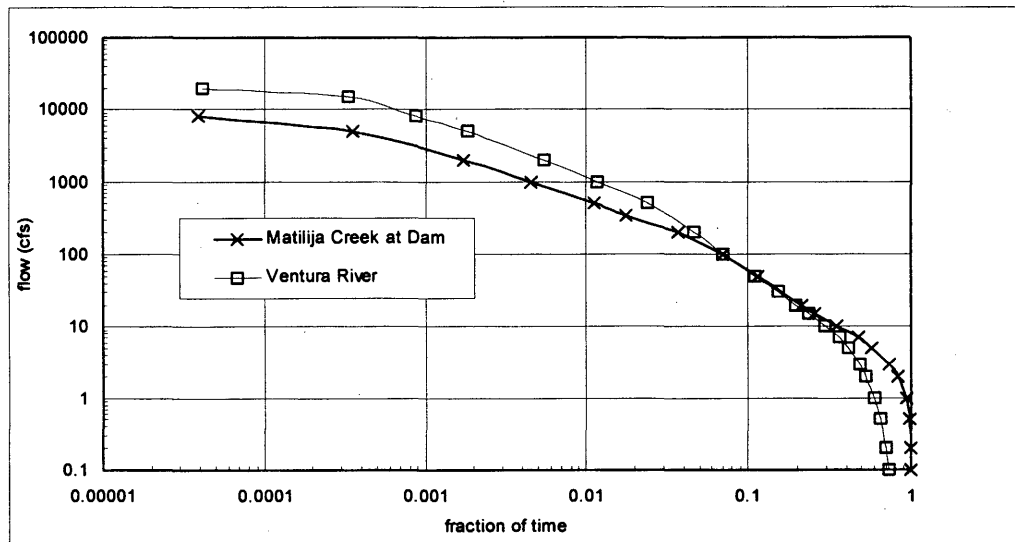


Figure 5. Flow Duration Curves for Matilija Creek and Ventura River.

A flood frequency analysis was performed on the yearly peak flows recorded on the Matilija Creek and on the Ventura River. Because dam removal is being considered, the flood frequency on Matilija Creek should be the flood frequency without the effect of the dam. To estimate the yearly peak flows, the record of the upstream gage was used to obtain the peak flows from 1947 to 1969, and before 1947 and after 1969 the peak flows at the downstream gage were used. The yearly peak flows at the upstream and downstream gages were considered equivalent after 1969 because the reservoir storage capacity after the 1969 flood was decreased to 2273 acre-ft due to sedimentation (CMWD) and there is only a small difference between the upstream and downstream gages for high flows (Figure 6). Existing Matilija Dam may provide some flood attenuation for small more frequent flood events but does very little to attenuate peak flows in large less frequent flood events. Flood routing study will quantify the present impact that Matilija Dam has on flood attenuation. Flood routing requirements will be address in subsequent studies as needed.

The peak flow data was ordered from the smallest value to the largest, and the non-exceedence probabilities were calculated from the ordered data set using:

$$p = \frac{i - a}{n + 1 - 2a}$$

where  $p$  is the probability of non-exceedence,  $i$  is the ordered location of the data,  $n$  is the total number in the data set ( $n = 62$ , in the present data set) and  $a$  is a constant. Bedient and Huber (1992) suggest  $a = 0.4$  when the exact distribution is unknown and this value is adopted here.

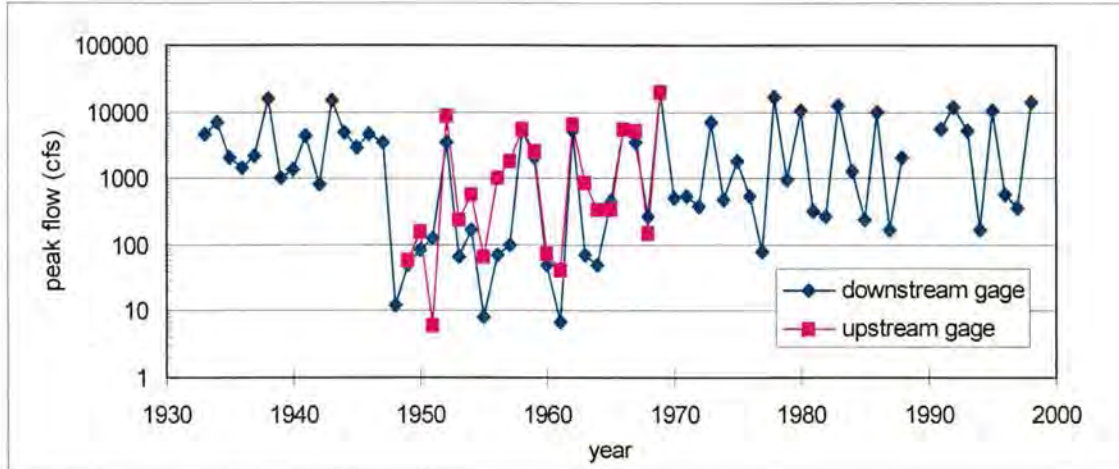


Figure 6. Peak flow record upstream (USGS gage 11114500) and downstream (USGS gage 11115500) of Matilija Reservoir.

The method prescribed by the United States Water Resources Council in Bulletin 17B was used to analyze the flood frequency. In this method, the log-Pierson Type III distribution is fit to the data set:

$$F_Q(q) = \int_x^q \frac{(\ln x - \varepsilon)^{r-1}}{x\lambda^r \Gamma(r)} \exp[-(\ln x - \varepsilon)/\lambda] dx$$

where  $\lambda$  is a scale parameter,  $r$  is a shape parameter, and  $\varepsilon$  is a location parameter. The method of moments was used to calculate  $\lambda$ ,  $r$  and  $\varepsilon$  as follows:

$$\lambda = 0.5\sigma_{\ln q} \gamma_{\ln q}$$

$$r = 4\gamma_{\ln q}^{-2}$$

$$\varepsilon = \mu_{\ln q} - r\lambda$$

where  $\mu_{\ln q}$ ,  $\sigma_{\ln q}$ ,  $\gamma_{\ln q}$  are the mean, standard deviation and skewness of  $\ln Q$ . The method in Bulletin 17B also suggests modifying the skewness if the period of record is not sufficient to compute it. It was found that a skewness of -1.0 was most appropriate for both Matilija Creek and Ventura River. This is a large negative skewness as compared to the average regional skewness which is about -0.3. However, using a skewness of -0.3 gives a 100 year flow that is approximately twice as large as the largest flow ever recorded. The final fitted probability distribution and the measured data are shown in Figures 7 and 8.

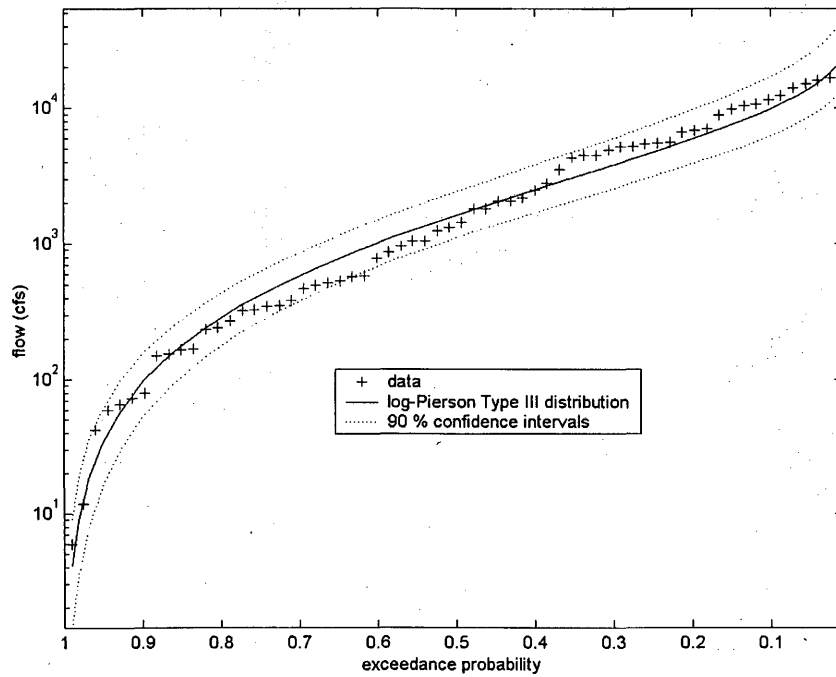


Figure 7a. Flood frequency at Matilija Dam (compilation of USGS gages 1114500 and 11115500).

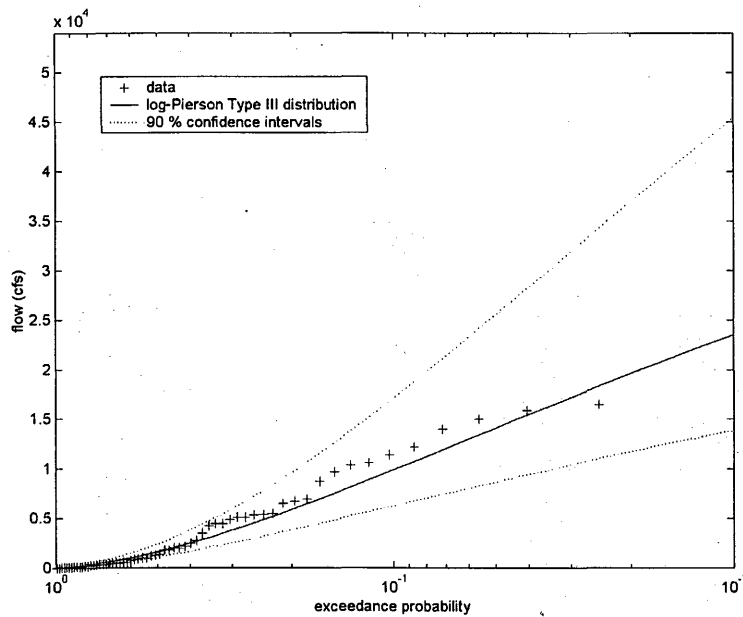


Figure 7b. Flood frequency at Matilija Dam (compilation of USGS gages 1114500 and 11115500).

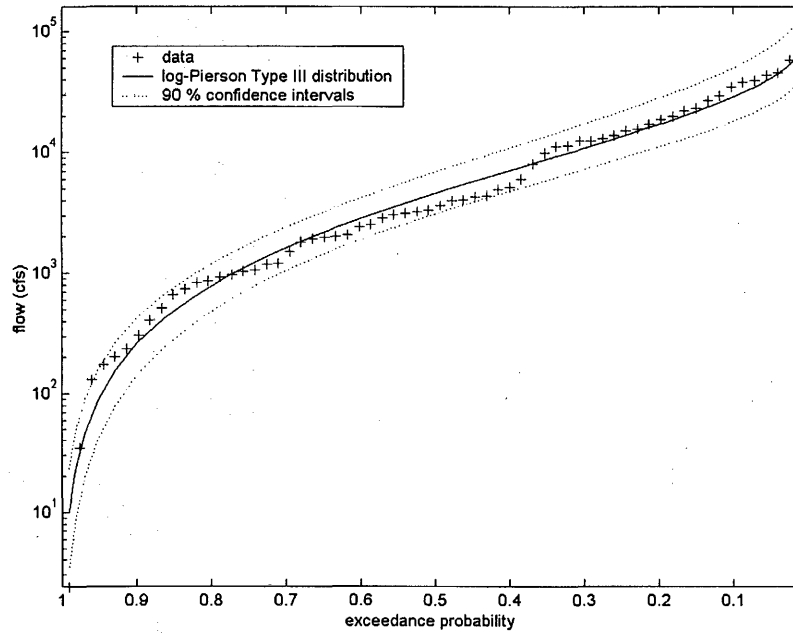


Figure 8a. Flood Frequency of Ventura River at 11118500.

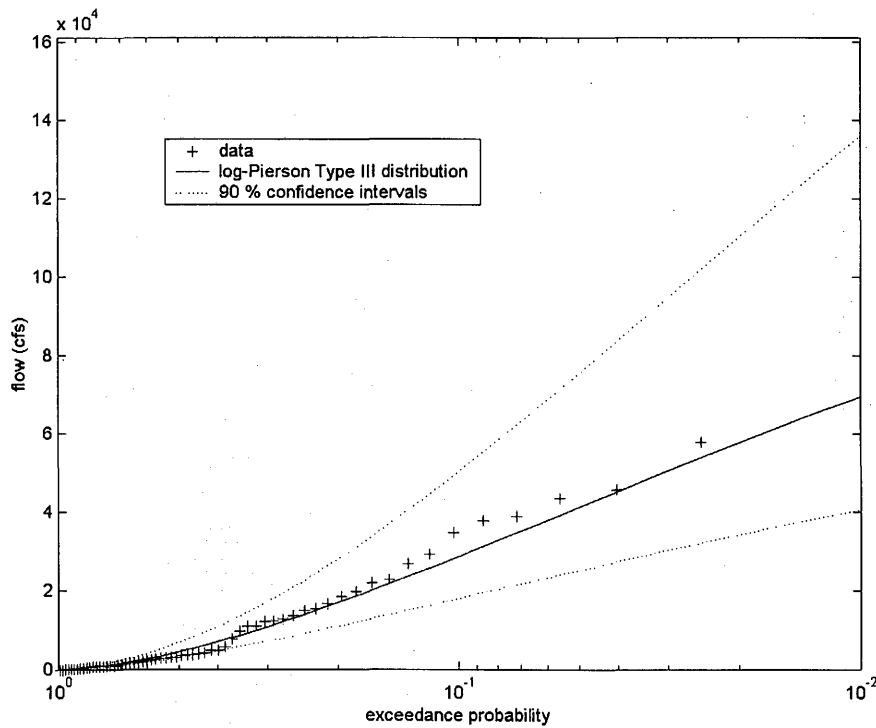


Figure 8b. Flood Frequency of Ventura River at 11118500.

There is significant error in calculating large return periods from limited data sets. The method prescribed in Bulletin 17B, Appendix 9 of the United States Water Resources Council [11], was used to compute the 90 percent confidence intervals and these are shown on Figures 7 and 8. There is a 0.90 probability that the actual return flows will be within the computed bounds if the underlying probability distribution is correct. Both a linear and log scale of exceedance probability are shown. This is because both the low probability events and the expected events will be important in analyzing the sediment management of the dam removal project.

The flows with a recurrence interval of 2, 2.33, 5, 10, 25, 50 and 100 years are given in Table 4. The return flow is simply 1 divided by the exceedance probability. The computed values for the Ventura River at USGS gage 11118500 are in agreement with the reports published by the USACE and FEMA, which estimated the 100-year flood to be 68,000 ft<sup>3</sup>/s [9,2]. The estimate derived here is slightly different because there is an increased length of record. The computed values at Matilija Dam are less than those computed by FEMA. For example, FEMA computed the 50 year return flow downstream of Matilija Dam to be 23,500 ft<sup>3</sup>/s. The difference is small compared to the confidence intervals on the 50 year storm (Figure 7b).

Table 4. Return flows in ft<sup>3</sup>/s at Matilija Dam and for Ventura River at USGS gage 11118500.

return period(yr)	exceedence probability	flow at Matilija Dam	flow at USGS gage 11118500
2	0.5	1600	4600
2.33	0.429	2200	6200
5	0.2	5900	17000
10	0.1	9900	28800
25	0.04	15500	45400
50	0.02	19600	57800
100	0.01	23500	69500

2. Sediment Transport in the Ventura River Basin - The Ventura River basin is part of the Transverse Ranges in California, which is a geographical area dominated by east-trending ranges and valleys transecting the northwesterly structural grain of most of coastal California [10]. Uplands in the basin area are underlain primarily by sedimentary rocks consisting of Tertiary sandstones, shales, and limestones.

This area has some of the highest sediment yields recorded in the United States. This is largely because it is located in an active tectonic region where watersheds are locally lifted up as much as 25 feet per 1000 years [10]. The steep slopes in the upper reaches of the watershed produce most of the sediment supplied to the river. Mass wasting of the hillslopes is a common mechanism by which sediment is moved into the river channel and then transported downstream. Types of mass wasting include dry sliding, slumping and earthflows, and debris flows [10]. The river channel is not experiencing aggradation over long time scales and there is an approximate balance between rate of uplift due to faulting and the rate of downcutting by the fluvial system [12].

Forest fires can also have a large impact on the sediment production of the area [13]. This is because most of the sediment production in the basin is derived from the hillslopes and not from the river channel and a fire markedly increases the erodibility of the land surface. The burn rate in Los Angeles county is 1 percent/yr and probably similar in Ventura County [10]. The ratio of the sediment yield year after a burn to the sediment yield 10 or more years after burn is probably between 11.9 to 35.0 in Ventura County. The sensitivity to fire depends upon vegetative type, seasonal timing of fire, and flows -- therefore, it is difficult to predict.

Several previous studies have estimated the sediment yield for the Ventura basin. Taylor [14] used sediment discharge data to estimate a sediment yield of 4.2 acre-ft/mi<sup>2</sup>/yr for Ventura Basin. Scott and Williams [10] estimated sediment yields between 1.6 to 6.8 acre-ft/mi<sup>2</sup>/yr for headwater basins of the Ventura River. Hill and McConaughy [15] estimated a sediment yield of 2.78 acre-ft/mi<sup>2</sup>/yr for Ventura Basin, with Matilija and Casitas dams in place. Removing the effect of the Casitas and Matilija dams gives an average sediment yield of approximately 5.0 acre-ft/mi<sup>2</sup>/yr for the Ventura River basin. Based on the estimated 6.0 million cubic yards of sediment deposited behind Matilija dam since its construction, and using trap efficiency from the Brune Curve [16], the sediment yield is 2.5 acre-ft/mi<sup>2</sup>/yr upstream of Matilija Dam. The last estimate of 2.5 acre-ft/mi<sup>2</sup>/yr is considered the most accurate for the Matilija basin because all the other estimates were for the Ventura River basin as a whole.

The longitudinal profile of the Ventura River is shown in Figure 9 (from FEMA 1997). As is common for river systems, the bed slope is greatest at the upstream end (0.023) and smallest near the mouth (0.0065). At approximately river mile 8 and river mile 14.5 there are discernable breaks in the bed slope of the river. The breaks in slope correspond to the distinct reaches on the Ventura River (Table 5). From Robles Diversion Dam to the confluence with San Antonio Creek, the Ventura River is primarily a braided channel because it has difficulty transporting the amount of bed material supplied. The channel shifts as sediment is deposited and then cuts a new channel through old deposits. In the vicinity of Robles diversion dam there has been extensive sediment removal by CMWD. Every 2 to 5 years an average volume of 47,000 yd<sup>3</sup> is removed from that location (CMWD). The years of sediment removal correspond to high flows years that move large amounts of sediment along the river.

The river channel from the San Antonio Creek confluence to the mouth of the Ventura River has historically been more braided, based on aerial photos from 1945 [17]. However, due to the construction of the levee in 1948 and reduced sediment loads because of Matilija Dam (1947) and Casitas Dam (1958), the river has become less braided and is mostly a single channel. The final distinct reach of the Ventura River is near the mouth of the river. The river channel in this reach is comprised of a number of distributary channels. These distributary channels can be reoccupied during periodic floods as happened during the flood of February 12, 1992 which resulted in the flooding of the Ventura Beach Recreation Vehicle Resort which had been built across temporarily abandoned distributary channels [18].

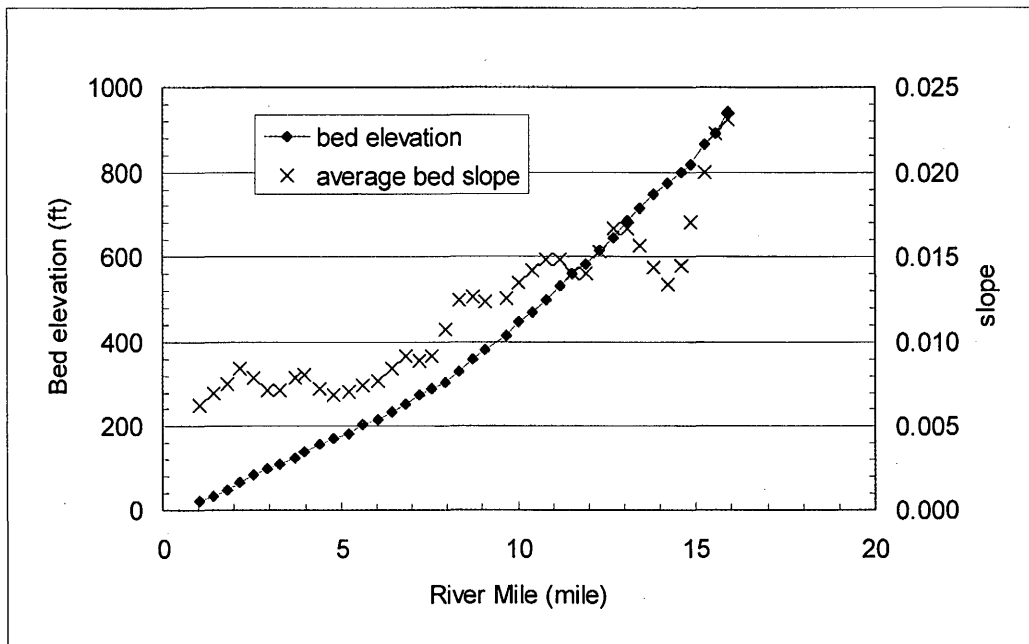


Figure 9. River bed elevation and slope from mouth of Ventura River to Matilija Dam.

Table 5. Location in terms of River Mile

Landmark	river mile	Description
Matilija Dam to upstream of Robles Diversion	16.23 - 15	Steep channel, Mostly single channel
Near Robles Diversion to upstream of Confluence with San Antonio Creek	15 - 8	Braided channel
San Antonio Creek Confluence	8 - 0.5	Mostly single channel
Mouth of Ventura River	0.5 - 0.0	Distributary channel

The distinct river reaches can also be seen on a plot of the largest particle size (termed the critical diameter) that can be moved in different flood events. To calculate the critical diameter, Yang's 1973 critical velocity criteria was used. The channel geometries were taken from the 1997 FEMA [21] study which provided an average channel width. The flow profiles were calculated assuming steady flow and the Manning's roughness coefficient values were taken from the FEMA study as well. The braided stream reach corresponds to a critical diameter for the mean annual flood of approximately 30 mm. The critical diameter increases both upstream and downstream of this reach. Hence, this river reach is expected to have the greatest difficulty passing sediment.

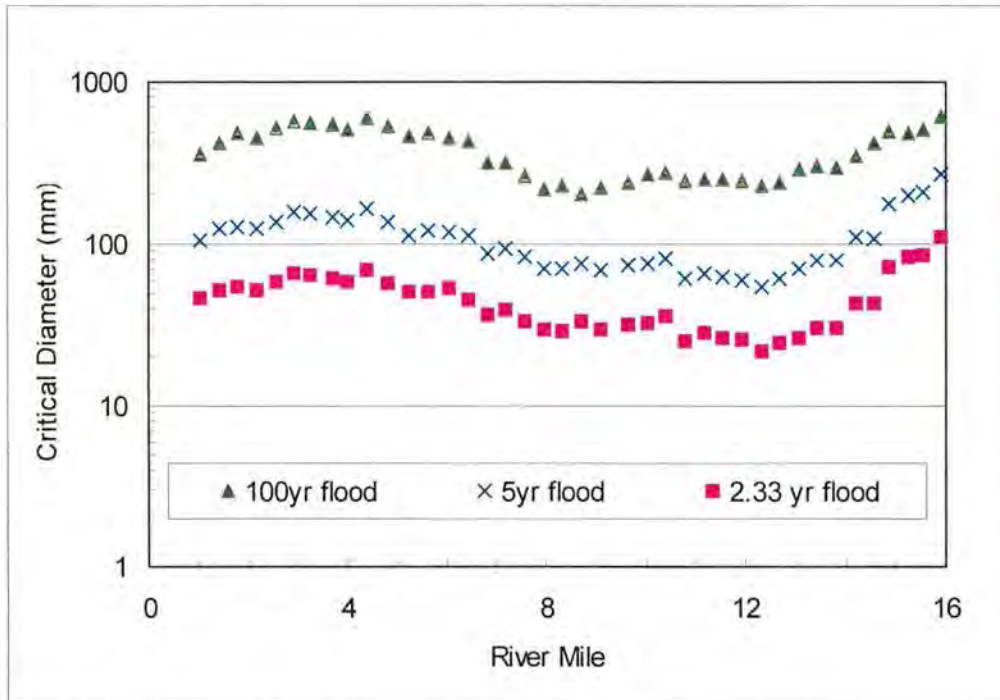


Figure 10. Critical diameter as a function of river miles.

The Ventura River is a mixed load system with a large range of sediment sizes in its bed, from less than 0.062 mm to over 3 ft in diameter (Table 7, Figure 11). Most all of the bed material is non-cohesive -- only 1 percent is finer than 0.062 mm [15]. Upstream of Matilija Dam, the bed is dominated by large cobbles and boulders (Figure 12). No size gradation tests upstream of Matilija Dam on Matilija Creek have been performed to date. The definition used for particle sizes in this report are in Table 6.

Table 6. Definition of particles sizes.

Class	size range (mm)
clay	0.0005 - 0.004
silt	0.004 - 0.062
sand	0.062 - 2
gravel	2 - 64
cobble	64 - 250
boulder	250 - 4000



Table 7. Size gradation at USGS gage 11118500 (From Hill and McConaughy [15]).

size(mm)	0.062	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048
% finer	1	2	5	11	16	19	22	26	31	37	44	74	92	97	99	100



Figure 11. The Ventura River near USGS gage 11118500.



Figure 12. Bed material approximately 5 miles upstream of Matilija Dam on Matilija Creek.

USGS collected sediment load data from USGS stream gage 11118500 (Ventura River near Ventura) from 1969-1973 and from 1975-1981, and from USGS stream gage 11117500 (San Antonio Creek at Casitas Springs) from October 1976 to September 1978. The results are presented in Hill and McConaughy, [15]. They found that during the period of sediment sampling on the Ventura River, 92 percent of the total sediment transported in the Ventura River occurred during 5 storms averaging 10 days each. Relatively infrequent storms dominate the movement of sediment in the Ventura River basin. The dominance of storm events is also shown in Figure 13 where the years corresponding to the 5 storms were the only years to show significant sediment transport.

Over 98 percent of the total sediment load in Ventura and San Antonio Creek is suspended. Approximately 96 percent of coarse sand load (0.062 mm to 2 mm in diameter) is suspended. While larger particles are moved during large floods, it comprises a relatively small portion of the total load. The relative amount of coarse material being transported increases with increasing flow rate. Because large particle sizes dominate the bed material, they are important in determining the channel geometry.

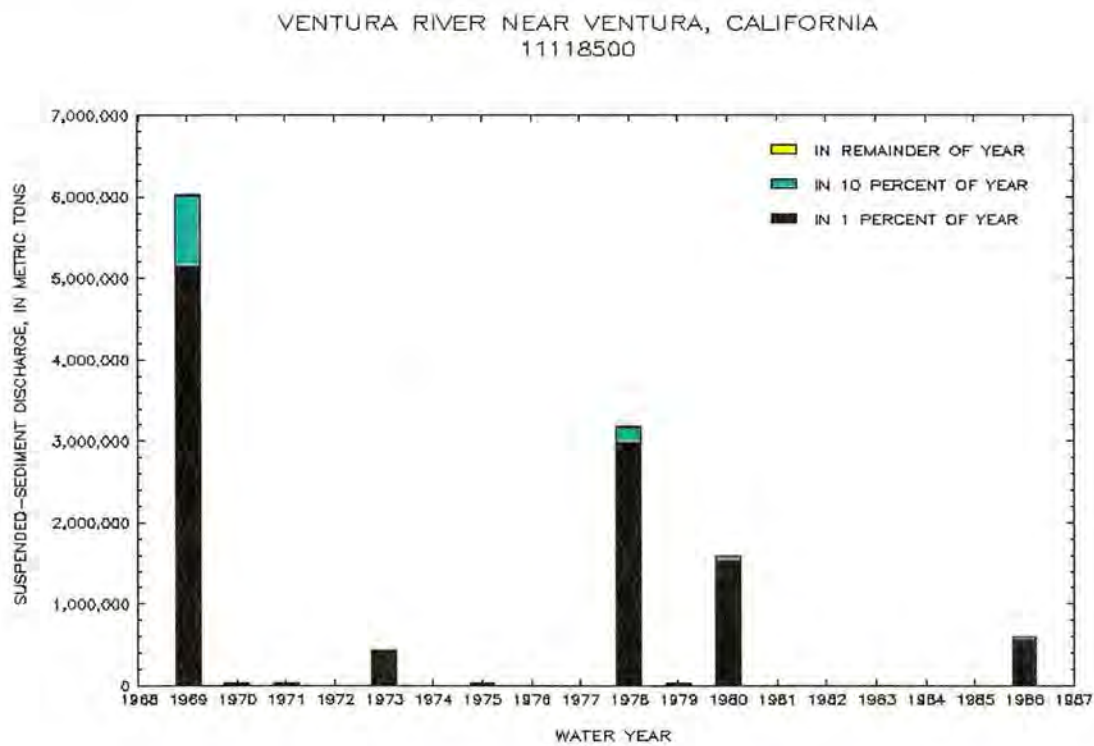


Figure 13. Suspended Sediment Loads in Ventura River, there was no data recorded from 10/1/73 to 9/30/74 and from 10/1/82 to 9/30/85 (figure from USGS <http://webserver.cr.usgs.gov/sediment/>).

Hill and McConaughy also developed sediment rating curves for the Ventura river and San Antonio Creek at the gage sites. The following relation was fit to the suspended sediment data:

$$\log C = a + b \log Q$$

where  $Q$  is the instantaneous flow rate in the river in  $\text{ft}^3/\text{s}$  and  $C$  is the sediment concentration in  $\text{mg}/\text{l}$ . The coefficients  $a$  and  $b$  were fit to the total suspended sediment concentration and the suspended sand concentration, where sand was defined as sediment with a particle size between 0.062 mm and 2 mm.

Table 8. Regression coefficients derived by Hill and McConaughy [15].

	Ventura River		San Antonio Creek	
	Total Suspended	Suspended Sand	Total Suspended	Suspended Sand
a	1.12	-1.88	1.04	-2.08
b	0.754	1.38	0.922	1.68

Curves were also fit to the bed load curves of Hill and McConaughy, but the equation corresponding to these curves was not given. Therefore, equations were fit to their curves. For the Ventura River a log form similar to the equation used for suspended sediment was used to fit their curve for bed load:

$$\log C = a + b \log Q, \quad a = -0.63, b = 0.77$$

where  $C$  is in  $\text{mg}/\text{l}$  and  $Q$  is in  $\text{ft}^3/\text{s}$ . An exponential function was fit to the bed load curve for San Antonio Creek using least squares regression. This gave a function that reproduced the curve fit by Hill and McConaughy to within a relative error of 10 percent over the entire range of flows, which is well within the range of experimental error.

$$C = a \left[ 1 - \exp(-b(Q - c)^d) \right], \quad a = 600, b = 0.0016, c = 17, d = 1.26$$

The sediment rating curves can be combined with the flow duration curves to obtain the effective sediment discharges for given flows. This was done by first fitting a exponential probability distribution to the flow duration curve of the Ventura river. Then, the sediment flow rate is multiplied by the corresponding ordinate of the probability distribution of the flow. The most flow that carries the most sediment over time is approximately  $1000 \text{ ft}^3/\text{s}$  for total suspended load, and approximately  $6000 \text{ ft}^3/\text{s}$  for the total coarse load (the addition of the suspended sand plus the bed load). The mean annual flood is also estimated to be  $6200 \text{ ft}^3/\text{s}$  (Table 4). Because the sediment in the bed is predominantly gravel, cobbles, and boulders, it is the movement of the larger sizes that controls the shape of the channel. Therefore, the dominant flows in channel formation are considered to be flows that are  $6000 \text{ ft}^3/\text{s}$  or larger.

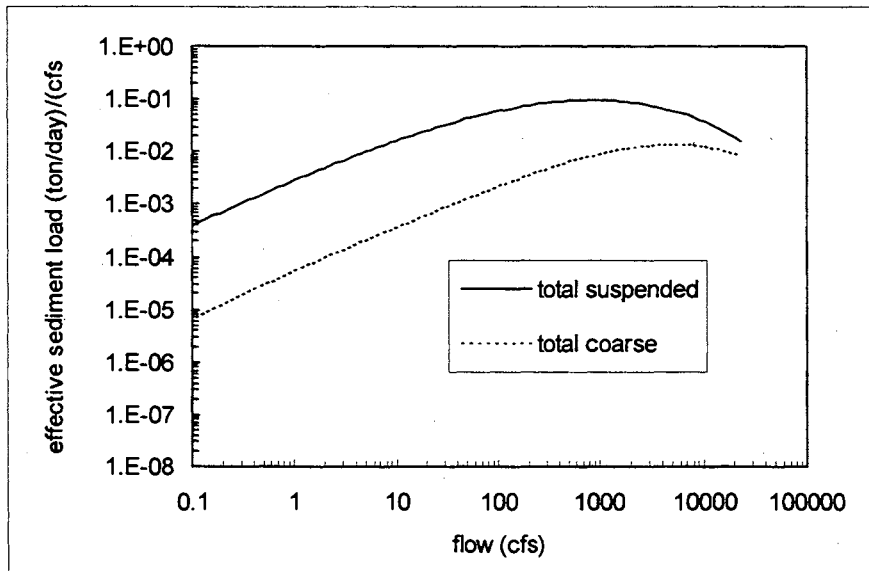


Figure 14. Effective sediment loads. Coarse load is that load with particle sizes larger than 0.062 mm.

3. Sediment Deposition in Matilija Reservoir - Sedimentation in the Matilija Reservoir has been of concern since its construction [19] and several surveys have tracked the progression of sedimentation in Matilija Reservoir. Table 9 contains a record of the active storage and deposited volume in the reservoir. Approximately 2600 acre-ft was lost in 1965 due to the 30 foot notch removed from the dam. The deposited volume between the building of the dam and 1999 was estimated by using the survey data from the silt control lines. The survey in 1999 is documented in Sturm and McCulla [3]. The reservoir trap efficiencies were taken from the lower envelop of the Burne curve, where the trap efficiency is defined as the sediment deposited in the reservoir divided by the sediment inflow to the reservoir multiplied by 100 percent. A 15-year moving average was used to calculate the average inflow to the reservoir. The trap efficiencies are subject to a great degree of uncertainty because the Burne curve does not take into account the extreme hydrological variability that exists in Matilija Creek. Further numerical modeling and comparisons with similar reservoirs is necessary to develop better models of the trap efficiency.

The elevations from the silt control lines were used to plot the approximate deposition history in the reservoir (Figure 15). The first deposition occurred mainly in the upper reaches of the reservoir and also in the stream channel immediately upstream of the dam. The 1969 flood however, deposited approximately 1,000 acre-ft of sediment in a relatively uniform manner over the entire length of the reservoir. Between 1969 and 1978 deposition occurred in the area directly upstream of the dam face. This was in part due to the fact that the dam height was reduced in 1965 and the previous delta that had formed when the reservoir elevation was higher was partially eroded and a new delta formed further downstream. From 1978 to 1986, there was only a small amount of deposition. Deposition increased from 1986 to

Table 9. Reservoir depositional history. Trap efficiencies estimated using lower envelope of Brune Curve [16]. Deposited Volume estimated from Silt Control lines, except for 1999 when complete survey was done. -- indicates that no data was available or was not computed.

Year	Dam Crest Elevation	Reservoir Storage (acre-ft)	Est. Trap Efficiency (%)	Est. Deposited Volume (10 <sup>6</sup> yd <sup>3</sup> )	Est. Deposited Volume (acre-ft)
1947	1125	7018	90	0	0
1958	1125	6718	92	0.50	310
1964	1125	6488	88	0.97	600
1965	1095	3856	83	0.97	600
1970	1095	2473	76	3.0	1840
1978	1095	--	--	4.0	2510
1983	1095	1480	65	--	--
1986	1095	--	--	4.3	2710
1994	1095	930	47	--	--
1999	1095	500	35	6.0	3720

1999 and the deposition layer increased slightly over the length of the reservoir. The layer was more uniform from 1986 to 1999 because the delta corresponding to the lower dam elevation was already formed. In general, the grain size is expected to decrease in the downstream direction toward the dam. The flow energy decreases toward the dam and therefore the water is only able to transport finer material. The upper reaches of the reservoir will contain predominantly gravel sizes, or larger, and near the dam the deposits will be mostly silts and clays.

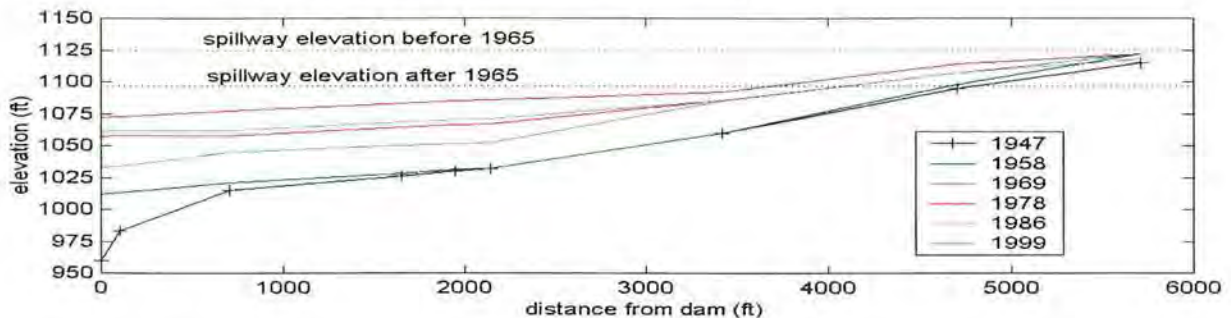


Figure 15. Depositional history in reservoir.

Sediment deposits have almost completely filled Matilija Dam, reducing the dam's present estimated capacity to 500 acre-ft (Figure 16). The current deposition pattern in Matilija Reservoir is shown in Figure 17. This figure is a plot of the elevations from the 1999 topographic map minus the elevations obtained from the 1947 topographic map. The depth of deposition is not accurate near the dam because the 1947 topography map had a water surface elevation of 1002 at the time of the survey. Therefore, the depth of deposition is up to 42 feet greater in the vicinity of the dam.

Starting at about 500 feet upstream from the dam, however, the depth of deposition is considered accurate.



Figure 16. Picture taken upstream of Matilija Dam looking downstream. Matilija Dam can be seen in upper left area of picture.

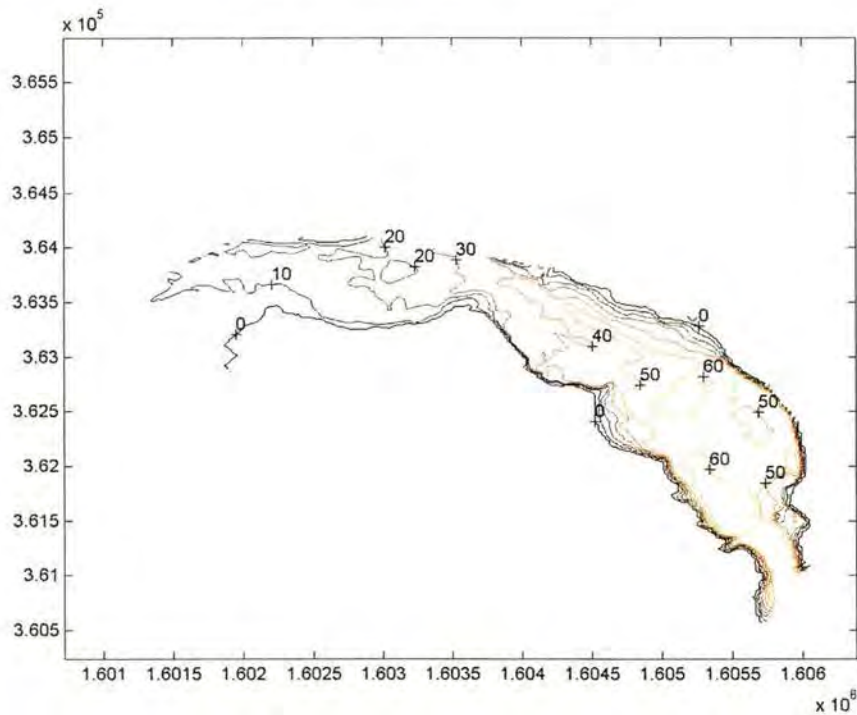


Figure 17. Current sediment deposition upstream of Matilija Dam. The x-y coordinates are in state-plane coordinates and the elevations are feet of deposition.

The depositional history of the reservoir was simulated using the stream flow record, assuming sediment rating curves and estimating reservoir trap efficiencies. The

stream flow record of the upstream USGS gage was used for the period 1947-1969 and the stream flow record from the downstream gage was used for the remainder of the simulation. The sediment rating curves obtained from San Antonio Creek by the USGS [15] were used without modification to simulate the sediment inflow into Matilija Dam. The suspended sediment rating curve was previously given in Table 8. It was assumed that all the bed load would be of gravel size or larger. The estimated bulk density of the sediment was 94 lb/ft<sup>3</sup>. The comparison between the computed deposition and the measured deposition as computed in Table 9 is found in Figure 18. As previously mentioned, most sediment movement takes place during high flow years and almost no sediment movement takes place during the low flow years. The computed deposition closely matches the measured deposition until 1983 where the departure from the measured deposition occurs in a single year. This error is propagated throughout the rest of the simulation. A probable cause of this behavior is that the sediment rating curves were obtained from data collected from 1969-1981. It is possible that the sediment rating curves changed after that period due to changes in climate, and/or burn history. Another possible cause of the discrepancy is the inaccuracy of the estimated trap efficiencies.

It would be possible to calibrate the sediment rating curves and/or the trap efficiencies to match the data more closely. However, because both affect the total deposition, it is difficult to distinguish between the effects of the two or to predict how much each one is in error. In addition, the match between the measured data and the computed is considered reasonable and therefore no modifications to the trap efficiencies or the sediment rating curves are made.

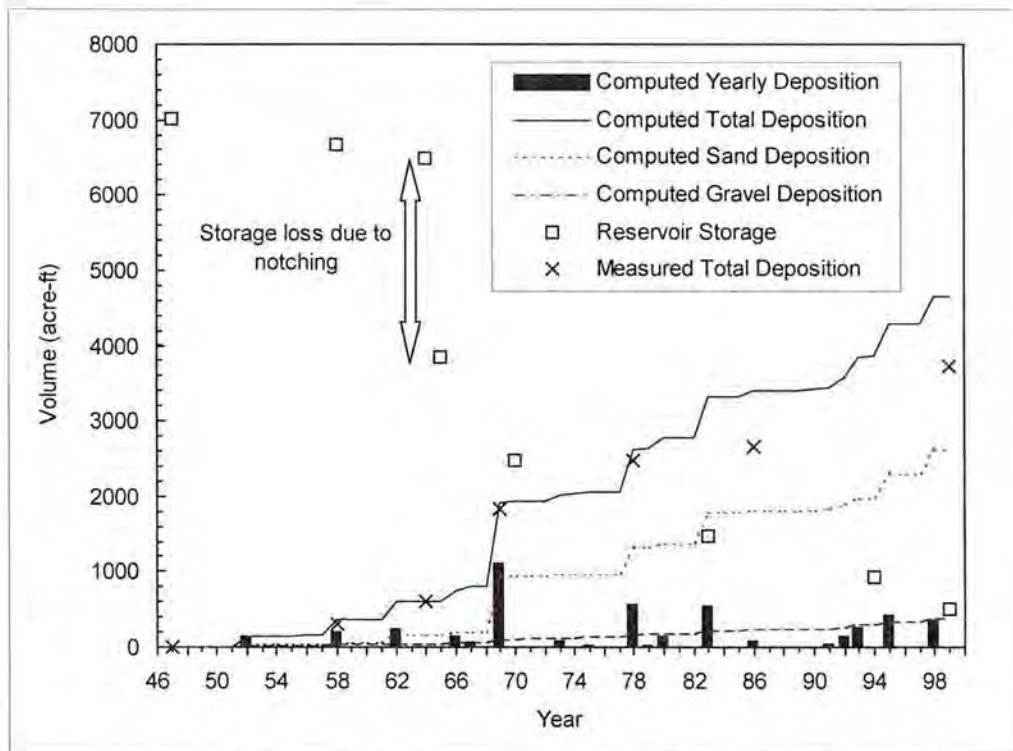


Figure 18. Simulation of reservoir deposition using sediment rating curve.

The purpose in simulating the historical deposition is two fold:

- ◆ It gives an estimate of the relative percentage of particle sizes in the reservoir.
- ◆ It gives credence to the assumption that the San Antonio sediment rating curve is applicable to Matilija Creek.

The percentages of particle sizes obtained from the historical simulation are given in Figure 19. The numbers in Figure 19 are simply the result of the historical simulation and are not derived from measurements of the actual size distribution. They may not represent the actual distribution in the reservoir due to the fact that the reservoir trap efficiencies are unknown and the sediment rating curve was taken from San Antonio Creek and not Matilija Creek. Based on visual field observations, the larger grain sizes are most likely underestimated in Figure 19.

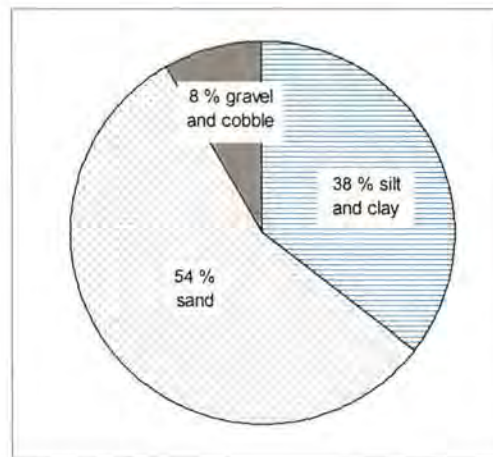


Figure 19. Particle size distribution of deposited sediments obtained from historical simulation.

To eliminate some uncertainty of the above estimate, and to provide information about the spatial distribution of the sediment sizes, it is necessary to sample particle sizes in the reservoir throughout its entire depth. In this stage of the investigation, surface samples of the sediment were taken throughout the reservoir. The description of this effort is found in reference [3]. In the inundated region next to the dam, 18 sediment samples were collected with a piston sampler to a depth of 1 to 2 feet. In the delta region, samples were collected every 1 to 2 feet using a hand auger to a maximum depth of 10 feet. The samples were analyzed for particle size, cohesive properties and chemical composition. The sample locations can be divided into 3 general areas: area A is the ponded region which extends approximately 1600 feet upstream of the dam; area B is the first part of the delta region from approximately 1600 feet to 1800 feet upstream; and area C approximately 1800 to 2100 feet upstream of the dam. The samples were combined to obtain average size gradations for each area (Figure 20). As is typical in reservoirs, the average particle size decreases as the dam is approached.



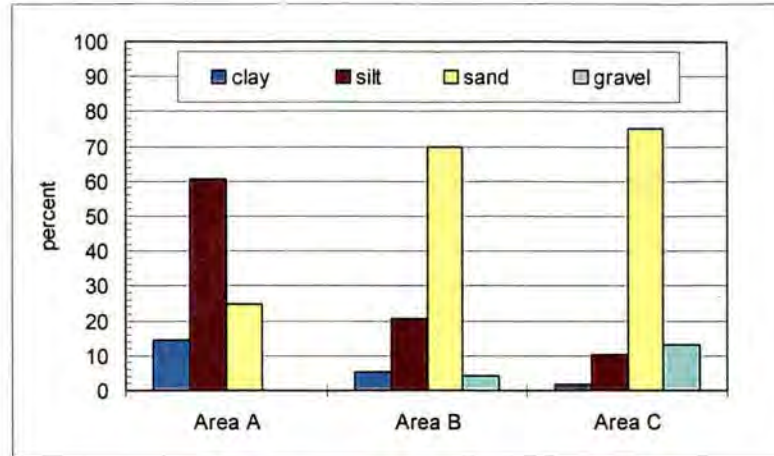


Figure 20. Measured size gradation of surface samples collected in December 1999.

Because there is no information on the size gradations further upstream of area C and because samples were not collected at large depths, it is difficult to estimate size gradations for the entire reservoir. However, to give an initial estimate by which to compare the results obtained from historical simulation, the following assumptions were made.

- ◆ The sediment is uniform with depth.
- ◆ The deposited sediment is 20 percent sand and 80 percent gravel and cobble in the most upstream reaches.
- ◆ There is a smooth transition in grain sizes throughout the reservoir

Gradations were assumed at each silt line and then the corresponding volumes of each size class were computed. The results are found in Figure 21. These estimates

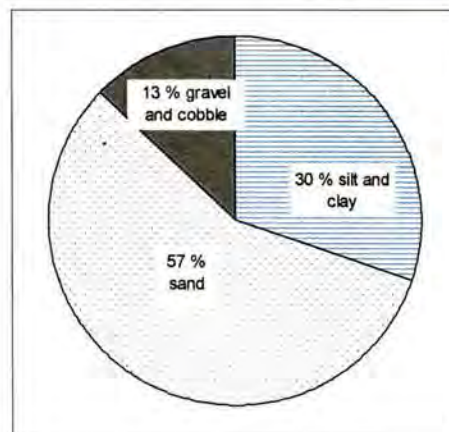


Figure 21. Particle size distribution of deposited sediment estimated from measured samples.

are again subject to large uncertainty. Further sampling must be done at greater depths and further upstream to eliminate some of this uncertainty. In any case, the percentages shown in Figure 21 agree rather closely to those obtained from the historical simulation except that there is a larger portion of gravels and cobbles and less silts and clays.

For the purposes of this document, the size gradations obtained from the historical simulation will be used for cost estimating purposes. This is done to remain consistent with the other alternatives. In particular, it is necessary to remain consistent with the alternative incorporating the slurry pipeline.

a. Chemical Composition of Sediment - There are no known sources of artificial contamination, such as mining, agriculture or industry upstream of Matilija Reservoir. There is a possibility, however, that various types of metals and sulfur compounds originating in hot springs upstream of the reservoir are adsorbed to the sediments deposited behind Matilija Reservoir. In particular, there is the possibility for Acid Mine Drainage (AMD). AMD refers to the acidic conditions that often occur in mine tailings due to the oxidation of iron pyrite (FeS). The acid conditions can cause the dissolution of heavy metals. As a first step in the investigation of these possibilities, the following laboratory analyses were performed on six samples obtained from area A, and six samples from areas B and C:

- ◆ ICP and ICP/MS analysis for 30 elements, including arsenic and mercury
- ◆ total sulfur analysis
- ◆ total organic carbon
- ◆ leaching tests

The detailed laboratory results are found reference [3]. Laboratory conclusions are as follows:

- ◆ The sediments samples collected in Matilija Reservoir had non-toxic metal concentrations
- ◆ The sulfur concentration measured in the sediment is just above protocol concentrations for Acid Mine Drainage (AMD). The sediment contains significant alkalinity that lessens the likelihood of AMD. AMD will not occur unless higher sulfur concentrations are present
- ◆ The alkalinity in the sediment, Matilija Reservoir, and Matilija Creek waters should be measured
- ◆ The sulfate concentrations in Matilija Creek and Reservoir should be measured
- ◆ Matilija Creek waters flowing through the sediment should be measured for dissolved oxygen

The County of Ventura (County) collected water samples in Matilija Creek near the Matilija Hot Springs in January, April, July, and November from 1976 to

1993. The sulfate concentrations have ranged from 208 to 282 mg/l, with a mean of 244 mg/l. The alkalinity (as measured as mg HCO<sub>3</sub><sup>-</sup>) ranged from 176 to 312, with a mean of 224. The pH of the water ranged from 7.1 to 8.4 with a mean of 8.1. The complete data set for this site and other sites in the Ventura River Basin is available from the County. In addition, CMWD has records of collected water samples in the Ventura River, Coyote Creek, Santa Ana Creek and the Casitas Reservoir since at least May 1988. The data collected by the County and CMWD can be used to further assess the likelihood of AMD and potential contamination problems associated with the release of sediment.

b. Potential Erosion of Sediments - After determining the quantity and properties of the sediment behind the dam, it is necessary to determine its fate. In cases where the reservoir is much wider than the river channel, it is possible that a majority of the deposited material will not be eroded behind the dam. Matilija Reservoir is relatively narrow, however, and it is likely that almost all of the deposited material will eventually be removed from behind the dam. There are two reasons that the most of the deposited material will eventually be removed.

- ◆ Matilija Creek is a braided channel with a large sediment load. In this type of river the main channel often shifts. Therefore, the entire valley has the potential to be eroded and become the main channel.
- ◆ Based on steady flow simulations in the pre-dam topography, the water width of extreme events is near the valley width. This was determined by computing the water surface profiles using HEC-RAS [20]. The cross section data was obtained from the silt control lines measured in February 1948. The Mannings *n* was assumed to be 0.05, which is typical for a channel with large boulders present. The 1997 FEMA study [21] also used *n* = 0.05 for the reach of Matilija Creek immediately downstream of the dam. The water surface profiles for the 100-year flood of 23,500 ft<sup>3</sup>/s and the 5-year flood of 5,900 ft<sup>3</sup>/s are shown in Figures 22 and 23. The values of the top width and hydraulic depths at each silt line are given in Table 10. As a comparison, the top width and average depth of the present deposits are also given. The average ratio of the 100-year flood topwidth to the depositional topwidth is 0.47.

Table 10. Top widths of water under pre-dam conditions.

siltline	deposits		top width of water (ft)		hydraulic depth (ft)	
	top width (ft)	depth (ft)	5900 ft <sup>3</sup> /s	23500 ft <sup>3</sup> /s	5900 ft <sup>3</sup> /s	23500 ft <sup>3</sup> /s
1	462	90	90	108	4.0	9.3
2	730	62	173	281	3.3	6.0
3	1125	54	283	455	2.6	4.3
4	620	32	113	300	4.8	5.6
5	850	19	279	571	2.4	4.1
6	980	7	189	623	3.3	3.0

The above are qualitative statements of the final state of Matilija Creek after an unspecified period of time and after complete dam removal. To predict the

Legend	
WS 23500 cfs	
Ground	
Bank Sta	
Ground	

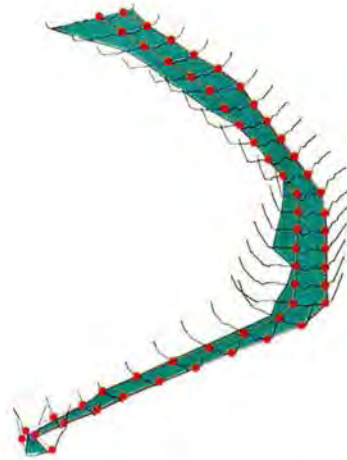


Figure 22. Water surface profile of 100-year flood (23500 ft<sup>3</sup>/s) through pre-dam topography.

Legend	
WS 5900 cfs	
Ground	
Bank Sta	
Ground	

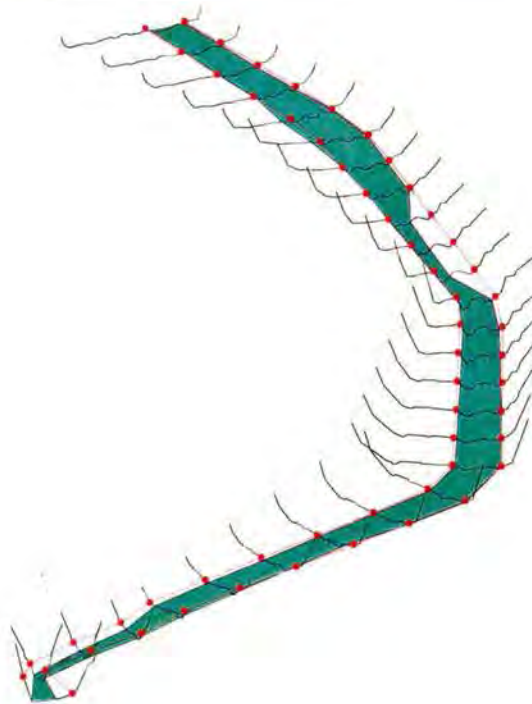


Figure 23. Water surface profile of 5-year flood (5900 ft<sup>3</sup>/s) through pre-dam topography.

actual rate of material removed, a sediment model needs to be developed that can predict the sediment transport and resulting channel morphology during the dam removal period. In addition, because stream flows are highly variable in Matilija Creek, the sediment flows will also be highly variable. Therefore, the predicted sediment transport within the reservoir is best described by statistical means.

4. Simulation of Dam Removal - The key factors in the Phased Natural Transport Alternative are the timing and the height of the dam notching and the timing and magnitude of the river flows. A simple mass balance model was used to obtain a reasonable estimate of dam removal time. No modeling of specific downstream impacts was done. The basic calculation procedure is summarized in Figure 24. The mass balance for the reservoir region is:

$$\Delta V_{res} = \Delta t(Q_{s,in} - Q_{s,out})$$

The mass balance for the downstream reach is:

$$\Delta V_{down} = \Delta t(Q_{s,out} - Q_{s,down})$$

A daily time step,  $\Delta t$ , was used in the model simulations. The sediment rating curve from San Antonio Creek was used to compute the sediment inflow rate into the reservoir ( $Q_{s,in}$ ). The reservoir trap efficiency for the incoming sediment was assumed to be zero and the sediment outflow rate ( $Q_{s,out}$ ) was set equal to the inflow rate.

Each model simulation continued until the dam was completely removed. The length of time to remove the dam, and the amount of time simulated in the model, depended on the pattern of flows (magnitude, duration, and frequency) during the dam removal process. The dam was assumed to be removed by draining the reservoir through a series of notch openings that would be cut into progressively lower elevations of the dam. The first notch would be cut into the top layer of the dam to drain the surface layer of the reservoir water and sediment and then the top layer of the dam would be removed under dry conditions. A second notch would then be cut into the remaining top layer of the dam to drain the next surface layer of the reservoir water and sediment. The process would then continue until the dam was completely removed. It was assumed that a notch could not be opened during high flow conditions and that the flow would have to be less than 500 ft<sup>3</sup>/s. The model also assumed that the top layer of sediment would be immediately eroded from the reservoir after each notch opening.

The model assumed that only one notch would be opened in the dam in a given year. The model also assumed and that the number of years between notch openings would depend on the length of time that was needed for the river to transport most of the reservoir sediments downstream to the coast. The model would allow another notch opening in the dam after all but 100,000 yd<sup>3</sup> of the previously released sediments had been transported to the coast. This volume is approximately equal to 0.1 feet of sediment spread out evenly over the entire downstream channel of the Ventura River (15.6 river miles with an average width of 300 feet).

The downstream transport capacity was calculated at the Matilija gage downstream of the dam and at the Ventura River gage. Channel geometries were assumed based on the USGS quadrangle sheets and 1997 FEMA study [21]. Yang's 1973 formula was used to calculate the river capacity for sand, while it was assumed that the silt and clays would be transported with a concentration of no more than 200,000 mg/l. It was assumed that if gravels and cobbles were removed from the reservoir, then they could also be transported downstream. It should be noted that high concentrations of fine material ( $> 30,000$  ppm) can increase the apparent water viscosity, reducing the sediment fall velocity and thereby increase the overall the sediment capacity. Based on these assumptions, the removal rate was limited by the amount of sand that the river could transport. Sizes larger and smaller than sand did not limit the rate at which dam removal took place. After calculating the sediment capacity at the Ventura gage, the normal sediment flow was subtracted from this capacity. The normal sediment flow was assumed to be that obtained from the sediment rating curves derived by Hill and McConaughy [15]. The downstream capacity was then calculated as the smaller of the capacity calculated at Matilija gage and the Ventura gage.

To sample the entire historical stream flow record, the dam removal modeling was done assuming that it began each year starting from the earliest period of record of the Ventura USGS gage, 1929. Using results from all the simulations, it is possible to calculate statistics of the dam removal. For example, the average time of removal and standard deviation of the time of removal can be calculated.

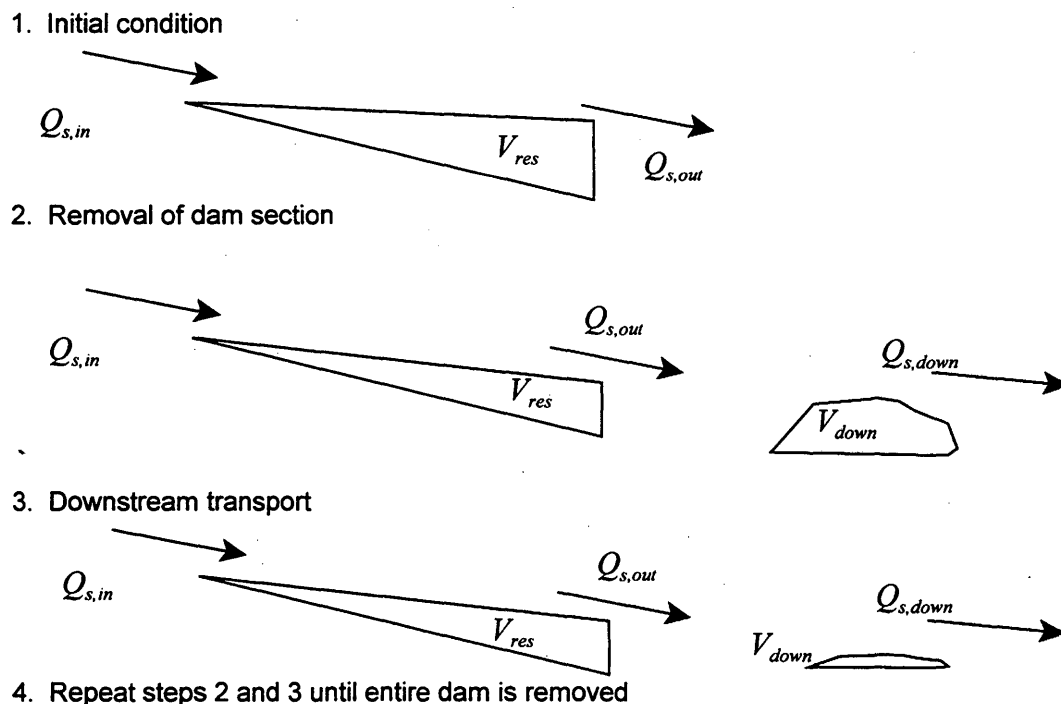


Figure 24. Calculation procedure used to estimate the dam removal time.

The data used to derive the time required for dam removal are as follows:

- ◆ Total sediment volume is 6.0 million  $\text{yd}^3$

- ◆ Sediment size gradation: 38 percent fines, 54 percent sand, 8 percent gravel and cobble
- ◆ Elevation of 1070 feet is sediment top, dam crest at 1095, base at 935, original bed on upstream side of dam is at 960. The height of sediment on the dam face is 110 ft
- ◆ Time of removal is from when first notch is cut until when last notch is made

The downstream impacts are uncertain for each of the removal heights. Further study and modeling is required to quantify impacts. Because of the uncertainty regarding downstream impacts, the notching height will likely be progressive, i.e. increasing over time. At Elwha Dam, the notching heights used were 15 ft with each notch over lapping the previous notch by 7.5 feet. However, on the Elwha river there is a consistent flow where the most effective sediment transporting flow is exceeded 10 percent of the time. In this case, the most effective sediment transporting flow is exceeded only 0.2 percent of the time. The average time of each notching is given in Table 11. The notching heights listed in Table 11 were derived based on previous studies and practical considerations. It is uncertain if these notching heights will cause undesirable downstream impacts or if greater notching heights are possible. Further work is needed to identify the optimal notching heights and sequence of notching heights. It should be emphasized that the notching heights in Table 11 were only derived so that a reasonable cost estimate of the Phased Natural Transport Alternative could be obtained. They are not the final recommended notching heights and could either be too conservative or cause downstream impacts that are too severe.

Table 11. Notching heights and average year of removal with respect to (wrt) start of dam notching.

notch	notch height (ft)	height of dam after notching (ft)	range of year of notch opening wrt start	average year of notch opening wrt start
1	5	105	0	0
2	5	100	1 - 7	3
3	10	90	2 - 11	5
4	10	80	3 - 13	8
5	15	65	4 - 17	11
6	15	50	7 - 22	15
7	15	35	10 - 25	17
8	15	20	11 - 28	21
9	20	0	13 - 33	24

Because of the uncertainty regarding the notching heights, the time of removal using different notching heights is given in Figure 25. The computed time of removal is shown by the data points and the fitted normal distribution curves are shown as solid lines. A normal distribution was fit to the computed time of removal data to quantify the variability of removal times. The notching heights of table 11 correspond to the proposed curve of Figure 25. Constant notching heights of 10, 20 and 30 feet were

also simulated. The mean time of removal for the notching heights of the proposed dam removal scenario was 24 years and ranged between 13 and 33 years with a standard deviation of 3.5 years. For a constant notching height of 30 feet the average time of dam removal is approximately 13 years; for a constant notching height of 10 feet the average time of dam removal is approximately 30 years. The impacts and the uncertainty associated with the impacts are likely too great for a notching height of 30 ft. Therefore, 13 years is considered an lower bound on the dam removal time given this method of dam removal.

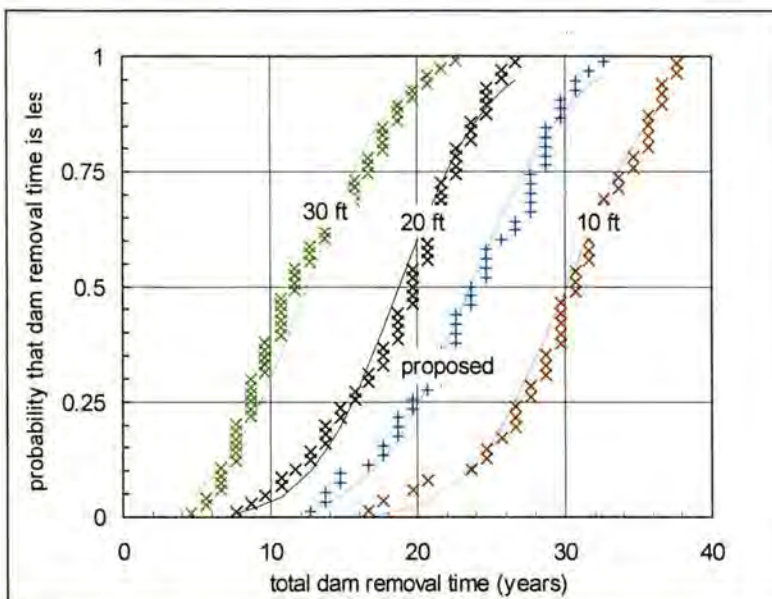


Figure 25. Probability that dam removal time is less than the given period. Each point corresponds to starting the dam removal in a different year of the historical stream flow record.

There are several ways to decrease the removal time. One method would be to combine it with other alternatives -- such as sediment removal or stabilization. Some of the sediment would be removed mechanically and some of it would be allowed to transport down the river. Another method to decreased the time required for Phased Natural Transport is to build levees along the river. This would allow for larger notching heights and therefore decrease the removal time. It may also be possible to construct outlet works so that more sediment can be released. Using outlets at the bottom of the dam would also allow very tight control on the amount of sediment released downstream. The downstream effects could be continually monitored and if they become too severe, the outlet could be shutoff and no sediment or water would be released through the outlet and the flow would be allowed to spill over the dam crest.

5. Potential Impacts - The Phased Natural Transport Alternative will have several potential impacts to the reservoir area and to the downstream reaches of the Ventura River. It should be kept clear that the following are statements of potential impacts and not certain impacts.

- a. Deposition of released sediment may increase flood damage - There is already significant development in the 100-year flood plain [9] and any increase to the



number of people and industries at risk of flooding may be unacceptable. If sediment loads are not carefully controlled, significant rises in bed elevation may potentially occur that may then be accompanied by an increase in flood stage. Of the 6.0 million yd<sup>3</sup> of reservoir sediment, 38 percent are of silt and clay size. If released downstream, these fine sediments would be transported in suspension and at nearly the speed of water. However, the remaining coarse sediment (62 percent) would tend to be transported predominantly near the bed and at speeds significantly slower than that of water. If the volume of coarse sediments (3.7 million yd<sup>3</sup>) were spread evenly over the entire downstream channel of the Ventura River (15.6 river miles with an average width of 300 feet), the resulting thickness would be 4 feet.

It is important to realize, however, that 1 foot of bed aggradation, for example, does not translate into a 1 foot rise in water surface elevation. One reason for this is that most of the deposition will take place in the pool regions of the river that presently do not convey significant amounts of water during high flows. Another reason for this is that most of the flood conveyance is in the upper part of the river cross section.

Levees could be built along the river to mitigate flooding impacts. This would increase the cost of the project, but could allow for much faster dam removal because larger volumes of sediment could be released downstream at any given time. It should also be noted that because people are already living in the 100-year flood, levee construction may be necessary no matter how slowly the dam is lowered.

The analysis of flood stage is made more complicated because flood damage in the region is sometimes caused by formation of new river channels and/or filling of old ones [10,18]. Assuming that the river bed does not change during a flood may under predict the extent of flood damage. Because the Phased Natural Transport Alternative will increase the sediment loads in the river, it will also increase the likelihood that such river course changes will occur during floods. Detailed modeling of the downstream river channel is needed to accurately predict impacts.

b. Sediment deposition at Robles Diversion Dam may increase - This is related to impact 1. It is likely that during dam removal, there will be increased sediment deposition at Robles Diversion Dam. They presently remove sediment after every large storm and this amount may increase under the Phased Natural Transport Alternative. Further sediment modeling will determine the potential for increase in deposition.

c. Fine sediments may temporarily degrade fish habitat - There is the potential that fine sands, silts, and clays will deposit along the Ventura river causing adverse affects to the fish habitat. However, based on the current bed material size gradations little fine material can deposit for extended periods in the Ventura river due to the steep channel and the high energy of the flows. It is possible, though, that fine material will be temporarily stored at places along the river before it is transported to the ocean.

d. Turbidity may rise in the Ventura River, effecting water quality - Based on the initial toxicity testing of the sediments behind Matilija Reservoir, the sediments are not expected to contain any significant concentration of heavy

metals or contamination other than nutrients. However, because a significant portion of the material behind the dam is silts and clays, there will be an increase in turbidity downstream of the dam, particularly during low flows. Silts and clays can increase undesirable water treatment by-products and can carry biological nutrients. Robles Diversion and the City of Ventura Diversion will both be adversely impacted by the rise in turbidity. Robles Diversion feeds into Casitas Reservoir and high turbidity levels can cause algae blooms in Casitas Reservoir (Susan McMahan, personal Communication on Feb 3, 2000.). At the City of Ventura diversion, they avoid diverting flows with high sediment concentrations and it is possible that they will be able to divert much less water during dam removal unless the increases in concentration are mitigated.

A rise in fine sediment concentrations can also harm fish in the Ventura River. The fine sediment effects fish directly by reducing the food-to-sediment feeding ratio, decreasing feeding, and damaging gills. Fine sediment effects fish indirectly by preventing access to clean gravel beds needed for spawning, reducing invertebrates and other food production, reducing pool size in river, and harming egg development. Additional studies should quantify the ability of fish to survive in turbid water.

The long term effect of dam removal on the turbidity is expected to be small. Presently the sediment trap efficiency is estimated to be 35 percent, and it is diminishing with each passing year. Therefore, the total sediment loads downstream of Matilija are approaching what they would be without the dam. It is probable most of the fine material already passes through the dam and therefore, the turbidity in the river as presently measured is likely what it will be after complete dam removal and the reservoir sediments have been transported downstream. Additional modeling will quantify the expected magnitude and duration of the turbidity rise over the entire Ventura River and the specific impacts on Robles Diversion, the City of Ventura Diversion and fish.

e. A large period of time before benefits of dam removal are realized - Based on the estimates given in this report, the likely time required for complete dam removal could range from 10 to 40 years. The large range is due to the potential variability in hydrology and the uncertainty regarding downstream impacts given certain dam removal heights. However, the time required for removal could be significantly shortened by building levees along the Ventura River to control the potential impacts from flooding due to river bed aggradation. This would allow for storage of sediment in the stream bed and would allow notching to occur before all the sediment was transported to the ocean.

Gravel mining of the stream bed would also speed dam removal. This would lower the bed elevations and allow for greater deposition of reservoir sediments. Another method to speed the dam removal process is to provide sluicing from the bottom of the dam in addition to notching the top of the dam. This would maximize the river's sediment transport capability.

f. Habitat upstream of reservoir will be converted - Any alternative involving dam removal necessitates the destruction of the unique habitat created by Matilija Dam. Several species of fish and water fowl are found in Matilija Reservoir and the cost of destroying their habitat will need to be considered. Of course, new river habitat will be created in place of Matilija Reservoir.

g. Resupply of beach sand - The release of sediment downstream has potential benefits as well. Because a large portion of the sediment behind the dam is in the sand size range, there will be a resupply of beach sand at the mouth of the Ventura River. Assuming all areas of the Ventura basin have the same sediment yield, the long term increase in sand supply would be approximately 30 percent as compared to the supply of recent history. During the dam removal process, the increase in sand supply could be much greater than 30 percent because of the contribution of the sediment stored behind the dam. Bailard [7] found that there would be significant long-term benefits to using the sand behind Matilija Dam for beach nourishment.

h. Increased uncertainty of impacts - Because the Phased Natural Transport Alternative relies upon a natural system to remove the sediment, the cost is substantially less, but there is increased uncertainty during the dam removal process. For example, if the region experiences an extreme drought, the length of time required for removal could be extended a significant amount of time. Because of the increased uncertainty, the Phased Natural Transport Alternative will require adaptive management schemes with intensive monitoring.

6. Summary - Matilija Dam is located in a watershed with a high sediment yield and variable hydrology. It is also almost completely filled with sediment. Downstream of the dam, there is significant development along the Ventura River. These factors must be carefully analyzed to develop a sediment management plan for the Phased Natural Transport Alternative. This document begins to give qualitative and quantitative description to these factors.

Because significant sediment transport only takes place during relatively rare events, the dam removal process may require many years to complete. A dam removal scenario was used for cost estimating purposes, but because the link between notching height and downstream effects has not been sufficiently studied, the dam removal scenario given here is not final. Much more work should be done to performing quantitative analysis of the potential impacts resulting from the Phased Natural Transport Alternative. A suggested work plan is outlined for completion in the next phase of the project in the section entitled "Additional Investigations for Future Studies."

#### J. Project Schedule and Estimated Cost

1. Development of Construction Logic and Duration - A preliminary bar chart indicating principal construction activities, estimated durations, proposed sequence and associated schedules for each dam removal alternative are provided in Appendix C. The schedules assume initial work at the dam site to begin April 1 and proceed through December of each year.

2. Field Cost Estimate for Dam Removal - Field cost estimates prepared for this study are summarized below. Detailed estimate worksheets are provided in Appendix D.

a. Alternative 1A - Mechanical Removal of Sediment Upstream - The cost estimate for this alternative was developed based on the scheme that sediments will be excavated and delivered upstream of the dam where they will be placed and compacted in a stabilized configuration. It is anticipated that this scheme

will require intensive dewatering and unwatering at the dam to allow for access of excavation equipment in a loading operation. Dewatering wells will be installed and pumped as necessary to draw water down to acceptable levels to allow excavation of the sediments by a tracked hydraulic excavator. It was assumed that these sediments would be loaded at a rate of approximately 750 Loose Cubic Yard (LCY - to account for swell in quantity due to handling) per hour requiring a fleet of 6 trucks in cycle delivering sediments to the stabilized fill. For this estimate, 6 wheel articulated trucks with a 20 CY capacity were assumed due to uncertainties of wet conditions, slopes, and primitive haul routes for this option. An average haul distance of 0.5 miles was used in the study for delivery of these sediments resulting in a truck cycle time of approximately 10 minutes. From this, it was assumed that each truck could achieve approximately 6 trips per hour.

The sediments would be dumped at the slope at a rate of 750 LCY per hour and placed and graded by use of track dozer and grader for final shaping. It is assumed that this material will be compacted by use of a vibratory smooth drum roller with a water tanker applying water for a suitable compactive effort. It was assumed that water could be obtained from reservoir, ponds, or dewatering wells as appropriate. A grade checker will be used for compliance to proper grades as designed.

As the excavated sediments surface begins to lower at the dam, this will allow access to the dam for preparation of concrete dam demolition. The dam will need to be demolished at approximately the same rate as the sediments are lowered. For this cost estimate, dam demolition was assumed to be performed by a drill and blast operation. Once sediment has been lowered at the dam exposing approximately 20 feet of the dam, the drilling operation will be implemented (as assumed in the cost estimate) preparing both vertical blast holes from the top of the dam and horizontal blast holes from the upstream face of the dam. For this estimate, drill holes were assumed to be placed on approximately a 3 foot drill hole pattern vertically and a 3 foot pattern horizontally between lift lines. This assumption was made to ensure the blasted product would result in minus 2 foot concrete debris (a requirement at the concrete recycler for acceptance). We believe the drill hole pattern to be conservative resulting in a conservative unit price for concrete dam demolition. As this Project study evolves and more detailed information is provided, this assumption will be evaluated and the drill hole pattern may be adjusted. It was assumed that the holes would be loaded with 0.5 lbs of explosive per linear foot (lf) of hole with an average assumption that we would use 1 delay and 1 blasting cap per hole and 20 lf of primacord per hole.

Once the drill holes have been blasted, it is assumed that the debris would be blast deposited on the upstream work area where a small portion will be further broken down with the use of a hoe-ram to meet the 2 foot maximum size requirement by the recycler. Any residual steel will be removed from the concrete and will be disposed of separately. The concrete debris was assumed to be loaded by a large front end loader at a rate of 200 LCY per hour requiring a fleet of 15 on-highway trucks with 20 CY capacity. An average haul distance of 31.8 miles was used in the study for delivery of this concrete debris to a recycler resulting in a truck cycle time of approximately 90 minutes. From this, it was assumed that each truck could achieve approximately 0.667 trips per hour.

Completing this option are stabilization of sediments with geogrid soil reinforcement, gabions, and topsoil with seeding for the top cover of the stabilized fill. Only locally native stock or sterile annual grasses will be used for re-vegetation.

This option is assumed to result in a two (2) season Project consisting of nine (9) month seasons allowing for winter rains.

b. Alternative 1B - Mechanical Removal of Sediment Downstream - The cost estimate for this alternative was developed based on the scheme that sediments will be excavated and delivered downstream of the dam where they will be stockpiled in a stabilized configuration. It is anticipated that this scheme will require intensive dewatering and unwatering at the dam to allow for access of excavation equipment in a loading operation. Dewatering wells will be installed and pumped as necessary to draw water down to acceptable levels to allow excavation of the sediment by a tracked hydraulic excavator. On-highway trucks with a 20 CY capacity were assumed for this option. It was assumed that each truck could achieve approximately 5 trips per day. Assuming a 6-day work week, the project could be completed in four 9-month construction seasons. Of special note, this particular option will result in approximately 330,000 truck trips to move the sediment to a temporary stockpile downstream which will directly impact the haul roads (which have been estimated for repair), local traffic, and residents. Project completion in four years is considered possible, however, the amount of truck traffic (approximately 325 trips per day) is ambitious. Extending the Project duration to 5 years would reduce the trips per day to approximately 280 and reduce traffic concerns. This would increase the cost slightly. The cost would remain within the range of uncertainty for this level of estimate. Further study is required to determine the allowable hauling rate.

The sediments would be dumped at the downstream stockpile, placed and graded by use of track dozer and grader for final shaping. It is assumed that this material will be compacted by use of a vibratory smooth drum roller with a water tanker applying water for a suitable compactive effort. It was assumed that water could be obtained. A grade checker will be used for compliance to proper grades as designed. Final drainage and erosion measures will be required on and around the temporary stockpile in this option. Stabilization of this magnitude is assumed necessary due to the unknown duration the temporary stockpile will be in place. This level of stabilization will be adequate for multi-year durations if required.

As the excavated sediments surface begins to lower at the dam, this will allow access to the dam for preparation of concrete dam demolition. The dam will need to be demolished at approximately the same rate as the sediments are lowered. For this cost estimate, dam demolition was assumed to be performed by a drill and blast operation. Once sediment has been lowered at the dam exposing approximately 20 feet of the dam, the drilling operation will be implemented (as assumed in the cost estimate) preparing both vertical blast holes from the top of the dam and horizontal blast holes from the upstream face of the dam. For this estimate, drill holes were assumed to be placed on approximately a 3 foot drill hole pattern vertically and a 3 foot pattern horizontally between lift lines. This assumption was made to ensure the blasted product would result in minus 2 foot concrete debris (a requirement at the

concrete recycler for acceptance). It was assumed that the holes would be loaded with 0.5 lbs of explosive per lf of hole with an average assumption that we would use 1 delay and 1 blasting cap per hole and 20 lf of primacord per hole.

Once the holes have been blasted, it is assumed that the debris would be blast deposited on the upstream work area where a small portion will be further broken down with the use of a hoe-ram to meet the 2 foot maximum size requirement by the recycler. Any residual steel in the concrete will be removed and disposed of separately. The concrete debris was assumed to be loaded by a large front end loader at a rate of 200 LCY per hour requiring a fleet of 15 on-highway trucks with 20 CY capacity. An average haul distance of 31.8 miles was used in the study for delivery of this concrete debris to a recycler resulting in a truck cycle time of approximately 90 minutes. From this, it was assumed that each truck could achieve approximately 0.667 trips per hour.

This option will result in damage to haul roads downstream of the dam. For that reason, this estimate includes repair of approximately 12 miles of haul road to include excavation of existing surfacing materials, placement of new sub-base, and placement of 4-inch thick asphaltic concrete mat.

This option is assumed to result in a four (4) season project consisting of four (4) nine (9) month seasons. As previously stated haul rates may dictate the final durations and five (5) seasons may be required. Nine (9) month seasons were assumed to allow for winter rains.

c. Alternative 2 - Phased Natural Transport of Sediment - This option is essentially the same as Alternatives 1A and 1B as it relates to the method of concrete dam demolition except for the multiple construction season. Multiple construction seasons separated by several years will result in additional cost for mobilization and demobilization of equipment for each removal phase. Refer to previous notes for cost estimate assumptions for those activities. Inflation will result in higher costs in the future, however, for comparison purposes cost are given in present day worth. Sediments will be carried downstream naturally.

d. Initial Removal of the Dam to Elevation 1095.0 - This option is essentially the same as Alternatives 1A and 1B as it relates to concrete dam demolition. The only difference is that demolition will be to a set elevation on the dam (El. 1095). Refer to previous notes for cost estimate assumptions for concrete demolition activities.

3. Design and Construction Management - For the appraisal-level estimates and for comparison purposes, non-contract costs are assumed. These costs include an additional allowance of 5 to 15 percent of the total field costs for construction management. Percentages of field cost used for construction management are, 10 percent for alternative 1A, 5 percent for alternative 1B, 5 percent for alternative 1BB, and 15 percent for alternative 2. The construction management cost were selected based on the complexity and durations of each alternative. Design costs are also included in the non-contract costs. The design costs for a project are normally given as a constant percentage of the field costs. Using the same percentage of field costs for design cost estimates would result in an extremely large design cost for alternative 1B. In actuality the design cost for this alternative 1B would likely be approximately the same as for alternative 1A. To ensure that the design costs do not skew the comparison between these two alternatives a design cost estimate of 2

percent of the field cost of alternative 1A will be used for both alternatives 1A and 1B. The design cost for alternative 1BB will be higher than that of alternative 1B due to the complexity of the alternative. A design cost of 2 percent of the field cost will be used for alternative 1BB. The design costs for alternative 2 will be less than the others, but will be a larger percentage of the field costs. An estimate of 7.5 percent of the field cost will be used for alternative 2.

Other non-contract costs that will affect the total Project costs include air quality and wetlands mitigation. For the appraisal-level estimates an additional 2 percent of the field cost for air quality mitigation and \$70,000 per acre for wetland mitigation are assumed for all alternatives. The cost for wetlands mitigation can vary depending on how and where it is accomplished. The value used above was provided as an average for wetlands mitigation in the area. An estimate of 20 acres of wetlands is assumed resulting in a wetlands mitigation cost of \$1,400,000. The cost of buying the 9-acre parcel of land directly downstream of the dam will be included. It is assumed this purchase could be negotiated for \$700,000. This purchase price is solely based on property tax assessment, see Appendix A, Area of Matilija Dam and Property Proposed for Purchase. Determining the actual purchase price of this property is beyond the scope of this investigation.

Removal of Matilija Dam will have impacts on the sediment accumulation at Robles Diversion Dam located just downstream of Matilija Dam. The stilling basin upstream of Robles Diversion Dam is currently cleaned of sediment approximately every 5 years. With the removal of Matilija Dam this cycle will increase. To prevent the need for continual cleaning of the stilling basin, a facility to transport sediment through the structure was developed by Borcalli and Associates on behalf of the CMWD (see Appendix F for details). This structure will allow sediment to be flushed through Robles Diversion Dam during large flows reducing the need to clean the stilling basin. Removal of Matilija Dam and future operation of the proposed sediment transport structure at Robles Diversion Dam has raised concerns about future bank erosion in the downstream channel. Borcalli and Associates recommended a cost be added to the project to provide bank protection. An estimated cost was furnished with the cost estimate for the sediment transport structure. The estimated cost for the sediment transport structure and bank protection are \$1,649,500 and \$400,000. These costs will be added to the total Project costs to mitigate the impacts of the removal of Matilija Dam on Robles Diversion Dam.

Table 12. Total cost estimates for removal of Matilija Dam

Alternative	Field Cost	Non-Contract Cost	Total Project Cost
1A - Mechanical Removal of Sediment Upstream	\$57,000,000	\$12,200,000	\$69,200,000
1B - Mechanical Removal of Sediment Downstream	\$130,000,000	\$14,400,000	\$144,400,000
1BB - Mechanical Removal of Sediment Downstream by Slurry Pipeline - USACE	\$160,700,000	\$18,700,000	\$179,400,000
2 - Phase Natural Transport of Sediment	\$14,000,000	\$7,600,000	\$21,600,000

An additional cost estimate was completed for the possible initial removal of the dam to elevation 1095.0. This estimate resulted in a field cost of \$2,600,000. If this initial phase is accomplished under a separate contract then this cost should be subtracted from the costs given in table 12.

#### K. Project Benefits

Several benefits arise from the removal of Matilija Dam. Removal will eliminate existing public health concerns and future dam safety issues at the dam site. Matilija Dam has experienced deterioration due to alkali aggregate reaction since its construction.

Historically, the Ventura River supported a substantial steelhead run. Currently, the population of anadromous steelhead in the Ventura River is greatly reduced and may be below 200 fish. Removal of Matilija Dam will open sections of the mid to upper Matilija Creek thought to have been prime spawning habitat for the steelhead and may represent over half of the historically used habitat. Providing additional spawning habitat is the first step in restoring steelhead in the area. In addition to the potential restoration of steelhead runs to the Ventura River, removal of the dam will improve the aquatic and terrestrial habitat benefiting additional fish and wildlife species. Dam removal will also remove the current sediment trap at the dam allowing sediment to move naturally down the Ventura River to provide much needed material for beach replenishment. Removal of the dam will increase public access to the area which will increase recreational and outdoor education opportunities.

#### L. Conclusions

Removal of Matilija Dam is technically feasible, and would require an average duration of 2 to 25 years to accomplish in the field, for a total Project cost of between \$21,600,000 and \$179,400,000 (including contingencies and non-contract cost) depending on the chosen final removal alternative. Appraisal-level cost estimates are provided in Appendix D for alternatives 1A, 1B, and 2. Appraisal-level cost estimates are provided in Appendix G for alternative 1BB. Appraisal-level construction schedules are provided in Appendix C for alternatives 1A, 1B, and 2. Table 13 provides a comparison of the four dam removal alternatives.

A single alternative cannot be recommended at this time due to various unknowns associated with each alternative. The unknowns do not affect the technical feasibility of the individual alternatives, however, they do affect the overall desirability of the alternative to fulfill the stated Project objective.

Because of the multiple constraints on the Project and the potential for the various impacts, it is likely that a combination of alternatives will provide the best overall removal option. During the next phase of analysis to be completed by the Technical Task Force Committee, the Project should be viewed as an optimization Project in which the dam is removed in such a way as to maximum the net benefits (gross benefits less costs). For example, environmental considerations such as degradation of fish habitat, increased turbidity levels, air quality concerns, or final condition/designation of the area upstream of Matilija Dam could be incorporated into the Project as cost functions or as constraints. Benefits such as recreational and outdoor learning opportunities could also be incorporated into the Project as a cost function. It is realized that certain costs and benefits, especially related to social aspects, are difficult to express mathematically, but can still be incorporated during the development of the Project.



Table 13. Comparison of removal alternatives.

Alternative	Total Project Cost (Million \$)	Risk of Flood Damage	Traffic Impacts	Air Quality Impacts	Completion Time (years)	Supply Existing Sediment to Beach
1A	69.2	low	low	low	2	low
1B	144.4	low	high	high	4-5	low to high**
1BB	179.4	low	moderate	moderate	4*	moderate
2	21.6	high	low	low	25	high

\* Alternative assumes 31,000 acre-feet of water is available for sluicing fine grain sediment to the ocean to meet this schedule.

\*\* The final disposal site will dictate the amount of existing sediment available to the beach. The final disposal site has not been determined

#### M. Additional Investigations for Future Studies

Additional studies are necessary to refine and quantify impacts and to choose the optimal removal scenario. As a first step in developing an optimal dam removal scheme, the potential impacts listed before need to be quantified in terms of the various dam decommissioning scenarios. To provide sufficient information to quantify the impacts additional data is necessary. At a minimum, the following data should be collected in the next phase of the study:

- ◆ Current upstream and downstream of dam cross section surveys (either aerial or GPS)
- ◆ Complete aerial survey of the entire upstream and downstream reservoir areas including the reservoir rim and prepare topography for the area. The extent of the survey will need to be developed.
- ◆ Bed material upstream of Matilija Reservoir and downstream of dam to the ocean
- ◆ Samples taken in the reservoir rim and analyzed for physical properties
- ◆ Samples taken from the dam and analyzed for physical properties
- ◆ Stream gage and sediment load inflow record upstream of Matilija Dam
- ◆ Sediment load sampling in the Ventura River
- ◆ Sediment samples should be taken throughout the entire depth of the trapped sediment and analyzed for physical and chemical properties

- ◆ Continued water quality monitoring in Matilija Creek and Ventura River
- ◆ Complete inventory of people, businesses and structures affected by sediment release from Matilija Dam
- ◆ Long- term and short-term impacts of high sediment loads on fish and fish habitat
- ◆ Controlled sediment release. Before final scheduling of the dam removal, it would be beneficial to perform a small notching and closely monitor the resulting sediment release to provide valuable information to optimize the dam removal schedule
- ◆ Obtaining photos of the Matilija Reservoir area prior to construction of Matilija Dam to assist with restoration efforts at Matilija Reservoir if the dam was to be removed
- ◆ Fauna surveys in the Matilija Dam and Matilija Reservoir area, particularly for amphibians, reptiles, and birds. A need exists to determine if any species of special concerns are present in the study area
- ◆ Data regarding California red-legged frog (*Rana aurora draytonii*) presence in the study area and vicinity. A need exists to determine if this species is present in the study area
- ◆ Data on the age class structure of steelhead/rainbow trout found in the Ventura River mainstem
- ◆ Sampling of benthic invertebrates in Matilija Creek and the Ventura River.
- ◆ Beach profiles between Emma Wood State Park and Ventura Harbor.

Using the data collected above the following analyses should be performed:

- ◆ Estimate sediment transport capacity of the river channel all the way to the ocean. The sediment equations that are used to predict the sediment transport capacity of the river channel downstream need to be validated and revised if necessary. Sediment load measurements upstream and downstream of Matilija Dam can be used for this purpose. As part of this study, it is necessary to accurately determine the source and magnitude of the sediment supply for each grain size.
- ◆ Do further study and research into highly concentrated sediment flows to ascertain likelihood of hyper-concentrated flow effects
- ◆ Analyze effects of short term and long term rises in sediment load on fish and fish habitat
- ◆ Develop or choose a model to predict erosion within the reservoir region. The model should simulate channel formation and change in addition to sediment and hydraulic routing. Current 1-D models may prove insufficient for this purpose

- ◆ Develop or choose a model to route sediment downstream of dam. Conventional 1-D models may be sufficient for this purpose, but it may be necessary to develop or choose a 2-D sediment model if localized sediment problems are anticipated.
- ◆ Using the data collected during the controlled sediment release test, calibrate the numerical model to reproduce the data.
- ◆ Simulate various dam removal scenarios to develop relations between the notching scenario and downstream impacts listed in section entitled Potential Impacts of Phased Natural Transport Alternative. Many different options may be investigated at this step including combinations of alternatives, or options not yet considered.
- ◆ Incorporate knowledge of the relations between notching scenarios and downstream impacts into an optimization framework. Use the optimization framework to develop the dam removal scenario that maximizes benefits.
- ◆ An assessment of the value of this proposed restoration effort to the recovery of the steelhead run in the Ventura River watershed.
- ◆ An assessment of location where sediment can be directly deposited into the ocean.
- ◆ An assessment of locations where sediment can be temporarily stored and the likelihood that the sediment would be processed in the future.
- ◆ An assessment of locations on beneficial permanent storage downstream of the dam.
- ◆ Perform before and after hydrologic modeling of the Ventura River from its mouth to the Matilija dam site.
- ◆ An assessment of the impacts of storing/stabilizing the sediment upstream of the dam and the impacts to possible future designation as a Wilderness Area or a Wild and Scenic River.
- ◆ An assessment of the impacts of using the concrete excavated from the dam as slope stabilization upstream of the reservoir.
- ◆ An assessment of the impacts of increased heavy truck traffic on public roads along haul routes and in the immediate reservoir area.
- ◆ An assessment of the location, type, and quantity of any hazardous material that may be in the reservoir area.
- ◆ An assessment of potential future uses of the nine acre historical site and the reservoir area.

- ◆ An assessment of the impacts of the dam removal on water quality in the Ventura River at the Ventura City diversion structure located at Foster Memorial Park.
- ◆ Perform a model study to estimate shoreline changes between Emma Wood State Park and the Ventura Harbor to estimate changes that will occur as result of removing Matilija Dam.

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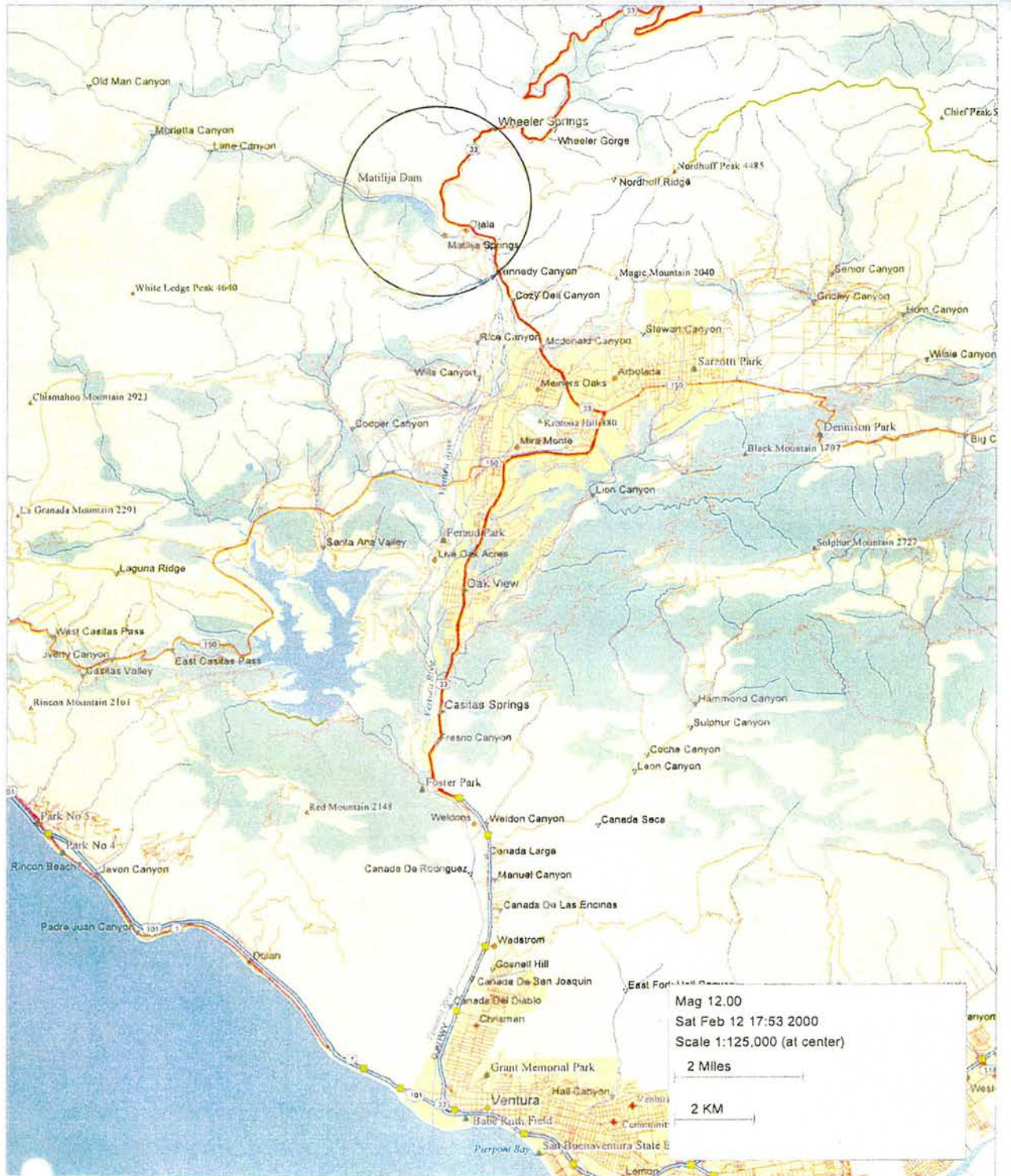
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## **Appendix A - Project Drawings**

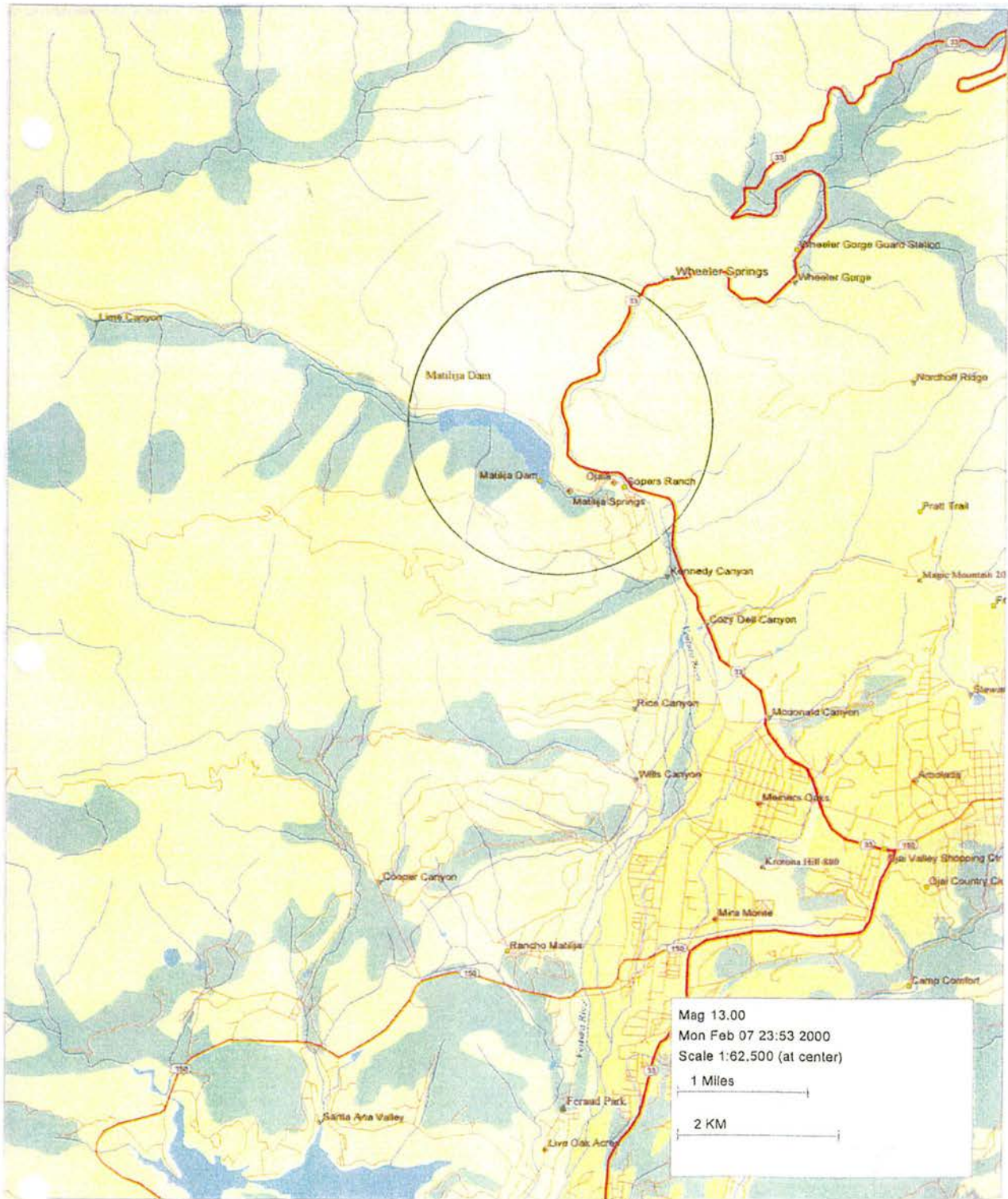
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2. Vicinity Map Matilija Dam
3. Matilija Dam / Reservoir - Major Land Holdings
4. Matilija Dam & Reservoir
5. Area of Matilija Dam and Property Proposed for Purchase
6. Haul Routs
7. Plan - Original Matilija Reservoir
8. Upstream Elevation of Original Dam
9. Plan Original Matilija Dam
10. Typical Sections Original Matilija Dam
11. Elevation After First Notching Activity
12. Downstream Elevation of Existing Dam
13. Ventura County - Monthly Rainfall for January, 1995





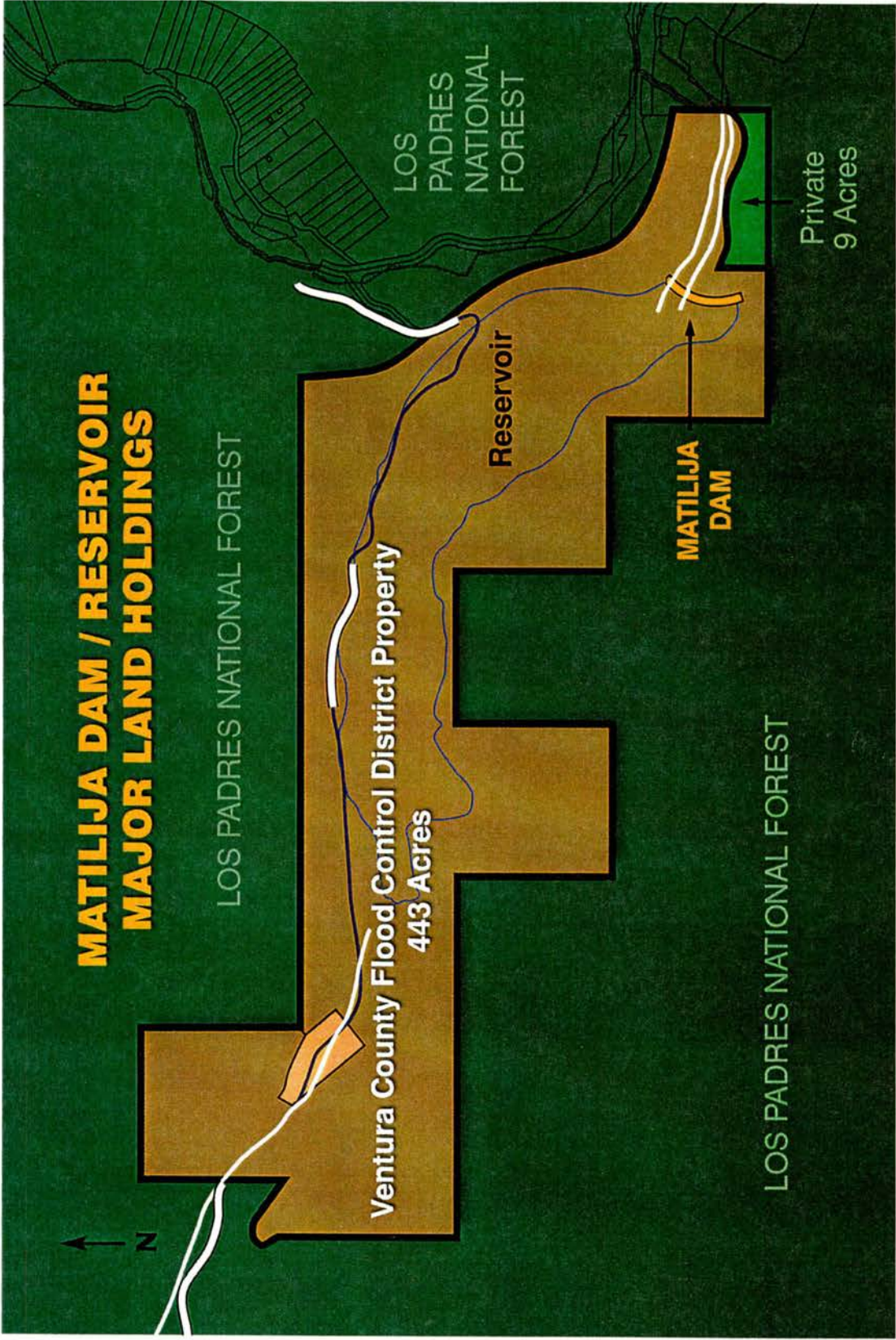


**LOCATION MAP MATILIJA DAM**



**VICINITY MAP MATILIJDA DAM**

**MATILIJA DAM / RESERVOIR  
MAJOR LAND HOLDINGS**



LOS PADRES NATIONAL FOREST

Ventura County Flood Control District Property  
443 Acres

Reservoir

MATILIJA  
DAM

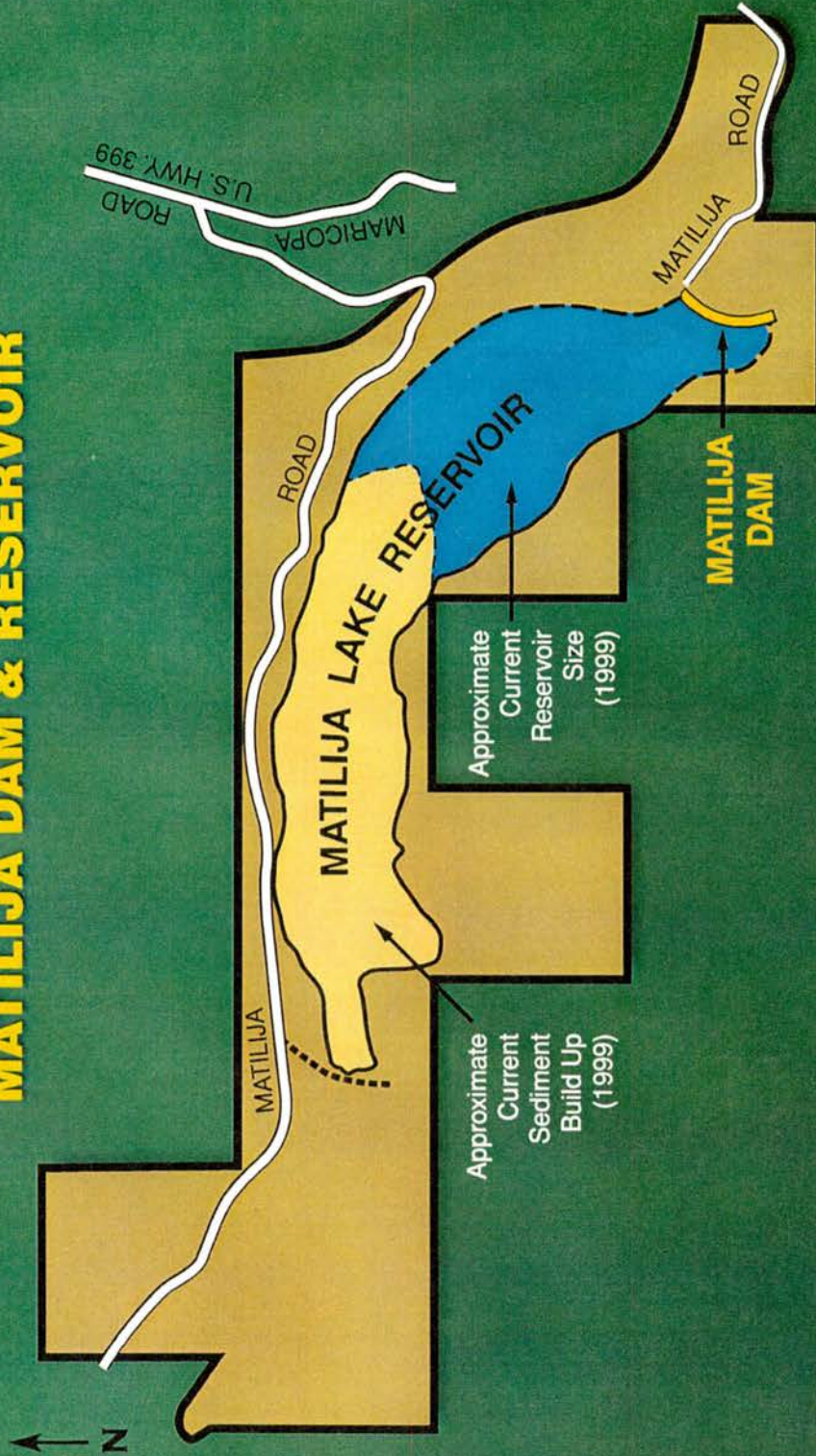
LOS PADRES NATIONAL FOREST

Private  
9 Acres

LOS  
PADRES  
NATIONAL  
FOREST



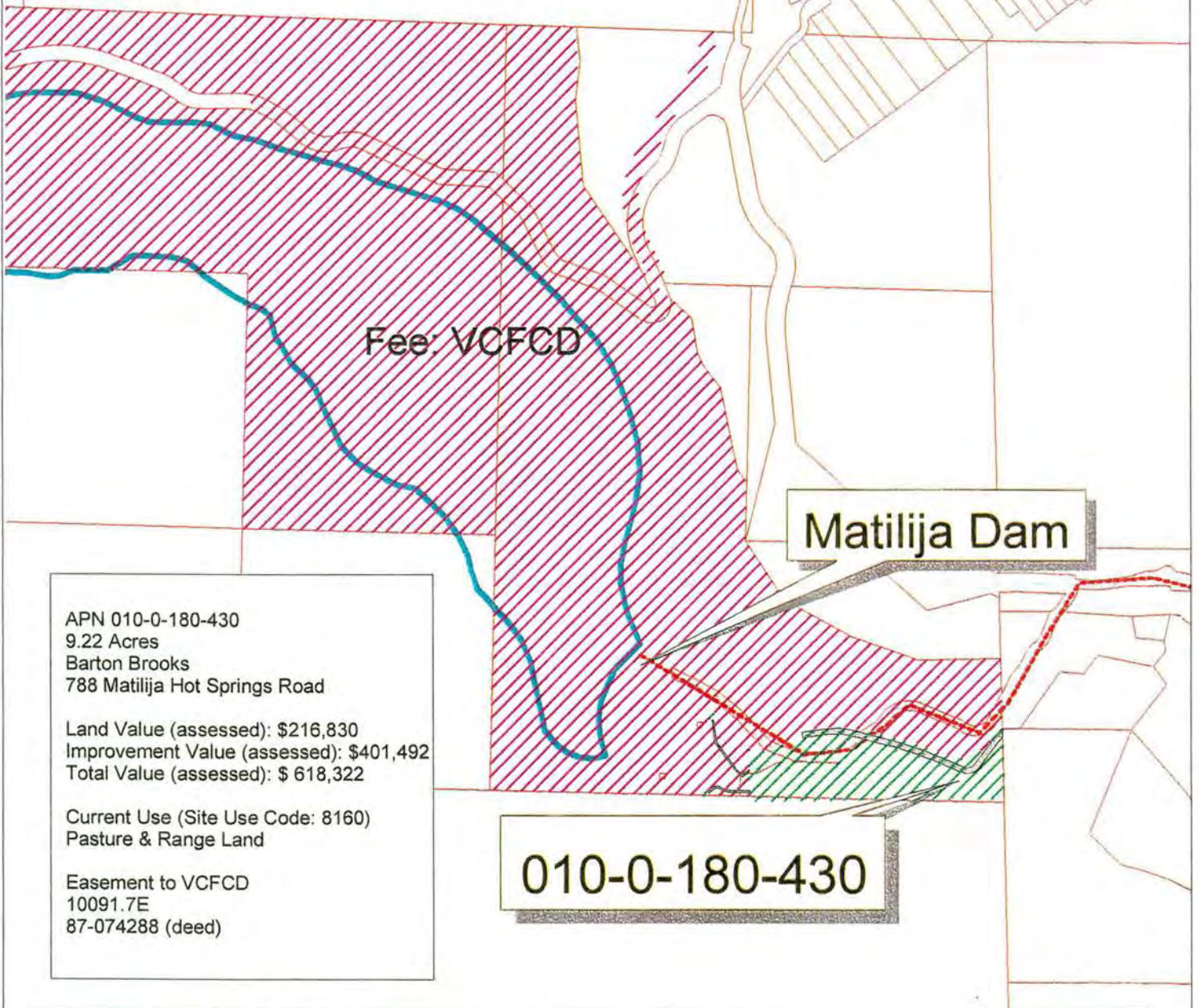
# MATILIJA DAM & RESERVOIR





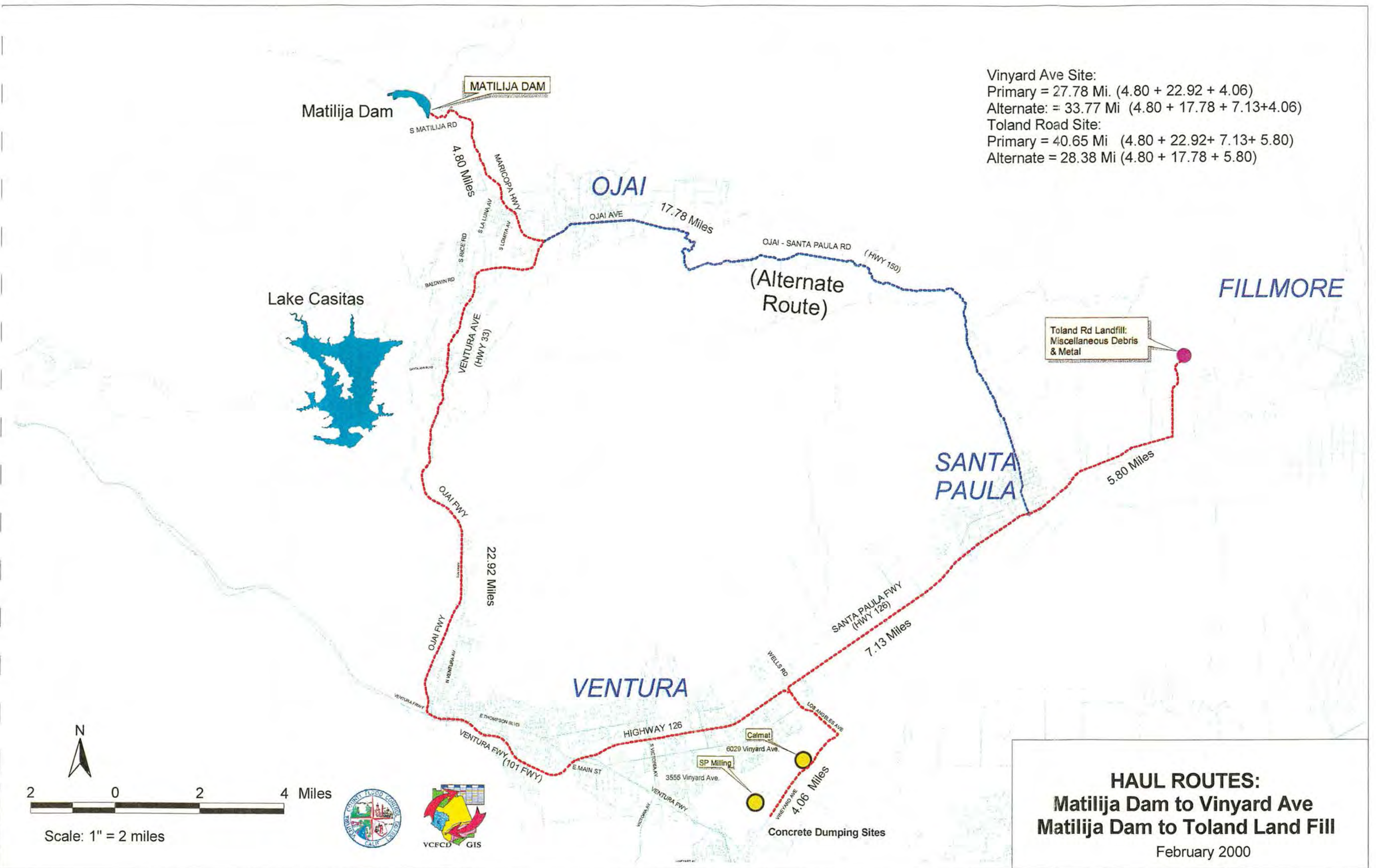
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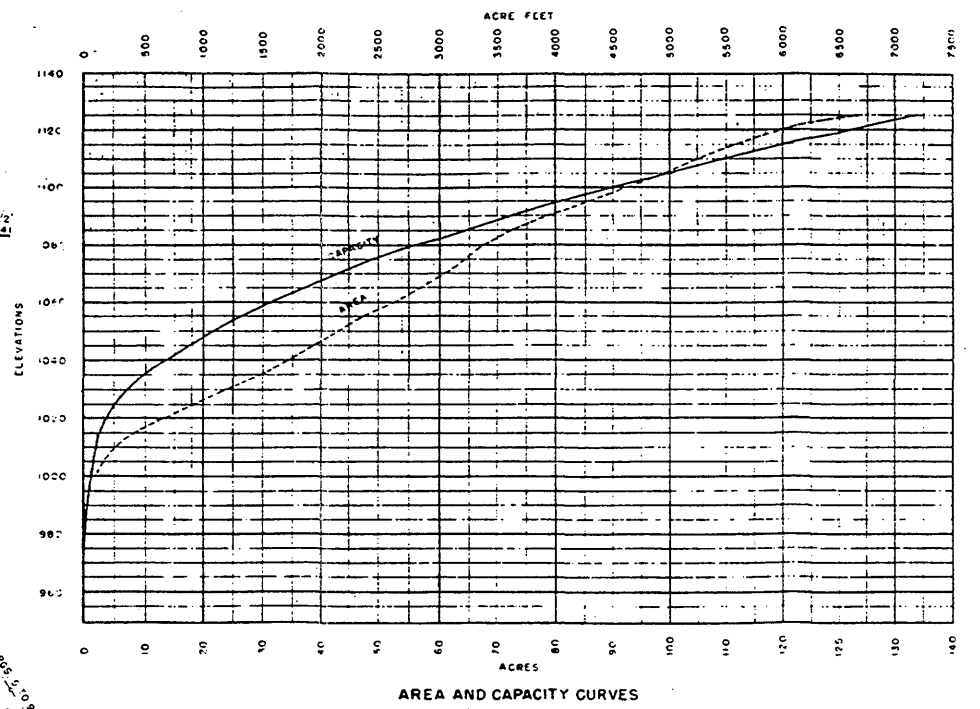
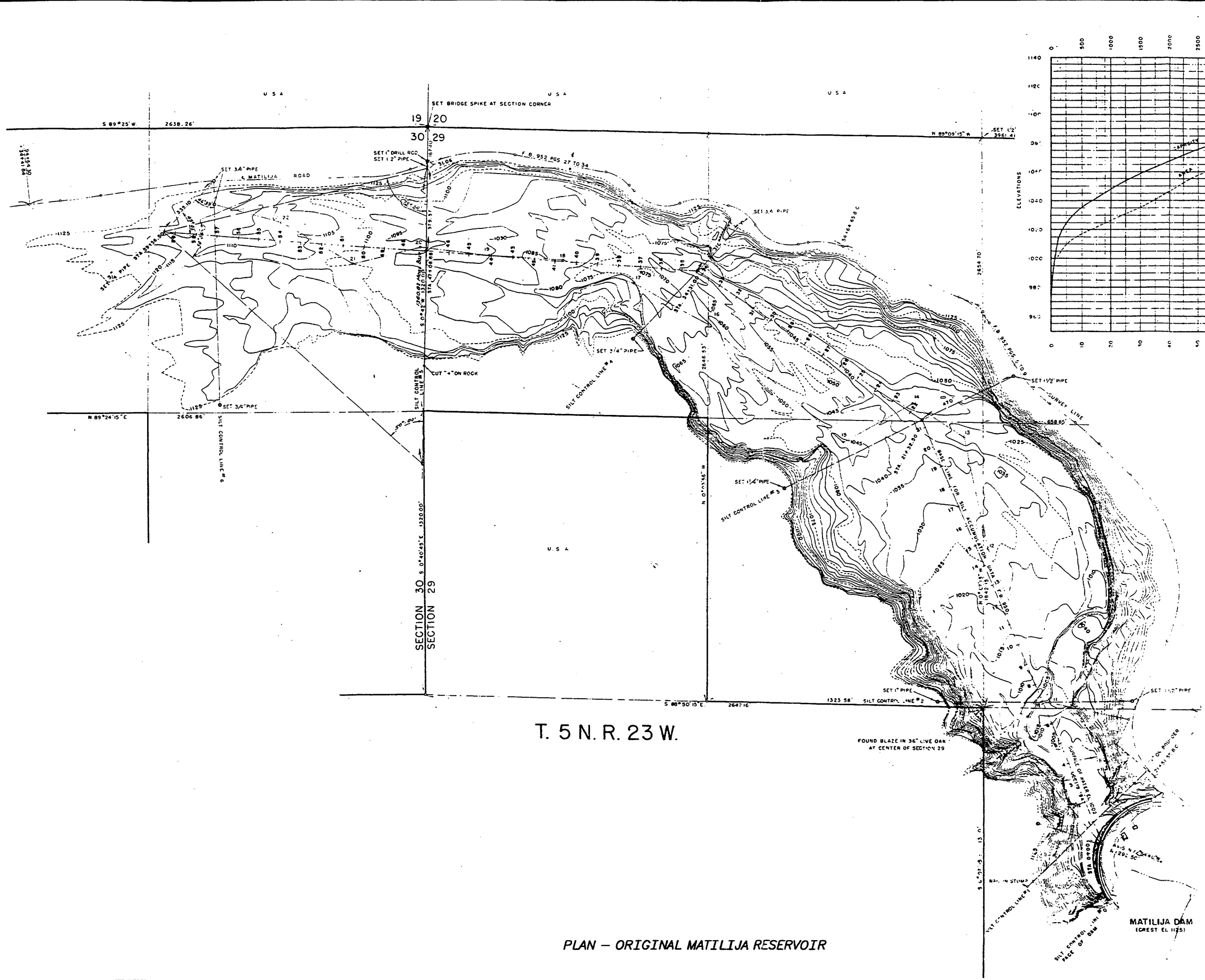
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**Area of Matilija Dam &  
Property Proposed for Purchase**


Ventura County  
Flood Control District  
February 2000





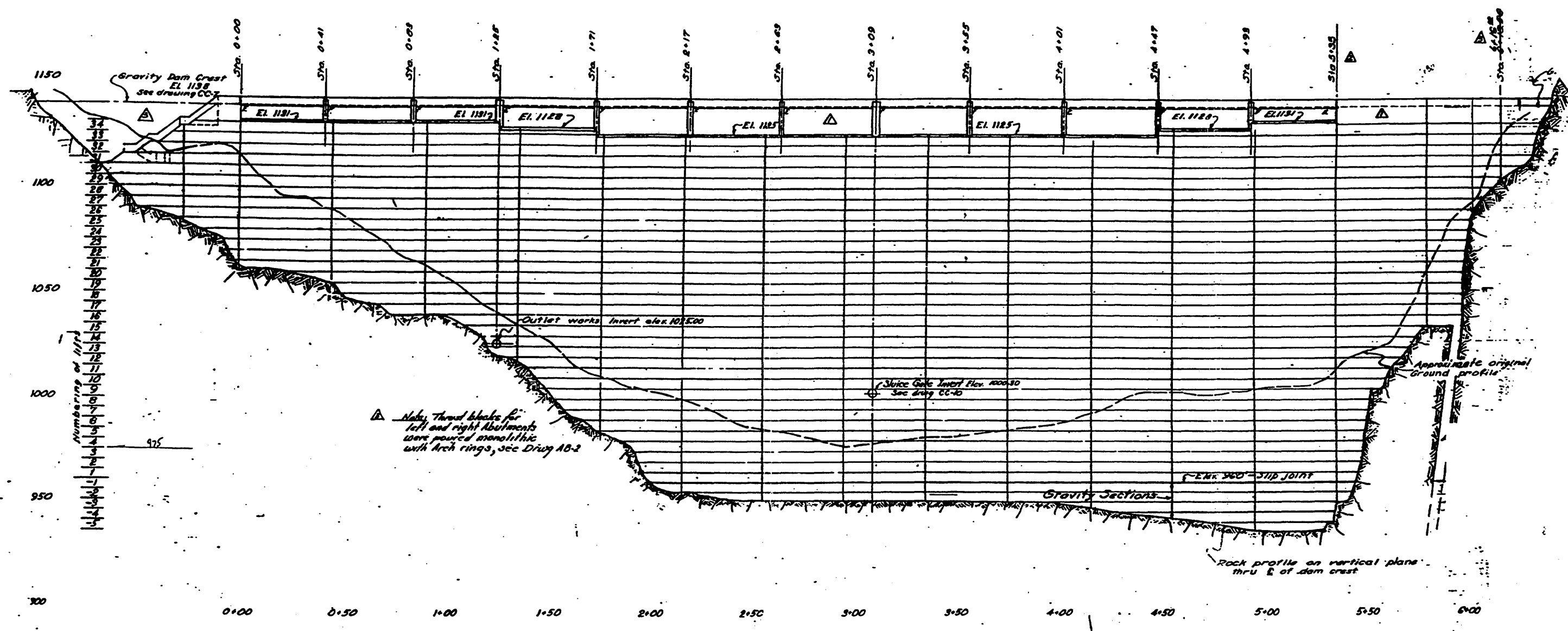
T. 5 N. R. 23 W.

PLAN - ORIGINAL MATILIJA RESERVOIR

 **ALWAYS THINK SAFETY**  
 UNITED STATES  
 DEPARTMENT OF THE INTERIOR  
 BUREAU OF RECLAMATION  
 VENTURA COUNTY  
 CALIFORNIA  
**MATILIJA DAM REMOVAL**

CADD SYSTEM AutoCAD	CADD FILENAME Unknown	DATE AND TIME PLOTTED Not Plotted
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D  
 C  
 B  
 A  
 USER



UPSTREAM ELEVATION OF ORIGINAL DAM  
(LOOKING DOWNSTREAM)

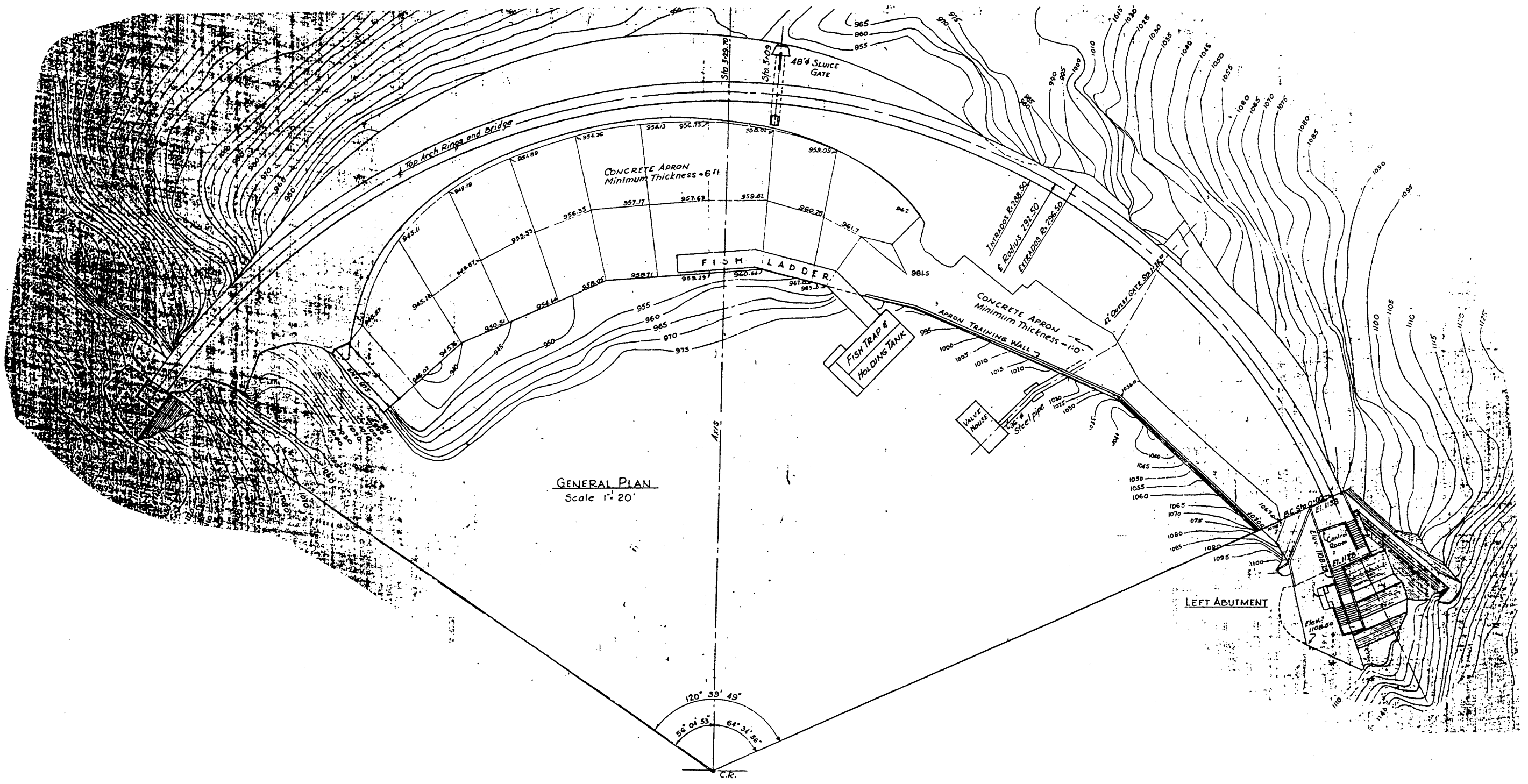
⊕ ALWAYS THINK SAFETY

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF RECLAMATION  
VENTURA COUNTY  
CALIFORNIA

**MATILIJA DAM REMOVAL  
ELEVATION**


GRID SYSTEM 1117	GRID NUMBER 1117	DATE AND TIME PLOTTED Not Plotted
DESIGNED C. L. HARRIS	CHECKED HARRIS	





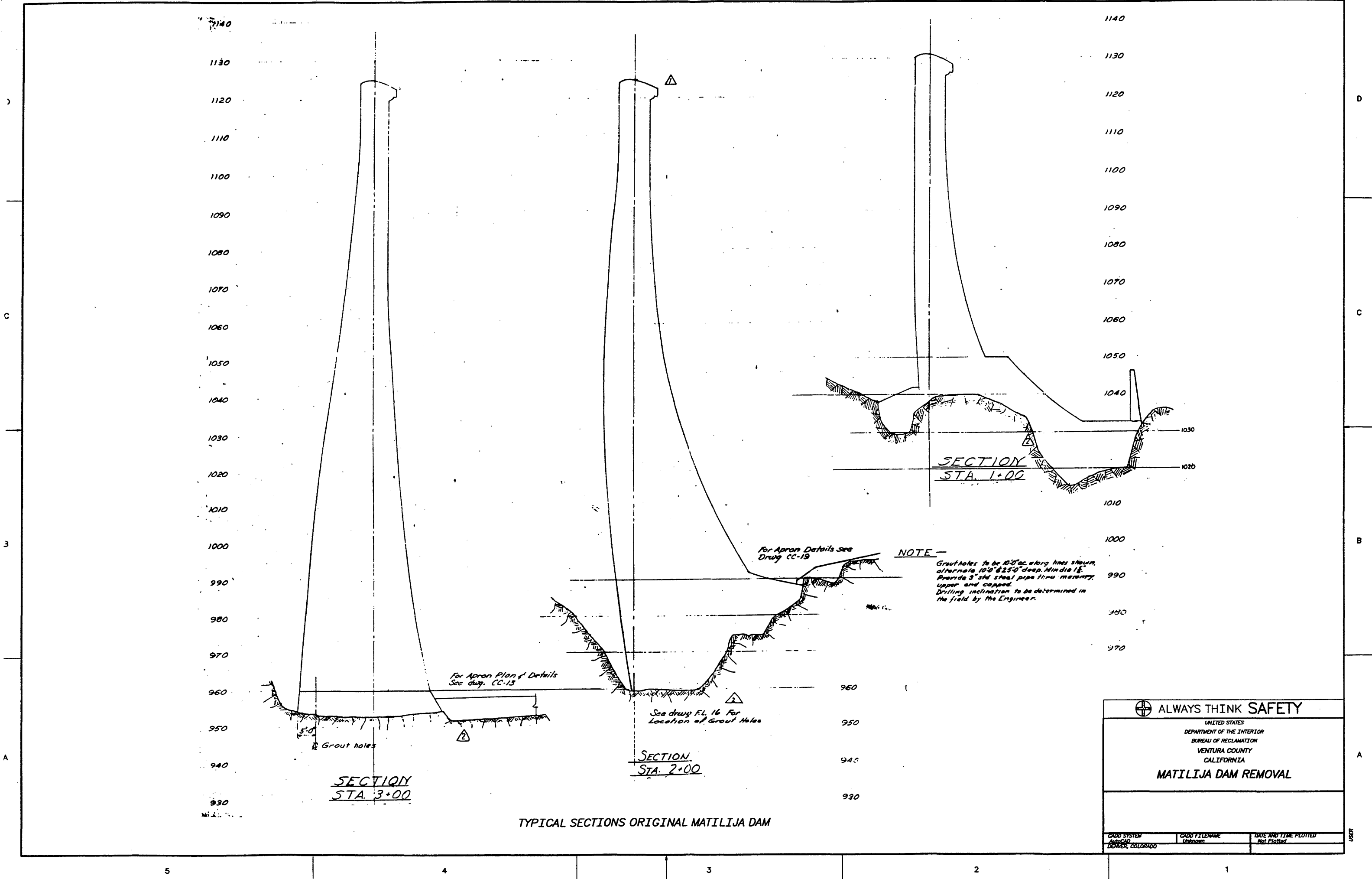
GENERAL PLAN  
Scale 1" = 20'

PLAN - ORIGINAL MATILIJA DAM

 <b>ALWAYS THINK SAFETY</b>		
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION VENTURA COUNTY CALIFORNIA		
<b>MATILIJA DAM REMOVAL</b>		
CAD SYSTEM AutoCAD DENVER, COLORADO	CAD FILENAME Unknow	DATE AND TIME PLOTTED Not Plotted


D  
C  
B  
A

D  
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B  
A



TYPICAL SECTIONS ORIGINAL MATILIJA DAM

**NOTE -**  
 Grout holes to be 10' x 10' along lines shown, alternate 10' x 25' deep. Min dia 1 1/2". Provide 3" std steel pipe thru masonry, upper and capped. Drilling inclination to be determined in the field by the Engineer.

 <b>ALWAYS THINK SAFETY</b>		
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION VENTURA COUNTY CALIFORNIA		
<b>MATILIJA DAM REMOVAL</b>		
CAD SYSTEM AutoCAD DENVER, COLORADO	CAD FILE NAME Unknown	DATE AND TIME PLOTTED Not Plotted

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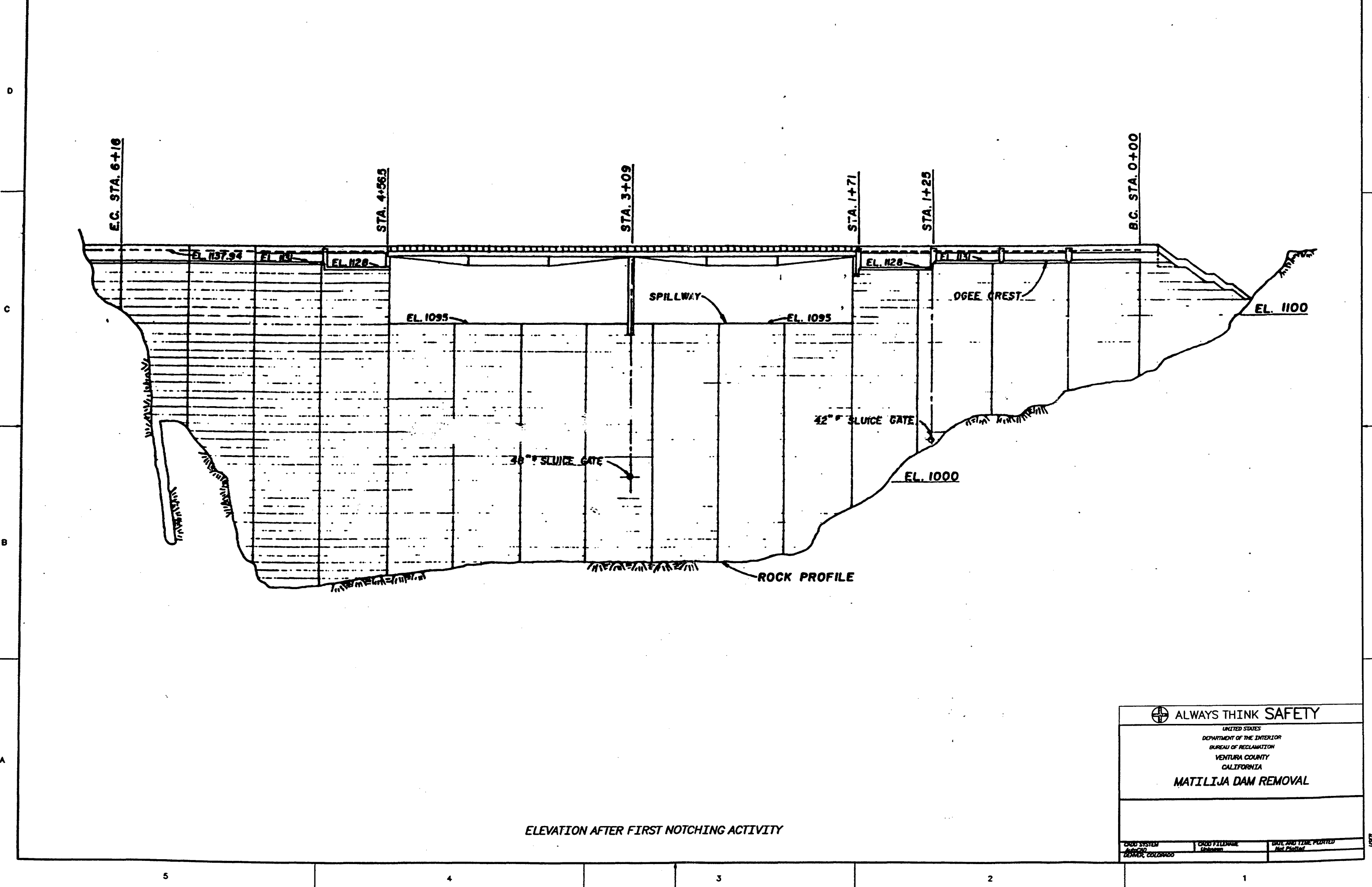
D

C


B

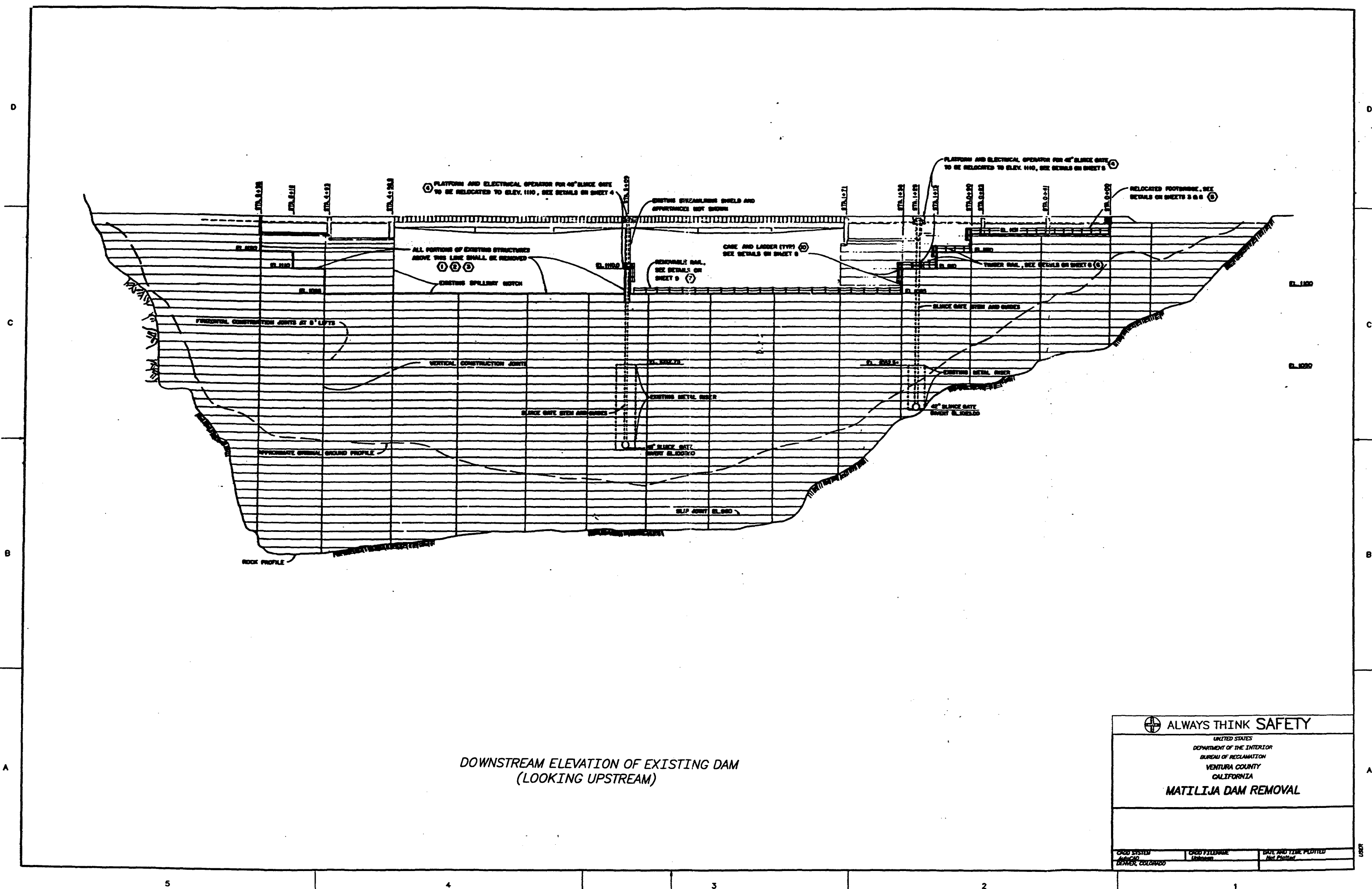
A

USER



ELEVATION AFTER FIRST NOTCHING ACTIVITY

 <b>ALWAYS THINK SAFETY</b>		
<small>UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION VENTURA COUNTY CALIFORNIA</small>		
<b>MATILIJA DAM REMOVAL</b>		
<small>GRID SYSTEM NAD 83 UTM ZONE 10Q</small>	<small>GRID ELEVATION Feet Meters</small>	<small>DATE AND TIME PLOTTED Not Plotted</small>

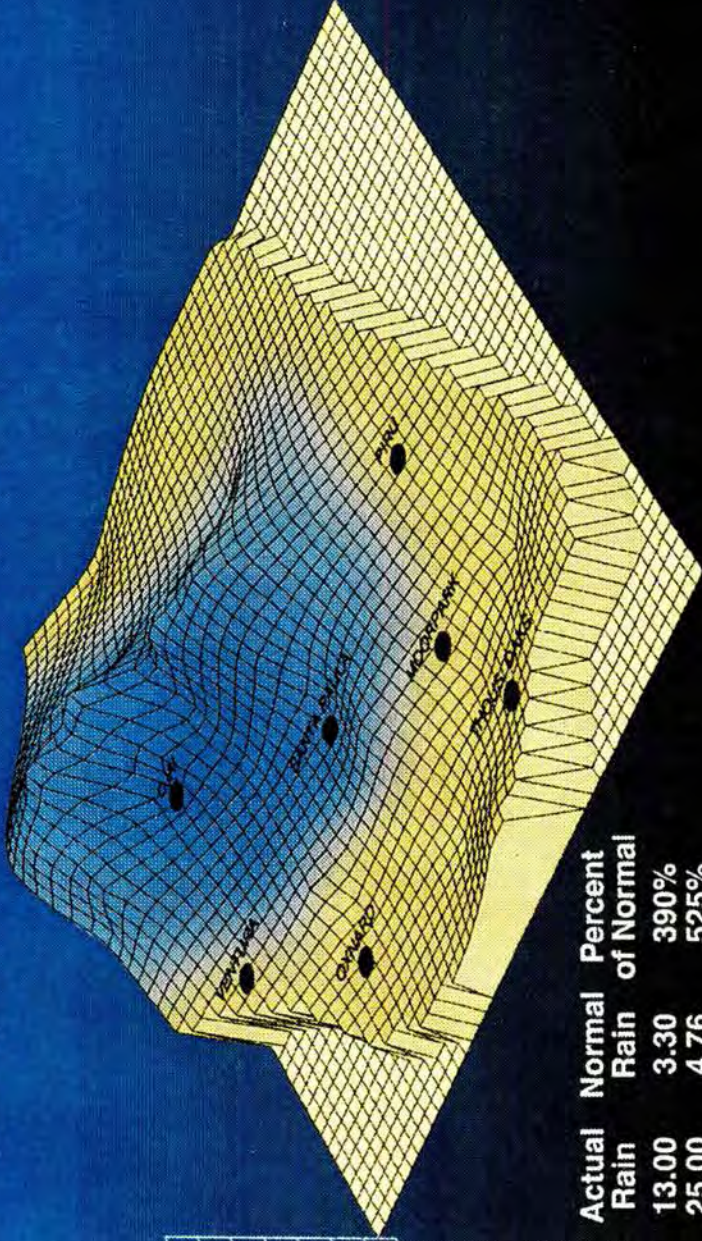


DOWNSTREAM ELEVATION OF EXISTING DAM  
(LOOKING UPSTREAM)

ALWAYS THINK SAFETY  
 UNITED STATES  
 DEPARTMENT OF THE INTERIOR  
 BUREAU OF RECLAMATION  
 VENTURA COUNTY  
 CALIFORNIA  
**MATILJA DAM REMOVAL**

GRID SYSTEM NAD 83	GRID SYSTEM Unknown	DATE AND TIME PLOTTED Not Plotted
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# VENTURA COUNTY MONTHLY RAINFALL FOR JANUARY, 1995



	Actual Rain	Normal Rain	Percent of Normal
Moorpark	13.00	3.30	390%
Ojai	25.00	4.76	525%
Oxnard	15.25	3.32	460%
Piru	22.00	4.01	550%
Santa Paula	20.00	3.69	540%
Thousand Oaks	14.50	3.48	410%
Ventura	17.00	3.01	560%

Prepared by: Jerrett McFarland  
VCFCDD, May 5, 1995

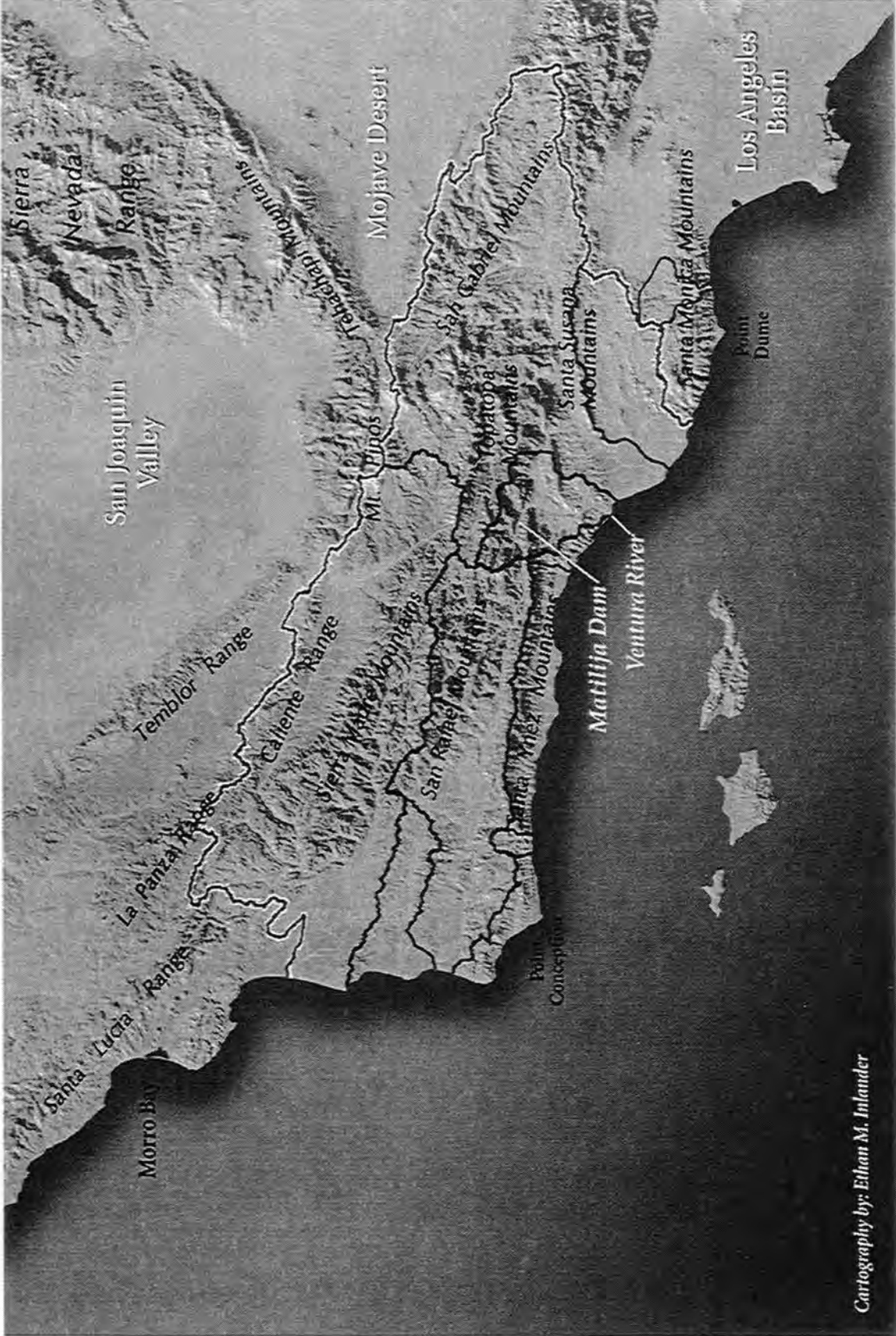


## **Appendix B - Project Photographs**

1. Location of Matilija Dam
2. View of a woman fishing in Matilija Creek. Early 1900's.
3. View of "Hanging Rock" and pre-dam Matilija Creek channel looking downstream. Early 1900's.
4. Typical view of the pre-dam channel of Matilija Creek (near damsite). Early 1900's.
5. View looking upstream at the channel of Matilija Creek in pre-dam reservoir area.
6. Matilija damsite (channel and right abutment) looking upstream. Early 1900's.
7. View looking upstream (north) at Matilija Dam after completion in 1947.
8. Matilija Dam spilling (existing dam).
9. Close up of small spill event - Matilija Dam (existing dam).
10. Wide angle view of Matilija Dam from downstream left abutment (existing dam).
11. View looking upstream at existing Matilija Dam and Existing Matilija Dam from upstream left abutment.
12. Existing outlet works intake and Existing access road on left reservoir rim.
13. Robles Diversion Dam during basin clean out activities.

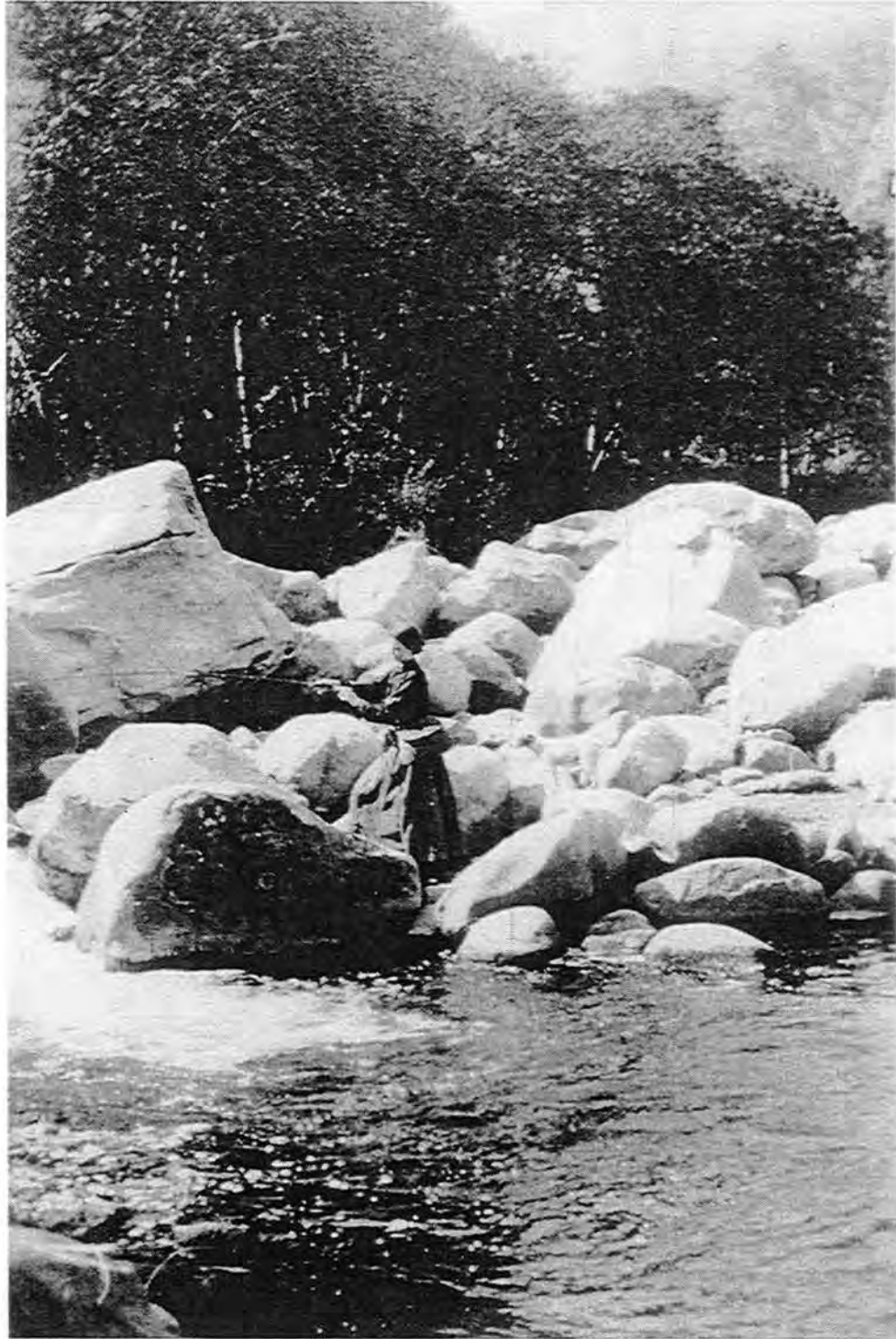






Cartography by: Ethan M. Inlander

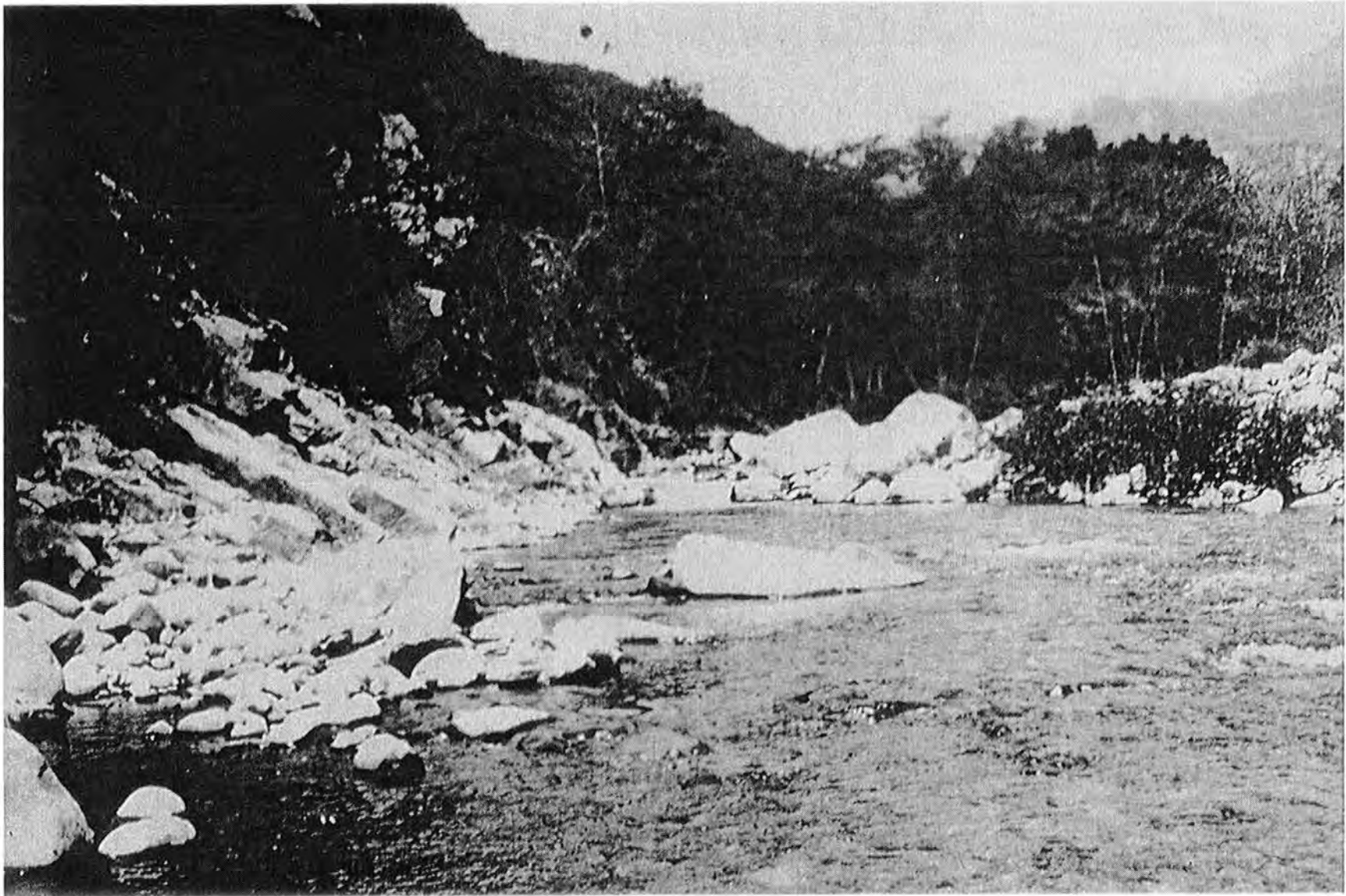
Location of Matilija Dam



View of a woman fishing in Matilija Creek. Note the 3- to over 5-foot diameter boulders flanking the pre-dam creek channel. Early 1900's.



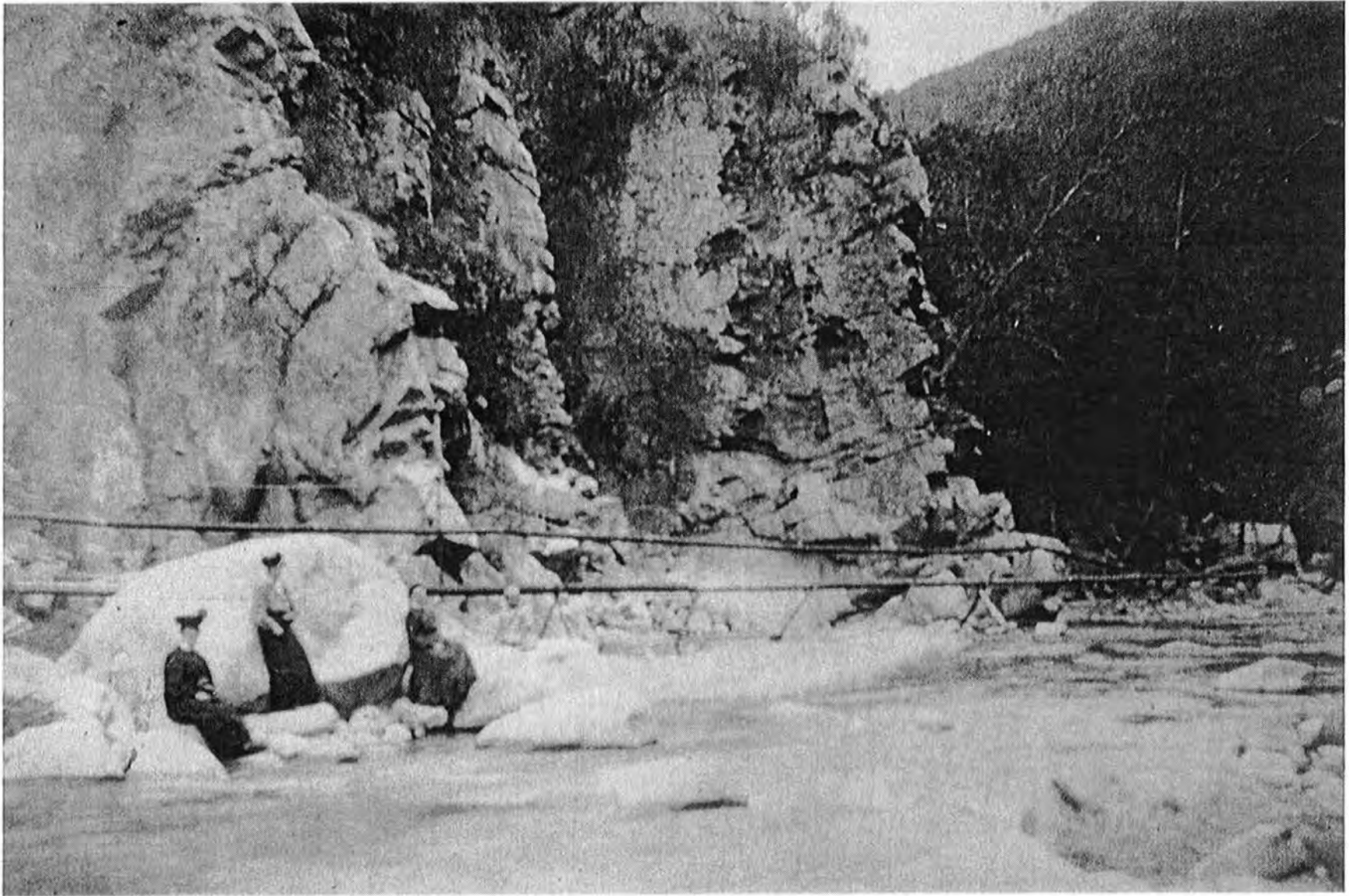
View of "Hanging Rock" and pre-dam Matilija Creek channel looking downstream. Early 1900's.



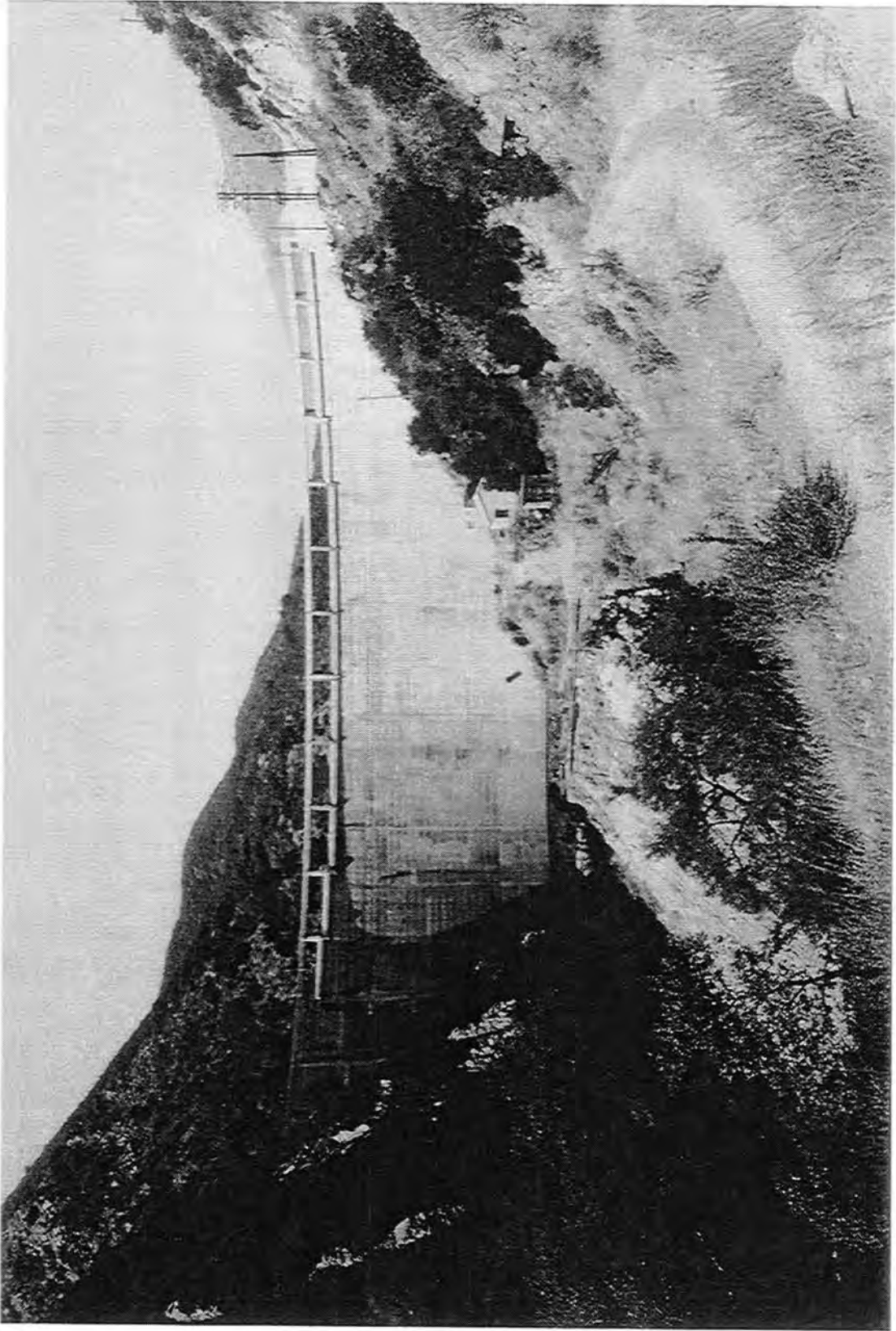
Typical view of the pre-dam channel of Matilija Creek (near damsite). Early 1900's.



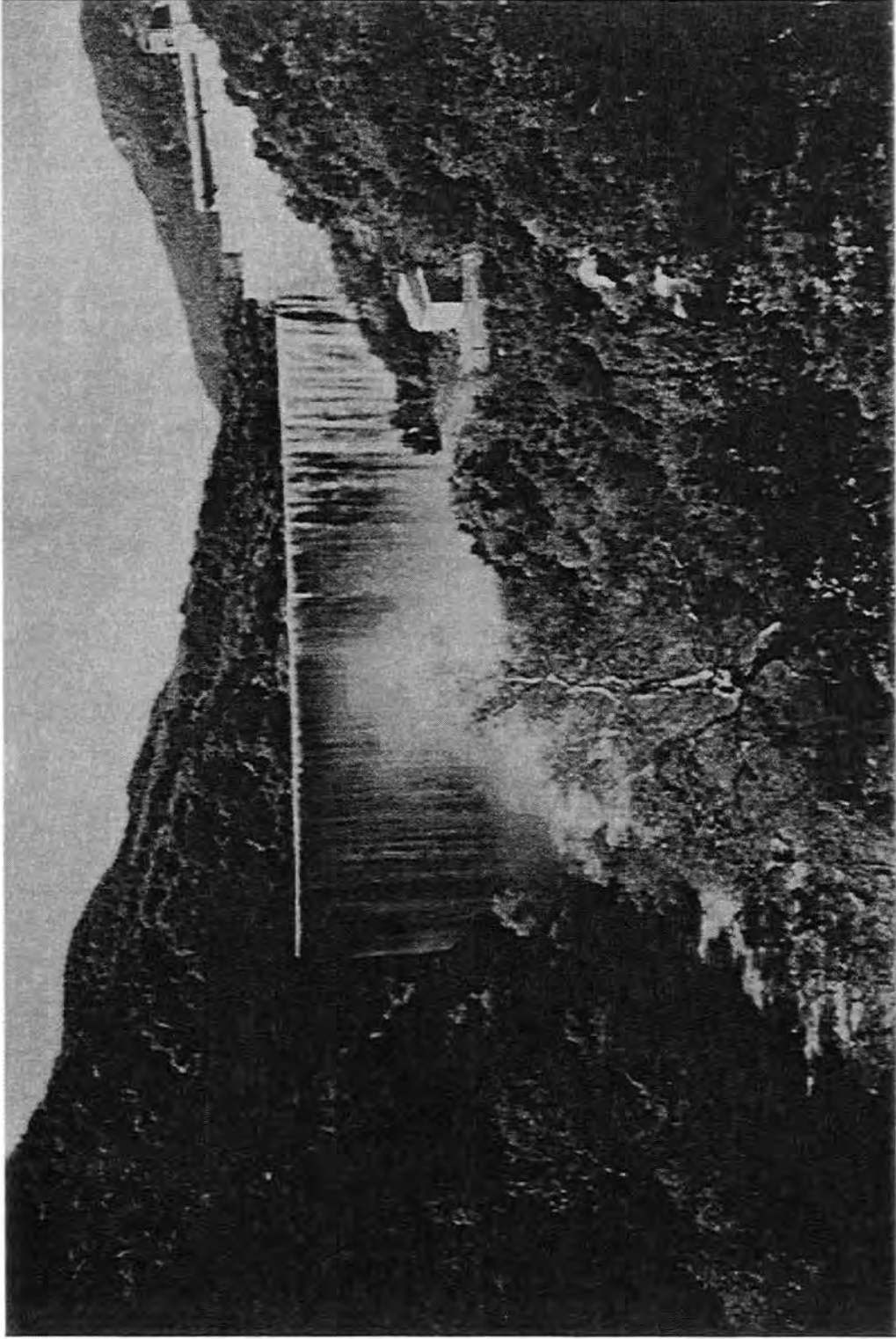
View looking upstream at the channel of Matilija Creek in the pre-dam reservoir area.



Matilija damsite (channel and right abutment) looking upstream. Early 1900's



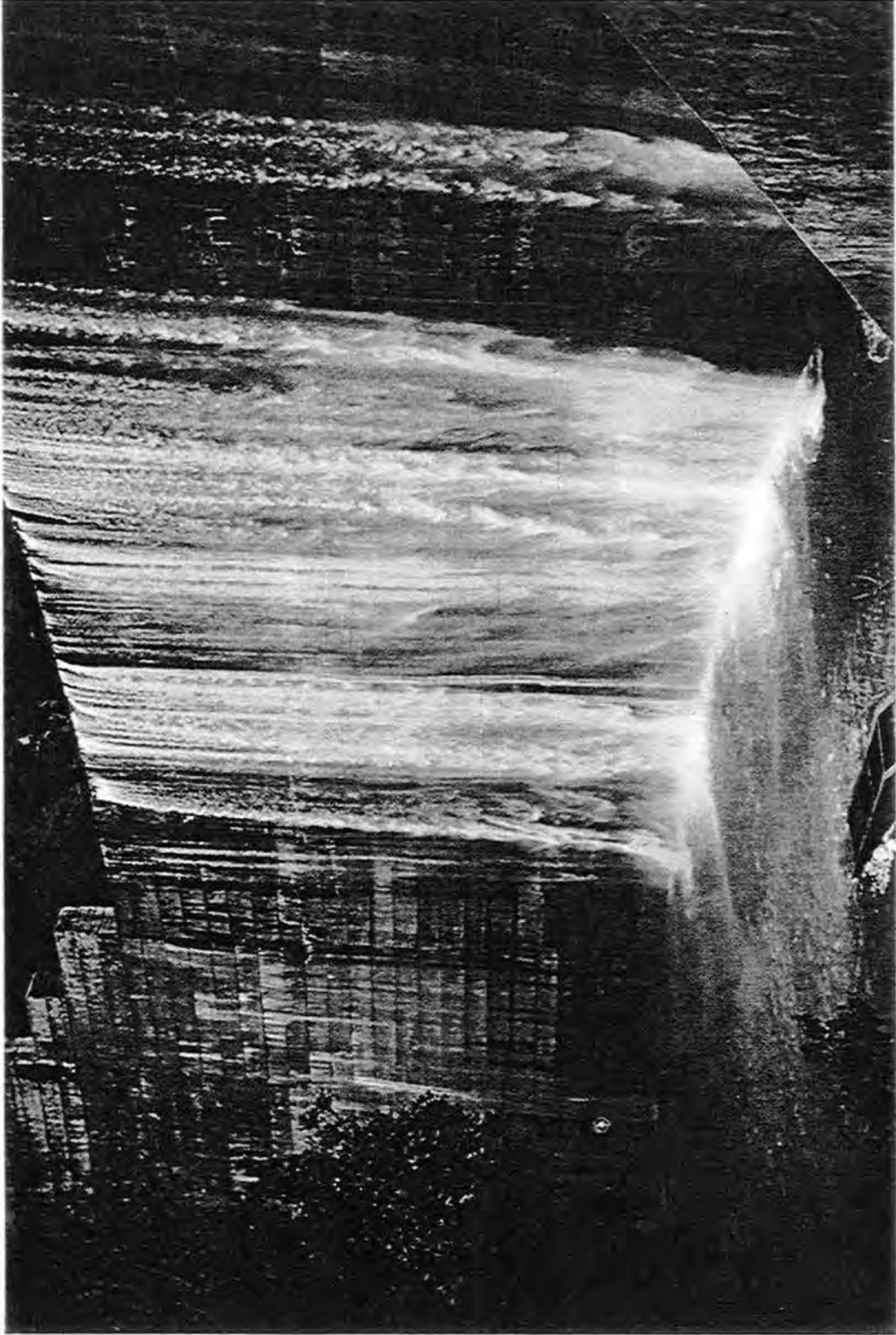
View looking upstream (north) at Matilija Dam after completion in 1947.



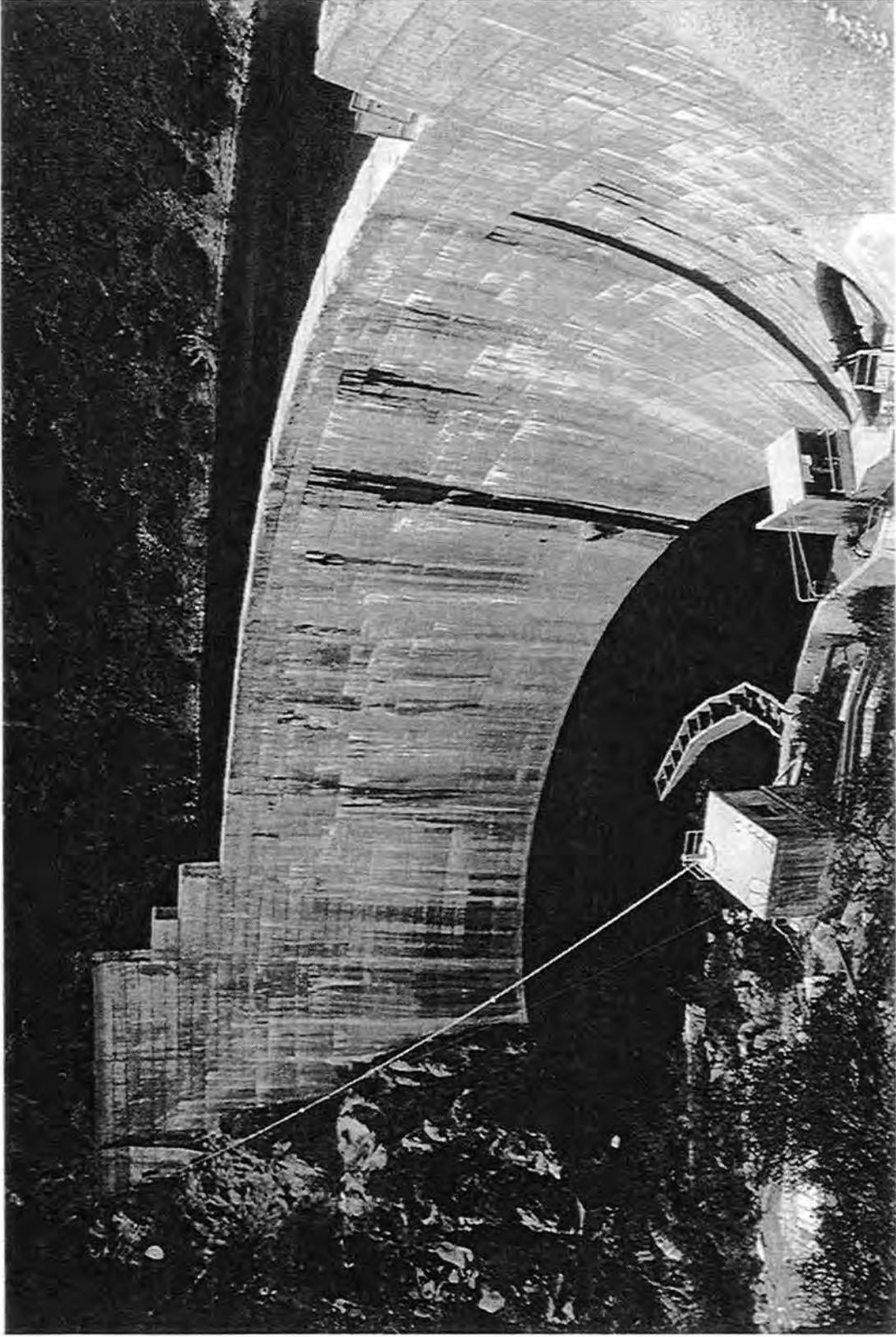
Mark Capelli (1997)

Matilija Dam Spilling





Close up of small spill event - Matilija Dam



Wide angle view of Matilija Dam from downstream left abutment.



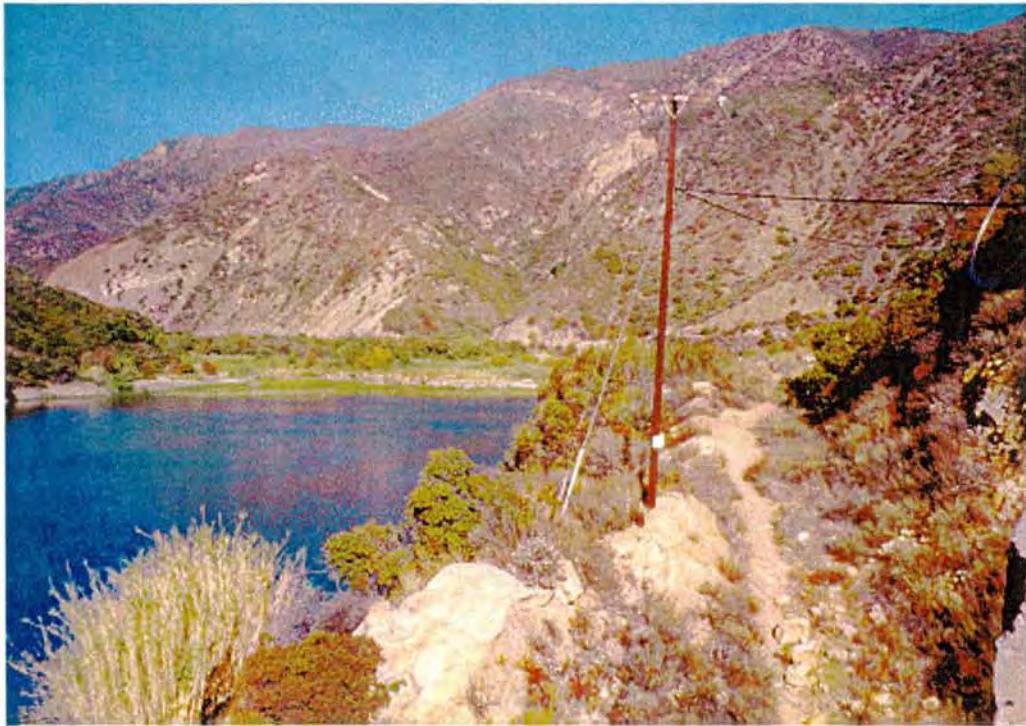
View looking upstream at the existing Matilija Dam



Existing Matilija Dam from upstream left abutment



Existing outlet works intake.



Existing access road on left reservoir rim.

















Robles Diversion Dam during basin clean out activities.



## **Appendix C - Construction Schedule**





Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Years
<b>1st Season - Year 1</b>					
100	Award Construction Contract / Issue NTP	10	MAR01	MAR12	 Award Construction Contract / Issue NTP
110	Mobilize Equipment	15	MAR15	APR02	 Mobilize Equipment
130	Fish Rescue	5	APR05	APR09	 Fish Rescue
150	Build/Improve U/S Access Road	10	APR05	APR16	 Build/Improve U/S Access Road
160	Build/Improve U/S Acces to Toe of Dam	5	APR05	APR09	 Build/Improve U/S Acces to Toe of Dam
220	Build D/S Cofferdam & Settlement Pond	10	APR05	APR16	 Build D/S Cofferdam & Settlement Pond
140	Drain Reservoir & Complete Fish Rescue	5	APR12	APR16	 Drain Reservoir & Complete Fish Rescue
170	Develop U/S Work Area for Dam Removal	5	APR19	APR23	 Develop U/S Work Area for Dam Removal
200	Inst Dewatering, Unwatering & Diversion Systems	15	APR19	MAY07	 Inst Dewatering, Unwatering & Diversion Systems
230	Remove D/S Structures (Except Control House)	22	APR19	MAY18	 Remove D/S Structures (Except Control House)
240	Mobilize, Drill & Blast Dam	10	APR26	MAY07	 Mobilize, Drill & Blast Dam
210	Pump Groundwater	45	MAY10	JUL12	 Pump Groundwater
250	Remove Dam to EI 1095	45	MAY10	JUL12	 Remove Dam to EI 1095
255	Dam Removal Complete to EI 1095	1	JUL13	JUL13	Dam Removal Complete to EI 1095 

Start Date: MAR01  
 Finish Date: JUL13  
 Data Date: MAR01  
 Run Date: APR11 09:41

MATD

Sheet 1 of 1

**Matilija Dam Removal**  
 Dam Removal to EI 1095



Start Date  
Finish Date  
Data Date  
Run Date

MAR01  
NOV15  
MAR01  
APR11 09:48

MA1A

Matilija Dam Removal

Sheet 1 of 1

Alternative 1A

Stabilization of Sediment U/S

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Years			
					1	2	3	4
<b>1st Season - Year 1</b>								
100	Award Construction Contract / Issue NTP	10	MAR01	MAR12	Award Construction Contract / Issue NTP			
110	Mobilize Equipment	15	MAR15	APR02	Mobilize Equipment			
130	Fish Rescue	5	APR05	APR09	Fish Rescue			
160	Build/Improve U/S Acces to Toe of Dam	5	APR05	APR09	Build/Improve U/S Acces to Toe of Dam			
220	Build D/S Cofferdam & Settlement Pond	10	APR05	APR16	Build D/S Cofferdam & Settlement Pond			
150	Build/Improve U/S Access Road	10	APR05	APR16	Build/Improve U/S Access Road			
140	Drain Reservoir & Complete Fish Rescue	5	APR12	APR16	Drain Reservoir & Complete Fish Rescue			
200	Inst Dewatering, Unwatering & Diversion Systems	15	APR19	MAY07	Inst Dewatering, Unwatering & Diversion Systems			
170	Develop U/S Work Area for Dam Removal	5	APR19	APR23	Develop U/S Work Area for Dam Removal			
230	Remove D/S Structures (Except Control House)	22	APR19	MAY18	Remove D/S Structures (Except Control House)			
210	Pump Groundwater	156	MAY10	DEC16	Pump Groundwater			
300	Excavate & Stockpile Sediment - Phase 1	156	MAY10	DEC16	Excavate & Stockpile Sediment - Phase 1			
240	Mobilize, Drill & Blast Dam	10	MAY10	MAY21	Mobilize, Drill & Blast Dam			
360	Erosion Control/Riprap at Stockpile Site	145	MAY24	DEC15	Erosion Control/Riprap at Stockpile Site			
250	Remove Dam to EI 1095 & Haul Conc to Recycle	45	MAY24	JUL26	Remove Dam to EI 1095 & Haul Conc to Recycle			
320	Remove Dam to Sediment Elevation	60	JUL27	OCT19	Remove Dam to Sediment Elevation			
330	Winterize Site	10	DEC17	DEC31	Winterize Site			
370	Winter Shutdown - 1st Season	90	JAN01*	MAR31	Winter Shutdown - 1st Season			
<b>2nd Season - Year 2</b>								
400	Rehab Dewatering, Unwatering, & Diversion Syst	15	APR01	APR21	Rehab Dewatering, Unwatering, & Diversion Syst			
405	Rehab U/S Work Area - Season 2	5	APR01	APR07	Rehab U/S Work Area - Season 2			
410	Pump Groundwater - Season 2	167	APR22	DEC16	Pump Groundwater - Season 2			
430	Excavate & Stockpile Sediment - Phase 2	167	APR22	DEC16	Excavate & Stockpile Sediment - Phase 2			
450	Erosion Control/Riprap at Stockpile Site - 2	137	JUN06	DEC16	Erosion Control/Riprap at Stockpile Site - 2			
420	Mobilize, Drill, & Blast Dam - 2	10	JUL19	AUG01	Mobilize, Drill, & Blast Dam - 2			
440	Remove Dam to Sediment Elevation & Haul - Ph 2	90	AUG02	DEC07	Remove Dam to Sediment Elevation & Haul - Ph 2			
460	Winterize Site - 2nd Season	10	DEC19	DEC30	Winterize Site - 2nd Season			
470	Winter Shutdown - 2nd Season	91	JAN01*	MAR31	Winter Shutdown - 2nd Season			
<b>3rd Season - Year 3</b>								
600	Rehab Dewatering, Unwatering, & Diversion Systems	15	APR02*	APR20	Rehab Dewatering, Unwatering, & Diversion Systems			
605	Rehab U/S Work Area - Season 3	5	APR02	APR06	Rehab U/S Work Area - Season 3			
610	Pump Groundwater - Season 3	166	APR23	DEC14	Pump Groundwater - Season 3			
630	Excavate & Stockpile Sediment - Phase 3	166	APR23	DEC14	Excavate & Stockpile Sediment - Phase 3			
620	Mobilize, Drill, & Blast Dam - 3	10	APR23	MAY04	Mobilize, Drill, & Blast Dam - 3			
640	Remove Dam to Sediment Elev & Haul to Recycle -3	90	MAY07	SEP12	Remove Dam to Sediment Elev & Haul to Recycle -3			
650	Erosion Control/Riprap at Stockpile Site - 3	136	JUN05	DEC14	Erosion Control/Riprap at Stockpile Site - 3			
660	Winterize Site - 3rd Season	10	DEC17	DEC31	Winterize Site - 3rd Season			
670	Winter Shutdown - 3rd Season	90	JAN01*	MAR31	Winter Shutdown - 3rd Season			
<b>4th Season - Year 4</b>								
800	Rehab Dewatering, Unwatering, & Diversion Systems	15	APR01*	APR19	Rehab Dewatering, Unwatering, & Diversion Systems			
805	Rehab U/S Work Area - Season 4	5	APR01	APR05	Rehab U/S Work Area - Season 4			
810	Pump Groundwater - Season 4	166	APR22	DEC13	Pump Groundwater - Season 4			
830	Excavate & Stockpile Sediment - Phase 4	166	APR22	DEC13	Excavate & Stockpile Sediment - Phase 4			
820	Mobilize, Drill, & Blast Dam - 4	10	APR22	MAY03	Mobilize, Drill, & Blast Dam - 4			
840	Remove Dam to Sediment Elevation & Haul Conc - 4	90	MAY06	SEP11	Remove Dam to Sediment Elevation & Haul Conc - 4			
850	Erosion Control/Riprap at Stockpile Site - 4	136	JUN04	DEC13	Erosion Control/Riprap at Stockpile Site - 4			
860	Site Rehab & Demobilize Equipment	10	DEC16	DEC30	Site Rehab & Demobilize Equipment			
900	MATILJA CREEK RESTORED	1	DEC31	DEC31	MATILJA CREEK RESTORED			

Start Date: MAR01  
 Finish Date: DEC31  
 Data Date: MAR01  
 Run Date: APR11 11:38

Matilija Dam Removal  
 Alternative 1B  
 Removal of Sediment - Downstream

Sheet 1 of 1

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Years																									
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
<b>Year 0</b>																														
100	Award Construction Contract / Issue NTP	10	MAR15	MAR26	☒																									
110	Mobilize Equipment	15	MAR29	APR16	☒																									
130	Fish Rescue	5	APR19	APR23	☒																									
150	Build/Improve U/S Access Road	10	APR19	APR30	☒																									
160	Build/Improve U/S Access to Toe of Dam	5	APR19	APR23	☒																									
220	Build D/S Cofferdam & Settlement Pond	10	APR19	APR30	☒																									
140	Drain Reservoir & Complete Fish Rescue	5	APR26	APR30	☒																									
170	Develop U/S Work Area for Dam Removal	5	MAY03	MAY07	☒																									
200	Inst Diversion, Unwatering &/or Dewatering Sys	15	MAY03	MAY21	☒																									
230	Remove D/S Structures (Except Control House)	22	MAY03	JUN02	☒																									
240	Mobilize, Drill & Blast Dam	10	MAY10	MAY21	☒																									
210	Maintain Work Area & Unwatering Systems	60	MAY24	AUG16	☒																									
250	Remove Dam to EI 1065 & Haul Conc to Recycle	60	MAY24	AUG16	☒																									
280	Demobilize Equipment	10	AUG17	AUG30	☒																									
<b>Year 3</b>																														
3110	Mobilize Equipment & Improve Access Roads	15	APR01*	APR19	☒																									
3220	Build D/S Cofferdam & Settlement Pond	5	APR22	APR26	☒																									
3170	Develop U/S Work Area for Dam Removal	5	APR22	APR26	☒																									
3200	Inst Diversion, Unwatering &/or Dewatering Sys	15	APR29	MAY17	☒																									
3240	Mobilize, Drill & Blast Dam	10	APR29	MAY10	☒																									
3250	Remove Dam to EI 1060 & Haul Conc to Recycle	20		JUN10A	☒																									
3210	Maintain Work Area & Unwatering Systems	20	MAY20	JUN17	☒																									
3280	Demobilize Equipment	10	JUN18	JUL01	☒																									
<b>Year 5</b>																														
5110	Mobilize Equipment & Improve Access Roads	15	APR01*	APR21	☒																									
5220	Build D/S Cofferdam & Settlement Pond	5	APR22	APR28	☒																									
5170	Develop U/S Work Area for Dam Removal	5	APR22	APR28	☒																									
5200	Inst Diversion, Unwatering &/or Dewatering Sys	15	APR29	MAY19	☒																									
5240	Mobilize, Drill & Blast Dam	10	APR29	MAY12	☒																									
5250	Remove Dam to EI 1050 & Haul Conc to Recycle	20	MAY13	JUN10	☒																									
5210	Maintain Work Area & Unwatering Systems	20	MAY20	JUN17	☒																									
5280	Demobilize Equipment	10	JUN18	JUL01	☒																									
<b>Year 8</b>																														
8000	Repeat Sequence - Dam Removal to EI 1040	65	APR02*	JUL02	☒																									
<b>Year 11</b>																														
11000	Repeat Sequence - Dam Removal to 1025	65	APR01*	JUL01	☒																									
<b>Year 16</b>																														
16000	Repeat Sequence - Dam Removal to EI 1010	65	APR01*	JUL01	☒																									
<b>Year 20</b>																														
20000	Repeat Sequence - Dam Removal to EI 995	65	APR01*	JUL01	☒																									
<b>Year 22</b>																														
22000	Repeat Sequence - Dam Removal to EI 980	65	APR01*	JUL01	☒																									
<b>Year 25</b>																														
25000	Repeat Sequence - Dam Removal to EI 960	65	APR02*	JUL02	☒																									
25001	MATILJA CREEK RESTORED	1	JUL03	JUL03	☒																									

## **Appendix D - Cost Estimates**



<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL POSSIBLE FIRST PHASE REMOVE DAM TO ELEV. 1095</b></p>	07-Mar-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization		1	LS	\$175,000.00	\$175,000.00
	2	Excavation of concrete dam	D-8130	3,100	cyds	\$40.00	\$124,000.00
	3	Excavation of concrete fish trap	D-8130	120	cyds	\$200.00	\$24,000.00
	4	Drilling for Blasting	D-8130				
		Horizontal holes		1,450	each	\$60.00	\$87,000.00
		Drilling horizontal holes		9,400	lin-ft	\$14.00	\$131,600.00
		Vertical holes		600	each	\$120.00	\$72,000.00
		Drilling vertical holes		7,000	lin-ft	\$10.00	\$70,000.00
	5	Process concrete for hauling	D-8130	3,220	cyds	\$3.00	\$9,660.00
	6	Hauling removed concrete to recycling plant	D-8130	3,220	cyds	\$15.00	\$48,300.00
	7	Removal and disposal of miscellaneous metalwork	D-8130	5,813	lbs	\$4.00	\$23,250.00
	8	Diversion and care of stream 3 cfs	D-8130	5,280	LF	\$200.00	\$1,056,000.00
	9	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
		Subtotal					\$1,920,810.00
		Unlisted items @ 10 percent					\$179,190.00
		Contract cost					\$2,100,000.00
		Contingencies @ 25 percent					\$500,000.00
		Field cost					\$2,600,000.00

<b>QUANTITIES</b>		<b>PRICES</b>	
BY <p style="text-align: center;">Ernie Hall</p>	CHECKED <p style="text-align: center;">J. Markley</p>	BY <p style="text-align: center;">D.L. Maag</p>	CHECKED <p style="text-align: center;"><i>RSCC 3/8/00</i></p>
DATE PREPARED <p style="text-align: center;">03/07/2000</p>	APPROVED	DATE <p style="text-align: center;">03/07/2000</p>	PRICE LEVEL

<b>FEATURE:</b>  <b>MATILJA DAM REMOVAL ALTERNATIVE 1A STABILIZATION OF SEDIMENT UPSTREAM</b>	12-Apr-2000	<b>PROJECT:</b>
		<b>DIVISION:</b> Civil Engineering
		<b>UNIT:</b>

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization		1	LS	\$2,800,000.00	\$2,800,000.00
	2	Excavation of concrete dam	D-8130	48,000	cyds	\$30.00	\$1,440,000.00
	3	Excavation of concrete fish trap	D-8130	120	cyds	\$200.00	\$24,000.00
	4	Excavation of concrete control house	D-8130	70	cyds	\$250.00	\$17,500.00
	5	Drilling for Blasting for dam removal					
		Horizontal holes	D-8130	8,100	each	\$60.00	\$486,000.00
		Drilling horizontal holes		115,000	lin-ft	\$14.00	\$1,610,000.00
		Vertical holes		7,000	each	\$120.00	\$840,000.00
		Drilling horizontal holes		115,000	lin-ft	\$10.00	\$1,150,000.00
	6	Process concrete for hauling	D-8130	9,638	cyds	\$10.00	\$96,380.00
	7	Hauling removed concrete to recycling plant	D-8130	72,285	cyds	\$10.00	\$722,850.00
	8	Removal and disposal of miscellaneous metalwork	D-8130	40,700	lbs	\$2.00	\$81,400.00
	9	Excavation of sediment at dam	D-8130	4,800,000	cyds	\$1.00	\$4,800,000.00
	10	Excavation of key trench	D-8130	45,400	cyds	\$10.00	\$454,000.00
	11	Placing and compacting sediment	D-8130	5,300,000	cyds	\$2.00	\$10,600,000.00
	12	Placing geogrid soil reinforcement - 12.4 oz/sqyd	D-8130	340,000	sqyds	\$7.50	\$2,550,000.00
	13	Repair road	D-8130	2	mi	\$300,000.00	\$600,000.00
		Subtotal					\$28,272,130.00

QUANTITIES		PRICES	
BY Ernie Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC 03/08/00
DATE PREPARED 03/02/00	APPROVED	DATE	PRICE LEVEL



<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 1A STABILIZATION OF SEDIMENT UPSTREAM</b></p>	12-Apr-2000	<b>PROJECT:</b>  DIVISION: <p style="text-align: center;">Civil Engineering</p> UNIT:
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PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	14	Filling gabion mats - riprap	D-8130	55,800	cyds	\$35.00	\$1,953,000.00
	15	Placing gabion mats - 9'x99'x1.5'	D-8130	1,150	each	\$5,000.00	\$5,750,000.00
	16	Placing riprap in key trench	D-8130	45,400	cyds	\$30.00	\$1,362,000.00
	17	Striping and replacing topsoil	D-8130	230,000	cyds	\$6.00	\$1,380,000.00
	18	Re- vegetating stabilized area	D-8130	70	ac	\$3,000.00	\$210,000.00
	19	Diversion and care of stream 3 cfs	D-8130	5,280	LF	\$200.00	\$1,056,000.00
	20	Dewatering	D-8130	1	LS	\$1,250,000.00	\$1,250,000.00
	21	Dust Abatement - 2 seasons		27,000	MGal	\$20.00	\$540,000.00
		Subtotal Sheet 2					\$13,501,000.00
		Subtotal Sheet 2					\$28,272,130.00
		Subtotal (All Items)					\$41,773,130.00
		Unlisted items @ 10 percent					\$4,226,870.00
		Contract cost					\$46,000,000.00
		Contingencies @ 25 percent					\$11,000,000.00
		Field cost					\$57,000,000.00

QUANTITIES		PRICES	
BY E. Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC 03/08/00
DATE PREPARED 03/02/00	APPROVED	DATE	PRICE LEVEL

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 1B REMOVAL OF SEDIMENT DOWNSTREAM</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization		1	LS	\$8,500,000.00	\$8,500,000.00
	2	Excavation of concrete dam	D-8130	48,000	cyds	\$30.00	\$1,440,000.00
	3	Excavation of concrete fish trap	D-8130	120	cyds	\$200.00	\$24,000.00
	4	Excavation of concrete control house	D-8130	70	cyds	\$250.00	\$17,500.00
	5	Drilling for Blasting for dam removal					
		Horizontal holes	D-8130	8,100	each	\$60.00	\$486,000.00
		Drilling horizontal holes		115,000	lin-ft	\$14.00	\$1,610,000.00
		Vertical holes		7,000	each	\$120.00	\$840,000.00
		Drilling vertical holes		115,000	lin-ft	\$10.00	\$1,150,000.00
	6	Process concrete for hauling	D-8130	9,638	cyds	\$10.00	\$96,380.00
	7	Hauling removed concrete to recycling plant	D-8130	72,285	cyds	\$10.00	\$722,850.00
	8	Removal and disposal of miscellaneous metalwork	D-8130	40,700	lbs	\$2.00	\$81,400.00
	9	Excavation of sediment at dam	D-8130	6,000,000	cyds	\$1.00	\$6,000,000.00
	10	Haul sediment to downstream disposal site	D-8130	6,000,000	cyds	\$10.00	\$60,000,000.00
	11	Place sediment at downstream disposal site	D-8130	6,000,000	cyds	\$1.00	\$6,000,000.00
	12	Repair roads	D-8130	12	miles	\$300,000.00	\$3,600,000.00
	13	Diversion and care of stream 3 cfs	D-8130	5,280	lf	\$200.00	\$1,056,000.00
	14	Dewatering	D-8130	1	ls	\$1,500,000.00	\$1,500,000.00
		Subtotal					\$93,124,130.00

QUANTITIES		PRICES	
BY Ernie Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC 03/08/00
DATE PREPARED 03/02/00	APPROVED	DATE	PRICE LEVEL

ESTIMATE WORKSHEET

**FEATURE:**  
**MATILJA DAM REMOVAL  
ALTERNATIVE 1B  
REMOVAL OF SEDIMENT DOWNSTREAM**

12-Apr-2000

**PROJECT:**

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**DIVISION:**  
Civil Engineering

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**UNIT:**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	15	Water for Dust Abatement - 4 seasons		37,500	MGal	\$20.00	\$750,000.00
	16	Re-vegetation		70	Acre	\$3,000.00	\$210,000.00
Subtotal Sheet 2							\$960,000.00
Subtotal Sheet 1							\$93,124,130.00
Subtotal							\$94,084,130.00
Unlisted Items @ 10 percent							\$10,915,870.00
Contract cost							\$105,000,000.00
Contingencies @ 25 percent							\$25,000,000.00
Field cost							\$130,000,000.00

QUANTITIES		PRICES	
BY E. Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC 03/08/00
DATE PREPARED 04/12/2000	APPROVED	DATE	PRICE LEVEL

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 2 NATURAL PHASED REMOVAL OF SEDIMENT</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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**Note: All cost shown in Present Worth \$**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>Phase 1</b>					
	1	Mobilization		1	LS	\$300,000.00	\$300,000.00
	2	Excavation of concrete dam	D-8130	11,200	cyds	\$40.00	\$448,000.00
	3	Excavation of concrete fish trap	D-8130	120	cyds	\$200.00	\$24,000.00
	4	Excavation of concrete control house	D-8130	70.0	cyds	\$250.00	\$17,500.00
	5	Drilling for Blasting	D-8130				
		Horizontal holes		3,600	each	\$60.00	\$216,000.00
		Drilling horizontal holes		29,000	lin-ft	\$14.00	\$406,000.00
		Vertical holes		1,700	each	\$120.00	\$204,000.00
		Drilling vertical holes		19,000	lin-ft	\$10.00	\$190,000.00
	6	Process concrete for hauling	D-8130	3,417	cyds	\$10.00	\$34,170.00
	7	Hauling removed concrete to recycling plant	D-8130	17,085	cyds	\$10.00	\$170,850.00
	8	Removal and disposal of miscellaneous metalwork	D-8130	28,200	lbs	\$3.00	\$84,600.00
	9	Excavation of sediment at dam	D-8130	4,500	cyds	\$3.00	\$13,500.00
	10	Diversion and care of stream 3 cfs	D-8130	5,280	LF	\$200.00	\$1,056,000.00
	11	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
		<b>Phase 2</b>					
	1	Mobilization		1	LS	\$39,000.00	\$39,000.00
	2	Excavation of concrete	D-8130	1,510	cyds	\$40.00	\$60,400.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		400	each	\$60.00	\$24,000.00
		Drilling horizontal holes		4,400	lin-ft	\$14.00	\$61,600.00
		Vertical holes		600	each	\$120.00	\$72,000.00
		Drilling vertical holes		3,000	lin-ft	\$10.00	\$30,000.00
	4	Process concrete for hauling	D-8130	453	cyds	\$10.00	\$4,530.00
	5	Hauling removed concrete to recycling plant	D-8130	2,265	cyds	\$10.00	\$22,650.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	600	lbs	\$3.00	\$1,800.00
	7	Excavation of sediment at dam	D-8130	4,500	cyds	\$3.00	\$13,500.00
	8	Unwatering (3 months)	D-8130	1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5280	LF	Assume in place from Phase 1	

<b>QUANTITIES</b>		<b>PRICES</b>	
BY	CHECKED	BY	CHECKED
Ernie Hall	J. Markley	D.L. Maag	RKC      03/08/00
DATE PREPARED	APPROVED	DATE	PRICE LEVEL
03/08/00			

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 2 NATURAL PHASED REMOVAL OF SEDIMENT</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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**Note: All cost shown in Present Worth \$**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
<b>Phase 3</b>							
	1	Mobilization		1	LS	\$62,000.00	\$62,000.00
	2	Excavation of concrete	D-8130	3,100	cyds	\$40.00	\$124,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		760	each	\$60.00	\$45,600.00
		Drilling horizontal holes		9,300	lin-ft	\$14.00	\$130,200.00
		Vertical holes		580	each	\$120.00	\$69,600.00
		Drilling vertical holes		5,800	lin-ft	\$10.00	\$58,000.00
	4	Process concrete for hauling	D-8130	930	cyds	\$10.00	\$9,300.00
	5	Hauling removed concrete to recycling plant	D-8130	4,650	cyds	\$10.00	\$46,500.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	1,200	lbs	\$3.00	\$3,600.00
	7	Excavation of sediment at dam	D-8130	9,400	cyds	\$3.00	\$28,200.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	
<b>Phase 4</b>							
	1	Mobilization		1	LS	\$68,000.00	\$68,000.00
	2	Excavation of concrete	D-8130	3,700	cyds	\$40.00	\$148,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		710	each	\$60.00	\$42,600.00
		Drilling horizontal holes		9,100	lin-ft	\$14.00	\$127,400.00
		Vertical holes		730	each	\$120.00	\$87,600.00
		Drilling vertical holes		7,300	lin-ft	\$10.00	\$73,000.00
	4	Process concrete for hauling	D-8130	1,110	cyds	\$10.00	\$11,100.00
	5	Hauling removed concrete to recycling plant	D-8130	5,550	cyds	\$10.00	\$55,500.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	1,400	lbs	\$3.00	\$4,200.00
	7	Excavation of sediment at dam	D-8130	8,800	cyds	\$3.00	\$26,400.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	

<b>QUANTITIES</b>				<b>PRICES</b>			
BY	CHECKED	BY	CHECKED	DATE	PRICE LEVEL		
E. Hall	J. Markley	D.L. Maag	RKC			03/08/00	
DATE PREPARED	APPROVED	DATE	PRICE LEVEL				
	03/08/00						

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILIJA DAM REMOVAL ALTERNATIVE 2 NATURAL PHASED REMOVAL OF SEDIMENT</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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**Note: All cost shown in Present Worth \$**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>Phase 5</b>					
	1	Mobilization		1	LS	\$80,000.00	\$80,000.00
	2	Excavation of concrete	D-8130	4,300	cyds	\$40.00	\$172,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		780	each	\$60.00	\$46,800.00
		Drilling horizontal holes		13,600	lin-ft	\$14.00	\$190,400.00
		Vertical holes		630	each	\$120.00	\$75,600.00
		Drilling vertical holes		9,400	lin-ft	\$10.00	\$94,000.00
	4	Process concrete for hauling	D-8130	1,290	cyds	\$10.00	\$12,900.00
	5	Hauling removed concrete to recycling plant	D-8130	6,450	cyds	\$10.00	\$64,500.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	1,600	lbs	\$3.00	\$4,800.00
	7	Excavation of sediment at dam	D-8130	13,300	cyds	\$3.00	\$39,900.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	
		<b>Phase 6</b>					
	1	Mobilization		1	LS	\$91,000.00	\$91,000.00
	2	Excavation of concrete	D-8130	5,100	cyds	\$40.00	\$204,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		860	each	\$60.00	\$51,600.00
		Drilling horizontal holes		13,100	lin-ft	\$14.00	\$183,400.00
		Vertical holes		870	each	\$120.00	\$104,400.00
		Drilling vertical holes		13,000	lin-ft	\$10.00	\$130,000.00
	4	Process concrete for hauling	D-8130	1,530	cyds	\$10.00	\$15,300.00
	5	Hauling removed concrete to recycling plant	D-8130	7,650	cyds	\$10.00	\$76,500.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	1,900	lbs	\$3.00	\$5,700.00
	7	Excavation of sediment at dam	D-8130	12,400	cyds	\$3.00	\$37,200.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	

QUANTITIES		PRICES	
BY E. Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC      03/08/00
DATE PREPARED 03/08/00	APPROVED	DATE	PRICE LEVEL

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 2 NATURAL PHASED REMOVAL OF SEDIMENT</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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**Note: All cost shown in Present Worth \$**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		<b>Phase 7</b>					
	1	Mobilization		1	LS	\$98,000.00	\$98,000.00
	2	Excavation of concrete	D-8130	5,900	cyds	\$40.00	\$236,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		670	each	\$60.00	\$40,200.00
		Drilling horizontal holes		14,400	lin-ft	\$14.00	\$201,600.00
		Vertical holes		950	each	\$120.00	\$114,000.00
		Drilling vertical holes		14,200	lin-ft	\$10.00	\$142,000.00
	4	Process concrete for hauling	D-8130	1,770	cyds	\$10.00	\$17,700.00
	5	Hauling removed concrete to recycling plant	D-8130	8,850	cyds	\$10.00	\$88,500.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	2,200	lbs	\$3.00	\$6,600.00
	7	Excavation of sediment at dam	D-8130	11,700	cyds	\$3.00	\$35,100.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	
		<b>Phase 8</b>					
	1	Mobilization		1	LS	\$94,000.00	\$94,000.00
	2	Excavation of concrete	D-8130	5,000	cyds	\$40.00	\$200,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		620	each	\$60.00	\$37,200.00
		Drilling horizontal holes		14,600	lin-ft	\$14.00	\$204,400.00
		Vertical holes		1,000	each	\$120.00	\$120,000.00
		Drilling vertical holes		15,100	lin-ft	\$10.00	\$151,000.00
	4	Process concrete for hauling	D-8130	1,500	cyds	\$10.00	\$15,000.00
	5	Hauling removed concrete to recycling plant	D-8130	7,500	cyds	\$10.00	\$75,000.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	1,900	lbs	\$3.00	\$5,700.00
	7	Excavation of sediment at dam	D-8130	10,600	cyds	\$3.00	\$31,800.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	

<b>QUANTITIES</b>		<b>PRICES</b>	
BY E. Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC                      03/08/00
DATE PREPARED 04/12/2000	APPROVED	DATE	PRICE LEVEL

<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 2 NATURAL PHASED REMOVAL OF SEDIMENT</b></p>	12-Apr-2000	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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**Note: All cost shown in Present Worth \$**

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Phase 9					
	1	Mobilization		1	ls	\$115,000.00	\$115,000.00
	2	Excavation of concrete	D-8130	7,800	cyds	\$40.00	\$312,000.00
	3	Drilling for Blasting	D-8130				
		Horizontal holes		470	each	\$60.00	\$28,200.00
		Drilling horizontal holes		11,900	lin-ft	\$14.00	\$166,600.00
		Vertical holes		1,100	each	\$120.00	\$132,000.00
		Drilling vertical holes		21,000	lin-ft	\$10.00	\$210,000.00
	4	Process concrete for hauling	D-8130	2340	cyds	\$10.00	\$23,400.00
	5	Hauling removed concrete to recycling plant	D-8130	11700	cyds	\$10.00	\$117,000.00
	6	Removal and disposal of miscellaneous metalwork	D-8130	2,900	lbs	\$3.00	\$8,700.00
	7	Excavation of sediment at dam	D-8130	10,100	cyds	\$3.00	\$30,300.00
	8	Unwatering (3 months)		1	LS	\$100,000.00	\$100,000.00
	9	Diversion and care of stream	D-8130	5,280	LF	Assume in Place from Phase 1	
		Subtotal					\$10,351,900.00
		Unlisted items @ 10 percent					\$1,148,100.00
		Contract cost					\$11,500,000.00
		Contingencies @ 25 percent					\$2,500,000.00
		Field cost					\$14,000,000.00

<b>QUANTITIES</b>		<b>PRICES</b>	
BY E. Hall	CHECKED J. Markley	BY D.L. Maag	CHECKED RKC                      03/08/00
DATE PREPARED 04/12/2000	APPROVED	DATE	PRICE LEVEL



**Appendix E - Notes from November 22-23, 1999 Brainstorming  
Session**



# MATILIJA DAM REMOVAL

## Brainstorming/Formulation Session

November 22-23, 1999

### Brief Descriptions of Tentative Alternatives for the Appraisal Level Removal Report

#### ALTERNATIVE 1 - MECHANICAL REMOVAL OF SEDIMENTS

- 1A. **Move Sediment Upstream of Dam and Stabilize:** A channel will be constructed to route stream flows along the left side of the reservoir. This alignment was recommended as a likely path for large flows in the area. The stream will be sloped similar to the slope of the pre-dam condition. Sediment will be placed on the right side of the reservoir, shaped and stabilized to match the surrounding topography. Topography of the area is not available yet so the total volume that can be stored in the reservoir area is not known. Additional storage appears to be available on the right side above the reservoir. The reservoir area is owned by the County of Ventura, however, the area above the reservoir is not. Clearance to place material in this area would need to be obtained. Top soil will be placed on the top of the sediment for re-vegetation. The slope on the stream side will be stabilized with riprap. This alternative will require striping of the existing vegetation in the deposit and removal zone. Some time will be required for re-vegetation so there will be visual impact during construction and for some time afterwards. This alternative will likely take more than one construction seasons. The dam will be completely removed and the concrete will be hauled to commercial sites downstream for processing and ultimate recycling. Metal work from the dam removal will be hauled to an appropriate disposal site. Removal of the dam will be staged to be lowered approximately 5 feet below the elevation of the sediment at all times. This will aid in dewatering of the sediment and protect the downstream area against large sediment flows in the event of a large flood. During the periods of no-construction, if required between construction seasons, the dam and the sediment will be lowered to the same elevation. This will prevent both large sediment discharges and sediment build-up during the no-construction period. Existing wetlands at the upstream end of the reservoir will be removed and will likely require mitigation. All construction activities associated with removal of the dam will require the use of fossil fuel, and dust suppression. Air quality will likely be required. Erosion control during construction will require significant effort to protect discharge water quality.
- 1B. **Remove Sediment Downstream of the Dam:** The dam will be completely removed and the concrete will be hauled to commercial sites downstream for processing and recycling. Metal work from the dam removal will be hauled to an appropriate disposal site. Removal of the dam will be staged to be lowered approximately 5 feet below the elevation of the sediment at all times. This will aid in dewatering of the sediment and protect the downstream area against large sediment flows in the event of a large flood. More than one construction seasons will likely be required for this alternative. During the periods of no-construction, if required between construction seasons, the dam and the sediment will be lowered to the same elevation. This will prevent both large sediment discharges and

sediment build-up during the no- construction period. Sediment will be removed from the reservoir area and hauled by truck to a disposal site downstream. The majority of the sediment in the reservoir will be removed returning the reservoir area to near pre-dam contours. It will be impossible to completely clean the area of all sediment. The disposal site is not known at this time but sites are said to be available. This is considered to be a significant issue regarding environmental impacts on the existing storage areas, future land use, erosion protection, construction related environmental impacts, cost, and stabilization concerns. These sites may be in the downstream flood plane. The sediment will be shaped/land-scaped and re-vegetated. It may be possible for some of the coarser sediment to be transported to commercial sources downstream for processing and recycling. Sediment studies to determine the material properties will be needed to determine if this would be possible. Existing wetlands at the upstream end of the reservoir will be removed and likely require mitigation. All construction activities associated with removal of the dam will require the use of fossil fuel and dust suppression. Air quality mitigation will likely be required. A great deal of road damage would be expected from heavy trucks on the haul routes. The haul routes would require complete replacement as a minimum due to wear from the haul.

- 1BB. Remove Sediment Downstream via a Slurry pipeline:** Sediment can be removed downstream via a slurry pipeline. The material could be transported to a stilling basin downstream for drying and placement of the sediment at a permanent storage location or transported directly into the ocean. If the sediment is transported to the ocean, then the sediment will be available for beach nourishment. Slurry pipelines are normally capable of transporting only fine material. Material sand size and larger would likely plug the slurry line. This would require the sediment to be processed if all sediment is to be removed. This alternative may be well suited to be used in combination with alternative 2. If the natural stratification of the reservoir is such that finer material is deposited near the dam with coarser material deposited in the upstream delta, it may be possible to dredge and transport the finer material and leave the coarser material to be washed down the stream naturally. The coarser material may be more suited for preservation of fish habitat. The dam would be removed as stated above. Wetlands mitigation would be required for the upstream wetlands. Air quality mitigation would also be required but not to the extent as with the two previous alternatives. It is expected this alternative will take considerably more time to accomplish than alternatives 1A and 1B.

#### **ALTERNATIVE 2 - PHASED NATURAL TRANSPORT OF SEDIMENT**

This alternative would require the dam to be removed in stages. The dam would be lowered some distance (assume 5 to 10 feet) and the sediment in the reservoir would be allowed to be removed by natural flow in the creek. This concept would be an overtopping sluicing operation. Initially the top portion of the dam (above water level) could be removed to the sediment elevation. The dam would likely then be notched to allow the sediment to erode a channel through the reservoir area. When the sediment level was down to the notch, the remaining dam will be lowered to the notch level and a new notch would be excavated. Some mechanical movement of the sediment (pushing the side slopes toward the channel) may be required to ensure the sediment is removed equally

across the reservoir. This would be repeated until the dam is removed. Each proceeding notch may also need to be moved to a different location on the dam to help erode the entire reservoir area. This would take a much longer time period than alternatives 1A and 1B, as it would depend on channel hydrology and weather. The sediment would eventually travel to the ocean supplying material for beach nourishment. Only small portions of the dam would be removed at one time which would reduce the quantity of concrete to be processed in each phase. The depth of each section to be removed and the estimated time between phases would depend on the sedimentation studies currently being completed.

#### ALTERNATIVE 3 - COMBINATION OF 1 AND 2 ABOVE

Alternative 3 would be some combination of the above alternatives. A combination of alternatives may well produce a less costly more appealing final product than any one individual alternative. This combination alternative, however, will not be carried forward at this point of removal process. The analysis performed for the individual alternatives will provide the necessary insight into potential combinations that can be further studied in the feasibility phase of the removal process.

#### ALTERNATIVE 4 - COMPLETE REMOVAL

Alternative 4 consists of complete removal of the dam without treatment of the sediment. Sediment directly upstream of the dam would be excavated and moved upstream to allow the concrete dam to be removed. After removal of the dam the sediment would be left to erode or re-vegetate in a natural manner. The sediment would likely erode slowly until large flood events occur. During large flood events the sediment would be carried either fully or partially to the ocean. The sediment reaching the ocean would be a source for beach nourishment and meet this portion of the project objective. Sediment which is not carried to the ocean would have the potential to cover existing spawning grounds and raise the flood plane in localized areas. This alternative is considered to have a high risk potential for extreme social and environmental damage. This alternative will not be carried forward at this time.

#### ALTERNATIVE 5 - NO ACTION ALTERNATIVE

The no action alternative would leave the dam in place. As the dam continues to fill with sediment it would eventually become a run of the river structure. Additional sediment would no longer be retained in the reservoir. This would provide material for beach nourishment but would not satisfy any other portion of the project objectives. This alternative will not be carried forward at this time.

#### ALTERNATIVE 6 - CONSTRUCTION OF FISH LADDER/BY-PASS

For this alternative a fish ladder or fish by-pass would be constructed to allow passage of the steelhead upstream either around or over the dam. The dam would be left in place. This alternative possibly could satisfy some portions of the project objectives, but would not fulfill the overall objective of the project. This alternative will not be carried forward at this time.



Notes from flip chart taken during brainstorming session:

### ISSUES

- ◆ Time for benefits is critical
- ◆ Transportation options
  - Mechanical Removal
  - Volume Quantity

### ALTERNATIVES

1. Mechanical removal of sediment.
  - 1A. Move sediment upstream of dam and stabilize.
  - 1B. Remove sediment downstream of dam.
  - 1BB. Remove sediment downstream via a slurry pipeline.
2. Phased natural transport of sediment.
3. Combination of 1 and 2 above.
4. Complete removal
5. No action
6. Construction of fish ladder/by-pass.

### Items that will be included in all removal alternatives

1. All concrete removed from the dam will be transported to a commercial source for recycling. This is to conform to Ventura Counties mandate to reduce solid waste disposal.
2. If contaminants are found they will be removed and properly disposed.
3. Wetland mitigation will be required for all alternatives.
4. Site restoration will be required for all alternatives.
5. A by-pass for Robles Diversion will be included for all alternatives to allow sluicing of sediment from the stilling basin at Robles.
6. The 9-acre privately owned property directly downstream of the dam will be re-acquired before construction.
7. 9-acres is designated a historical site - must protect.
8. A value engineering study using a risk based analysis framework will be conducted in the feasibility stage. This analysis will look at trade offs between cost, environmental impacts and public safety impacts to determine the most desirable alternative.

Alternative 1A - Mechanical Removal - Upstream  
Advantages (+) -- Disadvantages (-)

- + Due to canyon formation it would not be feasible to move sediment downstream of dam and stabilize close to dam.
- + Less traffic impacts
- Forest Service may not agree to allow disposal of sediment material upstream on their land. No technical reason is known at this time.
- + Keep fish habitat - No impact downstream.
- + Minimal impact to Robles Diversion Structure.
- Natural vs. Economics - May be less costly than downstream removal but will not leave upstream canyon in pre-dam condition.
- + Public safety concerns are minimized.
- May conflict with Wilderness Area Designation or Wild and Scenic Designation which the area may be designated in the future.
- + Avoids transportation on public roads, minimizes air pollution and public safety impacts.
- + Reservoir area is owned by Ventura County - May be able to store most/all on this property.
- May not be enough room on Ventura County property.
- Storing sediment on Ventura County property may eliminate the possibility of the county selling the property to the Forest Service as their part of the cost sharing for the project.
- Will not send all the sediment behind the dam downstream for beach nourishment.
- + Will require less time than transporting the sediment downstream or allowing natural staged removal of the sediment.
- May have some erosion during large floods.
- May limit public access?



Alternative 1B - Mechanical Removal - Downstream - Trucking

Advantages (+) -- Disadvantages (-)

- + Potential disposal site exist downstream possibly in the flood plane of the Ventura River (these sites have not been identified or studied). Disposal site will be downstream of Robles Diversion.
- + Minimal impact to Robles Diversion Structure.
- Will not send all the sediment behind the dam downstream for beach nourishment.
- Depositing sediment in the flood plane may raise the flood plane. Would need to coordinate with FEMA for flood zones, flood insurance impacts.
- Will cause traffic impacts on public roads, public safety.
- Will have pollution (air quality) issues.
- + Will protect fish habitat downstream.
- Will likely be more costly then upstream removal.
- + Will return the upstream area to more of a pre-dam condition
- + Trucking could provide control of type of material removed - may be able to process some material for resale/reuse.
- Major floods - higher risk of impacting the design.
- + Good for the trucking industry
- May be restricted bridges that would need modification.
- + Avoids use of Forest Service Lands.
- + No conflicts with wilderness designation

Alternative 1BB - Mechanical Removal - Downstream - Slurry Pipeline  
Advantages (+) -- Disadvantages (-)

- Water supply - need a large water supply for slurry
- Water discharge - Discharge water will need to be treated.
- Environmental impacts - pipeline construction - stilling basin
- Time frame - will take long period of time - can only work when water is available
- If all sediment is transferred it will require processing to reduce size.
- Applicability/usage of material ?
- EPA - Some material may be a pollutant - Trucking will provide control of removal and disposal.
- + Avoids use of Forest Service Lands.
- + No conflicts with wilderness designation

Conveyer belt - May be used with one of the other downstream removal alternatives to transport sediment downstream of Robles Diversion Structure

- Material size and composition - large material would require crushing - wet material cannot be moved on a conveyer belt.

Alternative 2 - Phased natural transport of sediment.

Advantages (+) -- Disadvantages (-)

- ◆ 5' to 10' increments time frame to be determined.
- ◆ Probably wont be able to place the notch in the center of the dam and have sediment be removed from both sides. Likely will need to alternate the notching from side to side to help remove all the sediment.
- ◆ May be able to remove a portion of the center of the dam below sediment elevation and install some type of overflow gate to regulate sediment discharge downstream.
- ◆ May be able to use the existing or abandoned outlet works to control sediment removal for upper portion of the reservoir.
- Long period of time before a measurable benefit.
- Lack of control of type sediment transported downstream.
- Deposits of sediment in the flood plane may raise the flood plane. Would need to coordinate with FEMA for flood zones, flood insurance impacts.
- + Notching may give some control over volume of sediment release over given time period.
- No control over natural deposit points.
- + Slug of sediment during large floods plus for beach nourishment.
- Slug of sediment during large floods may be minus for fish habitat.
- Multiple seasons of construction mobilization and demobilization each construction season.
- Construction cost may be hard to fund a project that runs for several (maybe as much as 50) years with several starts and stops.
- May require land purchase of land that would be most impacted by localized sediment deposition points.
- May have negative long term impacts on fish habitat.
- Negative impacts on Robles Diversion Structure.

Alternative 3. Combination of 1 and 2 above.  
Advantages (+) -- Disadvantages (-)

- + Less costly than alternative 1 - Project completed sooner than alternative 2.
- + Allows more control over variables.
- + May allow more flexibility if natural removal is not working.
- + May be able to be more selective as to which type of material is transported by which means.
- + May allow for some sediment material to be processed for commercial use.
- + May minimize major downstream impacts.
- + May be able to store some material for a short time and then process at a later date for reuse.
- + Accelerates fish habitat benefits over only natural removal.
- Would be difficult to schedule construction around possible natural events. - Would be hard to fund.
- + Can pick and choose between other alternative to minimize impacts and maximize benefits.

Additional Alternative Discussed.

- ◆ Move sediment to downstream side of dam and stabilize. This could act as a fish ladder.
- Material is erosive and velocities will be high downstream of the dam.
- Arch dam is not designed to have loading on downstream side. - Will compromise structural integrity.

## Removal of Dam

### Alternatives:

1. **Controlled Blasting**
    - Flying debris
    - Noise
    - Air blast - damage to structures.
    - + Economical - Experience
  2. **Chemical - drill and use expandable chemicals to crack concrete**
    - Normally not effective or economical for large projects.
  3. **Diamond wire rope sawcutting.**
    - + Is possible would likely be more costly than blasting but would not have some of the safety concerns of blasting.
  4. **Hoe-ram**
    - + Since the brainstorming meeting I have been informed of a 50-foot dam that was removed with hole-rams and it worked well. Reportedly in this instance the hoe-ram worked better in hard concrete and was less effective in poor concrete. The hoe-ram apparently punched into the concrete without the concrete cracking and breaking. The deteriorated condition of the dam concrete may effect this option.
    - May be hard to control breakline horizontal and vertical if used for alternative 2.
- ◆ **Baseline for disposal of concrete will be removal to a commercial source to process and recycling. This is to conform to Ventura Counties mandate to reduce solid waste disposal.**
    - ◆ Will need to identify takers for the concrete - although the amount of concrete in the dam is not a extremely large volume when more traditional disposal methods are considered it may be an overwhelming volume for a commercial processor. Multiple sources may be required or an agency processing site may be required.
    - ◆ Concrete will need to be broken into manageable size pieces after removed from the dam and trucked to the commercial processing plants.

### Timing - Schedule

- ◆ Dewatering of the sediment is a significant issue - If the dam is lowered say 10 feet and the material is allowed to drain, how long until the material is dry enough for mechanical removal? Sediment analysis currently underway will help to answer.
- ◆ Will assume an agreement will be made between the county and the water district to allow all inflow to be diverted - No storage will be required.
- ◆ Funding could likely drive the schedule.

### Funding

- ◆ Project likely \$100 million plus
- ◆ If Federally funded cost must be considered but should not be the driving force. Analysis should focus on benefits and potential benefits.

participants for some/all of the two day meeting

Federico Barajas	US Bureau of Reclamation	(916) 978-5066	fbarajas@mp.usbr.gov
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Ernie Hall	US Bureau of Reclamation	(303) 445-3244	ehall@do.usbr.gov
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James Bailard	BEACON	(805) 684-5747	





**Appendix F - Reconnaissance-Level - Spillway Gate Modification -  
Robles Diversion Dam -  
By: Borcalli and Associates, Inc., Sacramento, California.**



**CASITAS MUNICIPAL WATER DISTRICT**

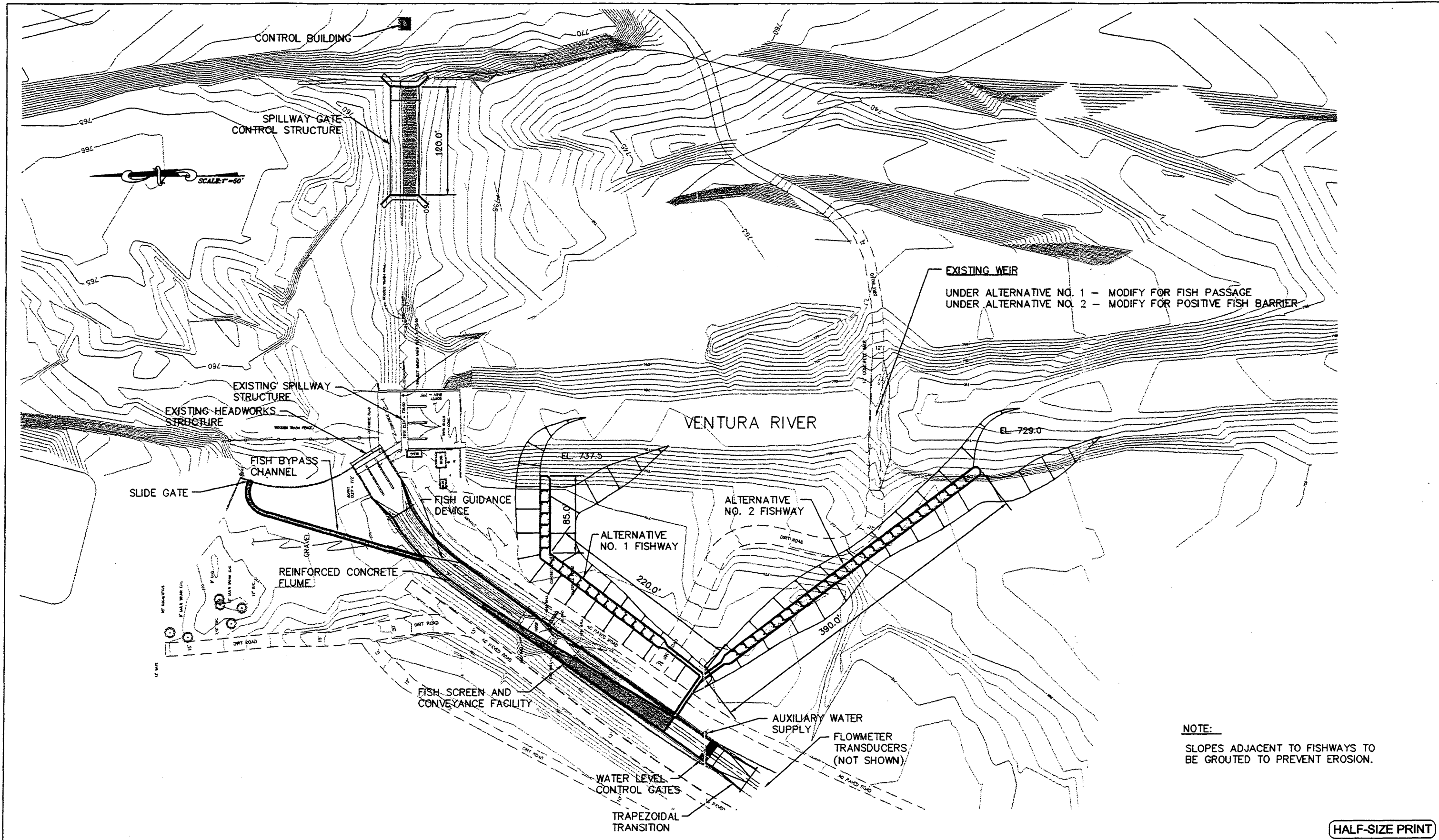
**ROBLES DIVERSION DAM  
FISH SCREEN AND FISHWAY PROJECT**

**SPILLWAY GATE STRUCTURE GATES  
RECONNAISSANCE-LEVEL OPINION OF PROBABLE COST<sup>1</sup>**

Item	Quantity	Units	Unit Cost, \$	Cost,\$
1. Excavation	1,700	CY	15	25,500
2. Structural Backfill	1,000	CY	10	10,000
3. Reinforced Concrete	520	CY	450	234,000
4. Obermeyer Spillway Gate System & Control Building	1	LS	785,000	785,000
Subtotal				1,054,500
5. Contingency @ 25%				265,000
Subtotal				1,319,500
6. Surveys, Engineering, & Construction Management @ 25%				330,000
<b>TOTAL</b>				<b>1,649,500</b>

<sup>1</sup>Does not include channel excavation and bank protection downstream.





**EXISTING WEIR**  
 UNDER ALTERNATIVE NO. 1 - MODIFY FOR FISH PASSAGE  
 UNDER ALTERNATIVE NO. 2 - MODIFY FOR POSITIVE FISH BARRIER

**NOTE:**  
 SLOPES ADJACENT TO FISHWAYS TO  
 BE GROUTED TO PREVENT EROSION.

**HALF-SIZE PRINT**

REV	DATE	BY	CHK	APPR	DESCRIPTION

DESIGNED BY:  
T. BULLER  
 DRAWN BY:  
T. BULLER  
 CHECKED BY:  
F. BORCALLI  
 IN CHARGE:  
F. BORCALLI  
 DATE:  
1/21/00

**BORCALLI & ASSOCIATES INC.**  
 CONSULTING ENGINEERS  
 1418W NORTH MARKET BOULEVARD, SUITE 500A  
 SACRAMENTO, CALIFORNIA 95834  
 TEL (916) 564-3300  
 FAX (916) 564-7622

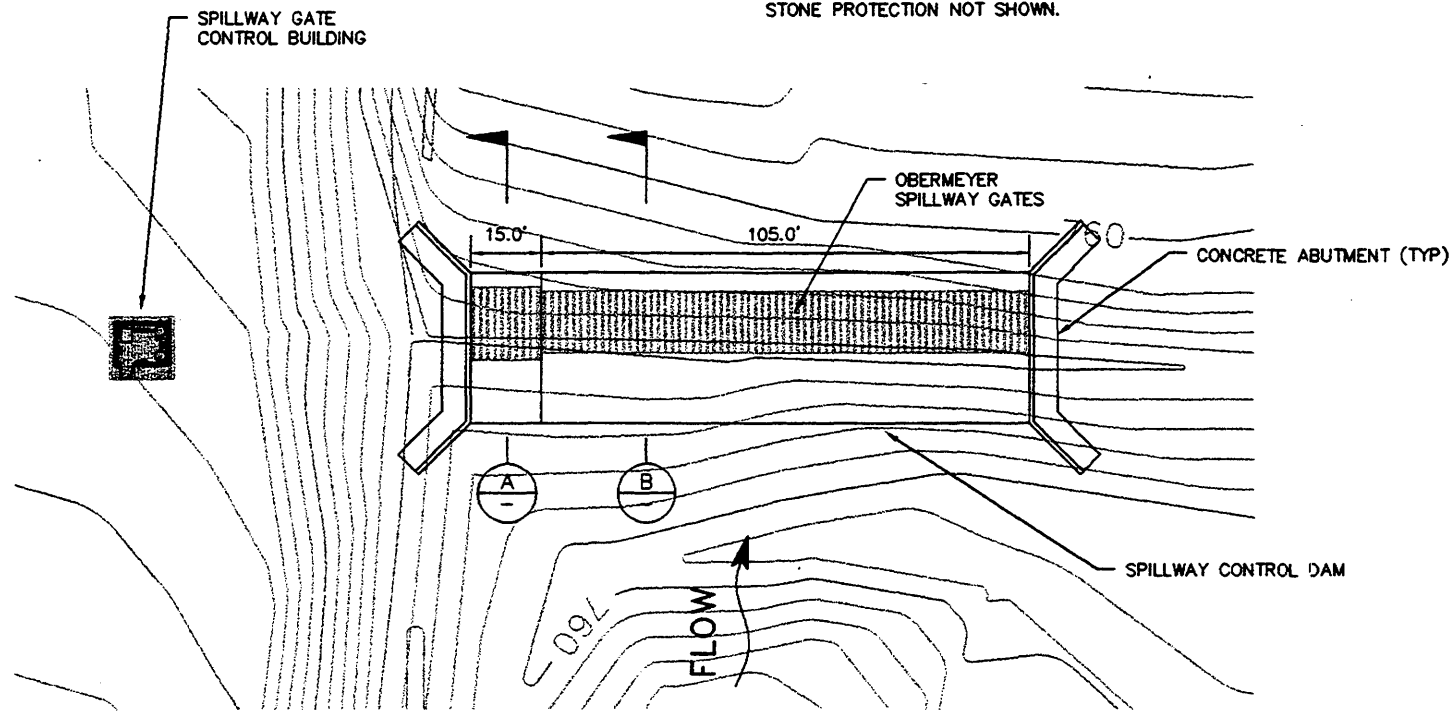
SUBMITTED: \_\_\_\_\_ APPROVED: \_\_\_\_\_

CASITAS MUNICIPAL WATER DISTRICT  
 VENTURA RIVER STEELHEAD RESTORATION AND RECOVERY PLAN  
**FISH SCREEN AND FISH PASSAGE FACILITIES  
 SITE PLAN**

SCALE OF ORIGINAL  
 1" = 50'  
 DRAWING NO. G-4 SHEET 5

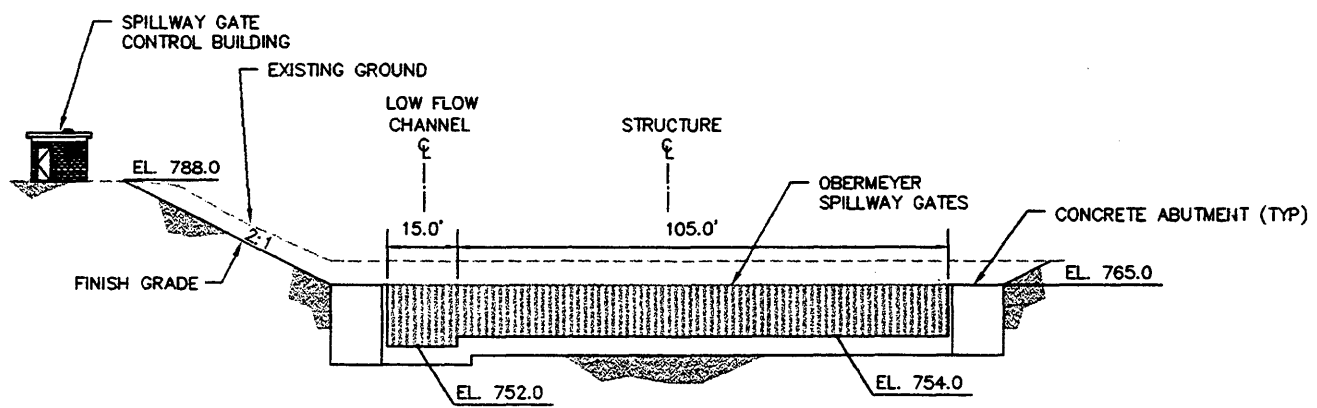
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NOTE: CHANNEL EXCAVATION AND LIMITS OF STONE PROTECTION NOT SHOWN.



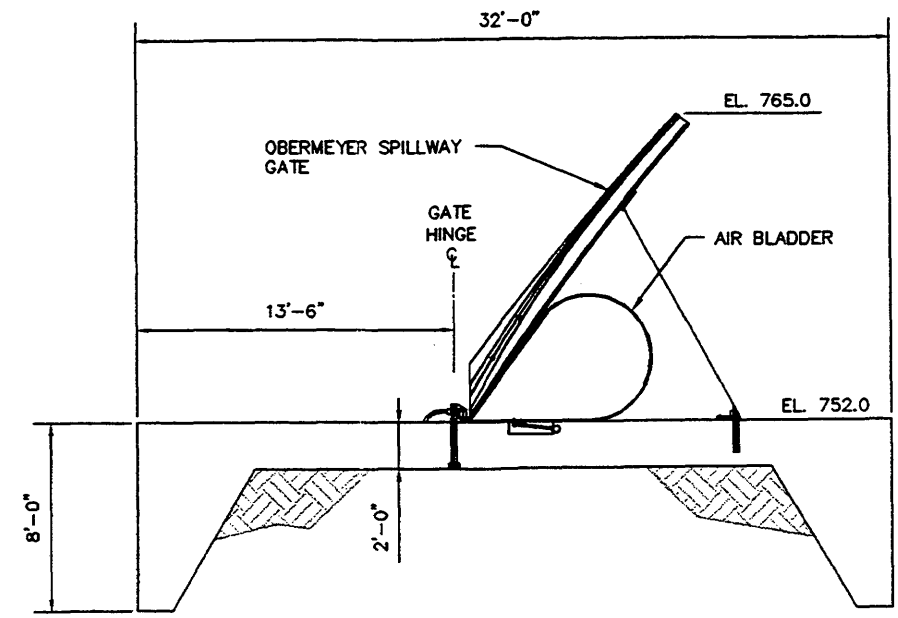
PLAN

SCALE: 1" = 20'



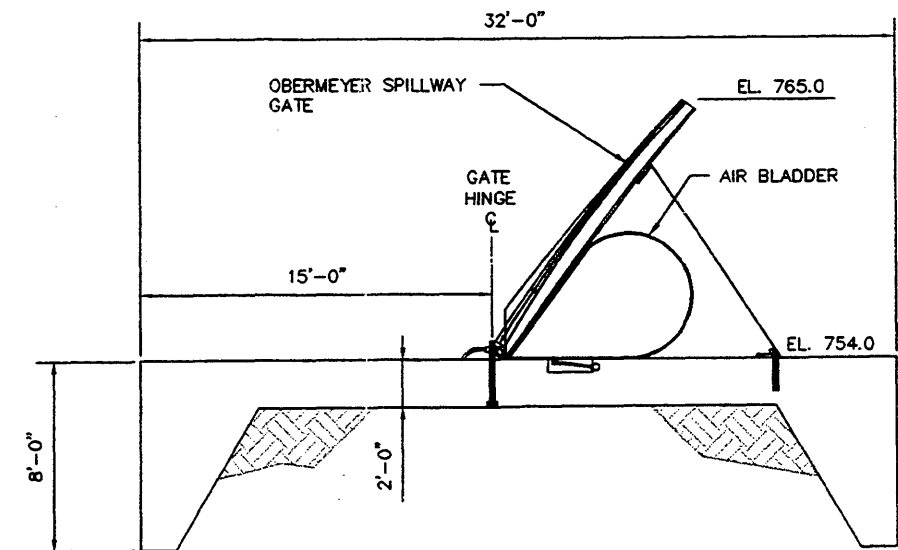
ELEVATION

SCALE: 1" = 20'



SECTION A

SCALE: 1/4" = 1'-0"



SECTION B

SCALE: 1/4" = 1'-0"

HALF-SIZE PRINT

REV	DATE	BY	CHK	APPR	DESCRIPTION	REV	DATE	BY	CHK	APPR	DESCRIPTION

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T. BULLER  
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CHECKED BY:  
F. BORCALLI  
IN CHARGE:  
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SUBMITTED

APPROVED

CASITAS MUNICIPAL WATER DISTRICT  
VENTURA RIVER STEELHEAD RESTORATION AND RECOVERY PLAN

SPILLWAY GATE STRUCTURE  
PLAN, ELEVATION, AND SECTIONS

SCALE OF ORIGINAL

AS SHOWN

DRAWING NO SHEET

SG-1

**Appendix G - Alternative 1BB and Beneficial Use Study by the  
United States Army Corp of Engineers.**





# Matilija Dam Decommissioning Appraisal Report Supplement and Preliminary Evaluation of Environmental Impacts



Los Angeles District  
US Army Corps of Engineers

April 2000



# **FINAL REPORT**

## **Matilija Dam Decommissioning Appraisal Investigations Report Supplement and Preliminary Evaluation of Environmental Impacts**

**April, 2000**

**U.S. Army Corps of Engineers  
Los Angeles District**





## Table of Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
<i>Environmental Impacts.....</i>	<i>1</i>
<i>Alternative 1BB.....</i>	<i>2</i>
<i>Beneficial Uses.....</i>	<i>2</i>
<b>INTRODUCTION .....</b>	<b>3</b>
<b>EXISTING ENVIRONMENT.....</b>	<b>5</b>
<b>ALTERNATIVE 1BB AND COST ESTIMATES.....</b>	<b>9</b>
STREAMFLOW AND DIVERSION .....	10
STRUCTURAL REMOVAL .....	11
SEDIMENT REMOVAL.....	11
<i>Sediment Composition.....</i>	<i>11</i>
<i>Water Supply.....</i>	<i>13</i>
<i>Slurry Pipe Design.....</i>	<i>16</i>
<i>Conveyor Design.....</i>	<i>18</i>
<b>POTENTIAL ENVIRONMENTAL IMPACTS OF ALTERNATIVES 1 AND 2.....</b>	<b>21</b>
GEOLOGY/SOILS/SEDIMENTS.....	21
SURFACE WATER/WATER QUALITY/GROUNDWATER.....	22
VEGETATION.....	23
AQUATIC HABITAT .....	24
FISH .....	25
WILDLIFE.....	26
THREATENED AND ENDANGERED SPECIES .....	26
AIR QUALITY/NOISE/LIGHT.....	27
CULTURAL RESOURCES .....	28
SOCIOECONOMICS .....	28
PUBLIC HEALTH AND SAFETY.....	28
TRANSPORTATION.....	29
RECREATION .....	30
LAND USE/AESTHETICS .....	30
ENVIRONMENTAL JUSTICE .....	31
<b>SUMMARY OF ENVIRONMENTAL IMPACTS.....</b>	<b>37</b>
<b>POTENTIAL METHODS TO AVOID, MINIMIZE OR MITIGATE FOR ADVERSE ENVIRONMENTAL IMPACTS.....</b>	<b>37</b>
<b>BENEFICIAL USES OF SEDIMENT.....</b>	<b>38</b>
BEACH NOURISHMENT.....	38
HABITAT RESTORATION.....	39
FLOODPLAIN REVEGETATION.....	39
COMMERCIAL REUSE .....	39

**REFERENCES ..... 40**

**ATTACHMENT A. Figures**  
**Figure 1.** Sediment Gradation Curves  
**Figure 2.** Proposed Slurry Pipe Alignment  
**Figure 3.** Proposed Slurry Pipe Profile  
**Figure 4.** Slurry Pipe Pumping Station Locations  
**Figure 5.** Slurry Pipe Typical Detail  
**Figure 6.** Proposed Conveyor System Alignment  
**Figure 7.** Conveyor System Typical Detail

**ATTACHMENT B.** Casitas MWD Water Rates

**ATTACHMENT C.** Historic Diversion at Los Robles

**ATTACHMENT D.** Water Supply Spreadsheets

**ATTACHMENT E.** Cost Estimates

**ATTACHMENT F.** Settling Pond Guidelines

**List of Tables**

**Table 1.** Special Status Species..... 8  
**Table 2.** Monthly Streamflow Statistics..... 11  
**Table 3.** Summary of Sediment and Slurry Characteristics ..... 14  
**Table 4.** Pipe Flow Using Variable Runoff..... 14  
**Table 5.** Pipe Flow Using Constant Runoff ..... 16  
**Table 6.** Summary Table of Environmental Impacts and Scale of Effect..... 32

## EXECUTIVE SUMMARY

Ventura County, the U.S. Bureau of Reclamation (USBR) and the U.S. Army Corps of Engineers, Los Angeles District (COE) have initiated reconnaissance level planning processes to preliminarily assess the feasibility and benefits of removing Matilija Dam on Matilija Creek in Ventura County, California. The major objectives of the USBR's study are to: 1) improve aquatic and terrestrial habitat along Matilija Creek and the Ventura River to benefit fish and wildlife species, particularly the endangered Southern California steelhead; 2) restore the hydrologic and sediment transport regime to support downstream coastal beach sand replenishment conditions; and, 3) enhance recreational opportunities along Matilija Creek (including U.S. Forest Service land) and the downstream Ventura River system.

The USBR is evaluating four alternatives for dam and sediment removal (all alternatives would include removing the concrete dam structure and hauling the material to a concrete recycler): 1A) mechanical removal of sediments and placement upstream of the dam; 1B) mechanical removal of the sediments and placement downstream in temporary or permanent disposal sites; 1BB) mechanical removal of the sediments and conveyance downstream by slurry/conveyor; and, 2) phased natural transport of sediments.

The COE has contracted with Tetra Tech, Inc.<sup>1</sup> to prepare preliminary plans and cost estimates for Alternative 1BB and evaluate the potential significant environmental impacts for Alternatives 1 (A, B and BB) and 2. Additionally, beneficial uses of the sediment will be identified, including beach nourishment and habitat purposes. This report contains that information as a second Appraisal Report Supplement to be provided to the COE and USBR. The COE will subsequently utilize the USBR Appraisal Investigation Report and Attachments as a basis for determining a federal interest in proceeding with a cost-shared study with a local sponsor.

*Environmental Impacts.* All of the alternatives evaluated have some adverse effects on the natural and human environment including 1) erosion and transport of fine sediments to downstream areas; 2) loss of lake and wetland habitat around the reservoir (primarily utilized by non-native fish and amphibian species); 3) upstream downcutting of creek bed; 4) loss of vegetation or other habitat at disposal site(s); 5) air quality and noise effects from demolition activities and transport of dam materials and sediments. The major differences between the alternatives are in the scale of sediment transport downstream, water quality impacts and effects on the human environment (traffic, public safety). Alternative 1A would have the potential for much more significant sediment transport and water quality effects than 1B or 1BB because the sediment will be placed in the floodplain of Matilija Creek and has the potential for short-term and long-term erosion. Alternatives 1B and 1BB have greater effects on the human environment because of the need for sediment transport by truck or pipeline/conveyor to a disposal site or sites. Alternative 2 would have very dramatic effects on downstream habitat due to the

---

<sup>1</sup> Formerly known as Simons, Li and Associates.

transport of 6 million cubic yards (CY) of sediment through the Ventura River and its estuary. While the bulk of sediment would be transported rapidly during high flow events there is still a significant potential for filling in aquatic habitats with fine materials during low flows. Since one of the primary goals of dam removal is to restore steelhead habitat, alternative 2 could have significant adverse impacts on steelhead habitat downstream of the dam for many years prior to providing any access above the dam (up to 25 years). This could reduce the viability of the steelhead run long before upstream habitat is accessible.

*Alternative 1BB.* Alternative 1BB outlines a plan for removing the sediment that has accumulated behind Matilija Dam. The volume of sediment is estimated at 6 million CY. The cost of removal is based on building a slurry pipeline and conveyor system to remove the sediment. The slurry pipeline would remove the fine sediment, and the conveyor system would remove the sediment that is too coarse to use in the slurry. The total field cost of this alternative is estimated at \$161 million. This cost includes dam demolition, excavation, sediment processing, water supply and conveyance, pumping, operation and maintenance, revegetation, and contingencies. The feasibility of this alternative depends largely on the water supply available for use in the slurry and the properties of the sediment stored in the reservoir. The sediment excavated from the reservoir would be sorted, and water would be added to the fine sediment before being pumped through the pipeline as slurry. The sediment settling out after discharge from the slurry pipe could be used for beach restoration. The coarse sediment would be moved by conveyor to a temporary stockpiling area downstream of the Los Robles Diversion. The cost estimate will be refined as more data become available.

*Beneficial Uses.* A significant percentage of the sediments are finer than 1 mm which may be smaller than the size suitable for beach nourishment. However, the sands and small gravels in the sediment would be excellent beach nourishment material. Any use of a specific size range of material would require sorting. If material is placed for beach nourishment it should be placed either higher than mean higher high water (MHHW) or in the subtidal zone to avoid impacts to intertidal species such as grunion. Some of the gravel and cobble material could also be utilized for spawning gravel enhancement in the Ventura River or its tributaries. Such placement would have to be investigated further to ensure there would not be increased flooding in localized areas from increased sediments. The finer silts may be suitable, when mixed with organic material, for topsoil. This material could be used in revegetation efforts around the existing reservoir and in downstream areas. The sands and gravels may also be suitable for commercial uses (while the fine material is likely unsuitable).



## INTRODUCTION

Ventura County, the U.S. Bureau of Reclamation (USBR) and the U.S. Army Corps of Engineers, Los Angeles District (COE) have initiated reconnaissance level planning processes to preliminarily assess the feasibility and benefits of removing Matilija Dam on Matilija Creek in Ventura County, California. The major objectives of the USBR's study are to: 1) improve aquatic and terrestrial habitat along Matilija Creek and the Ventura River to benefit fish and wildlife species, particularly the endangered Southern California steelhead; 2) restore the hydrologic and sediment transport regime to support downstream coastal beach sand replenishment conditions; and, 3) enhance recreational opportunities along Matilija Creek (including U.S. Forest Service land) and the downstream Ventura River system. It has been estimated that there could be significant long-term benefits from removing the dam for coastal beach erosion processes and increased production of the endangered Southern California steelhead population (Bailard, 1999; Capelli, 1999a; Chubb, 1997).

The USBR completed a draft Appraisal Investigations Report in February 2000 (USBR, 2000a). This report investigated the volume, material properties (gradation, plasticity limits and moisture content) and potential toxicity of the sediment behind the dam. The estimated volume of sediment behind the dam is 6 million CY, as revised in USBR (2000b). Samples were taken of the sediment in the reservoir bottom and upstream delta area. Samples in the reservoir bottom area were taken in the upper one foot of sediment and samples in the delta area were in the upper 10 feet of sediment. The reservoir bottom sediments were predominantly sandy silt with some organic materials and the delta area sediments were predominantly sands and silty sands with some lenses of sandy silt. Since the samples were only taken from the uppermost layers of sediment, the report acknowledges that it is likely there are layers of coarser materials such as gravels and cobbles beneath the sampled layers (some lenses of gravels were sampled in the delta area).

The sediment samples were tested for metals and total organic carbon. Some of the warm springs further up in the watershed contain sulfides which could oxidize into acidic sulfuric compounds and dissolve heavy metals into the water column. None of the samples exceeded levels of metals which could be classified as even potentially toxic by the California Sediment Standards (CCR 22 part 66261.24). Therefore, the sediment does not have any toxic metals at levels of concern. Additionally, the levels of sulfur in the surface sediment are not high enough to cause acid mine drainage conditions. It is likely that higher concentrations of sulfur exist deeper down in the sediments as a result of anaerobic biological processes.

The USBR (2000b) report also describes six alternatives to accomplish some or all of the project goals and preliminarily screened them based on the project goals and the potential impacts on the environment and other factors. The six alternatives are:

1) *Removal of Dam and Mechanical Removal of Sediments.*

a) Move Sediment Upstream of Dam and Stabilize. The dam would be lowered in multiple increments (estimated two year construction). The sediment would be mechanically excavated down to the depth of the next dam level and placed upstream along the right bank, creating a stream channel along the existing left bank of the creek/reservoir. The material would need to be temporarily stabilized after each increment of placement and then finally stabilized at

the end of construction with a variety of methods including gabions, riprap, geogrids and plantings. Designated as "Alternative 1A" in the USBR's Appraisal Investigations Report.

**b) Move Sediment Downstream of Dam.** The dam would be lowered in multiple increments (estimated four year construction). The sediment would be mechanically excavated down to the next dam level and transported by truck to a disposal site downstream. USBR (2000c) has identified two potential disposal sites, one downstream of the Los Robles Diversion Dam and one east of Ventura at Vineyard Avenue. It is possible that the material would be suitable for commercial resale. Designated as "Alternative 1B" in the USBR's Appraisal Investigations Report.

**c) Move Sediment Downstream of Dam Via a Slurry Pipeline and Conveyor.** The dam would be lowered in multiple increments (estimated five year construction). The sediment would be removed via a slurry (water and sediment) pipeline for the fine sediments (<1 mm) and a conveyor for the coarse sediments, to a disposal site downstream or to a beach nourishment location. The slurry would have significant handling required at a downstream disposal site that was not a beach nourishment location (dewatering of slurry, settling of fine materials, etc.). This alternative could take more time depending upon the availability of water for the pipeline. Designated as "Alternative 1BB" in the USBR's Appraisal Investigations Report.

**2) *Phased Natural Transport of Sediment.*** The dam would be lowered in increments to allow natural transport of the sediment during each high flow season. The proposal is to lower the dam to the existing sediment level and then create a notch in the dam lower than the sediment level which will pass sediment. Mechanical excavation of sediments along the edges of the reservoir may be required to ensure the notch passes all the sediment at one elevation. This alternative would likely take many years (estimated 25 year construction) depending on climatic conditions. This alternative would send most of the 6 million CY of material downstream into Matilija Creek and the Ventura River. Designated as "Alternative 2" in the USBR's Appraisal Investigations Report.

**3) *Combination of Mechanical Removal and Phased Natural Transport of Sediment.*** This alternative would mechanically remove some sediments and allow natural transport of others. This could allow for transport of gravels and suitable stream substrate materials, while removing fine sediments. This alternative will not be evaluated until the individual alternatives have been further evaluated. Designated as "Alternative 3" in the USBR's Appraisal Investigations Report.

**4) *Complete Removal of Dam in One Increment.*** This alternative would remove the dam and then allow natural distribution of the 6 million CY of sediments during one or more high flow seasons. The volume of sediment stored behind the dam would likely have severe effects on stream and floodplain habitat and flood control. This alternative will not be evaluated at this time. Designated as "Alternative 4" in the USBR's Appraisal Investigations Report.

**5) *Construction of Fish Ladder or Other Fish Passage Facilities.*** This alternative would leave the dam in place, but provide fish passage over the dam to the upstream reaches of Matilija Creek. As sediment accumulates behind the dam, eventually it would begin passing naturally over the dam. Designated as "Alternative 5" in the USBR's Appraisal Investigations Report.

**6) *No Action Alternative.*** This alternative would not remove the dam. As sediment accumulates behind the dam, eventually it would begin passing naturally over the dam. No fish

passage to the upstream reaches of Matilija Creek would be provided. Designated as "Alternative 6" in the USBR's Appraisal Investigations Report.

The COE has contracted with Tetra Tech, Inc.<sup>2</sup> (#: DACW09-99-D-0002, Task Order # 0014) to prepare preliminary plans and cost estimates for Alternative IBB and evaluate the potential significant environmental impacts for alternatives 1 (A,B and BB) and 2. Additionally, beneficial uses of the sediment will be identified, including beach nourishment and habitat purposes. This report contains that information as a second Appraisal Report Supplement to be provided to the COE and USBR. The COE will subsequently utilize the USBR Appraisal Investigation Report and Supplements as a basis for determining a federal interest in proceeding with a cost-shared study with a local sponsor.

## EXISTING ENVIRONMENT

Matilija Dam is located on Matilija Creek, a major tributary to the Ventura River which enters the Pacific Ocean in the City of Ventura. The Ventura River drains a watershed of approximately 226 square miles and Matilija Creek drains a subwatershed of approximately 55 square miles. Matilija Creek drains steep foothills and mountains within the east-west (transverse) trending Santa Ynez Mountain Range. The geological formations in this mountain range are a basement complex of crystalline rock overlain by thick layers of sedimentary deposits. They consist of sandstone, siltstone, clay shale, and mudstone (USACOE, 1980). The materials are easily erodible particularly following a fire when the stabilizing vegetation has been eliminated. The lower slopes are predominantly covered with chaparral vegetation communities and the high mountain peaks are dominated by Jeffrey pine (*Pinus jeffreyi*). The creeks support riparian vegetation dominated by cottonwoods (*Populus fremontii*), willows (*Salix* sp.) and other shrubby and herbaceous species. There are a few locations of native sycamore (*Platanus racemosa*) and alder (*Alnus rhombifolia*) riparian woodland (Mertes, et al, 1996). Matilija Creek and the North Fork of Matilija Creek join and form the mainstem Ventura River at river mile (RM) 15.6 and elevation 900 feet. The Ventura River continues down through lower elevations and more coastal scrub/shrub communities to the Ventura River Estuary and the Pacific Ocean.

The Ventura River contains one of the few remaining stocks of Southern California steelhead trout (*Oncorhynchus mykiss*) which are the anadromous form of rainbow trout. Historically, steelhead inhabited most coastal California streams as far south as Baja California (Chubb, 1997), but are now found primarily in the Santa Maria and Santa Ynez River in Santa Barbara County and the Ventura and Santa Clara Rivers in Ventura County (Capelli, 1999a). The pre 1940 population of steelhead in the Ventura River may have been 2000-5000 adults annually (Chubb, 1997; Capelli, 1999a). One of the major reasons for the decline of steelhead in southern California was the construction of water supply facilities (dams and other diversions) which in many cases blocked anadromous fish access to historic spawning and rearing areas and also reduced the flow of water in the streams and rivers. The Matilija Dam prevents fish passage to 10-20 miles of upstream spawning and rearing habitat. Currently, rainbow trout are resident in Matilija Creek upstream of the dam and may be a remnant of the formerly anadromous stock of steelhead. Plants of hatchery rainbow trout and steelhead in most of the Ventura River watershed have muddled the ancestry of the native stock, so it is unclear at this point if the native stock exists in many reaches of the watershed.

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<sup>2</sup> Formerly known as Simons, Li and Associates.

The Matilija Dam and Reservoir are surrounded by steep slopes with a chaparral plant community. Dominant plant species include laurel sumac (*Malosma laurina*), purple sage (*Salvia leucophylla*), ceanothus (*Ceanothus* sp.), California sagebrush (*Artemisia californica*), buckwheat (*Eriogonum* sp.), deerweed (*Lotus scoparius*), and yucca (*Yucca whipplei*) (Mertes, et al, 1997; USFWS, 2000). Chaparral can be important habitat for many species of large and small mammals, numerous birds, and reptiles. The Planning Aid Memorandum (USFWS, 2000) identified many species which typically inhabit chaparral, and includes mule deer (*Odocoileus hemionus*), black bear (*Ursinus americanus*), California quail (*Callipepla californica*), bushtit (*Psaltriparus minimus*), southern Pacific rattlesnake (*Crotalus viridis helleri*), and Great Basin fence lizard (*Sceloporus undulatus biseriatus*).

In the delta area of the reservoir there are between 20-35 acres of wetland habitats transitioning into riparian and floodplain habitats at the upper end of the reservoir (USBR estimates 20 acres, Mertes, et al; 1996 estimates 35 acres). USFWS personnel observed the wetlands and riparian habitats to be dominated by the non-native giant reed grass (*Arunda donax*), willows (*Salix* sp.), bulrush (*Scirpus* sp.), cattail (*Typha* sp.), watercress (*Rorippa* sp.) and unidentified grasses. Giant reed grass can be very invasive and is a dominant plant in floodplain and riparian areas upstream of the reservoir for one to two miles (M. Capelli, pers. comm.). A variety of mammals, waterfowl and amphibians utilize wetlands and seasonally wetted riparian and floodplain areas. USFWS (2000) identified many species which typically inhabit wetlands and riparian zones, and includes raccoon (*Procyon lotor*), ring-necked duck (*Aythya collaris*), green-winged teal (*Anas crecca*), yellow-rumped warbler (*Dendroica coronata*), Pacific tree frog (*Hyla regilla*) and California tree frog (*Hyla cadaverina*). It is likely that southwestern pond turtles (*Clemmys marmorata pallida*) also utilize many of the wetland and open water habitats in and near the reservoir. The reservoir and wetland habitats are also utilized by the non-native species, bull frog (*Rana catesbeiana*) which preys on the native frogs, including the threatened California red-legged frog (*Rana aurora draytonii*).

In the reservoir there are up to 50 acres (depending on season) of open water habitat. Resident rainbow trout (*Oncorhynchus mykiss*) and the non-native predatory smallmouth bass (*Micropterus dolomieu*) are known to occur in the reservoir (USFWS, 2000). The arroyo chub (*Gila orcutti*) may also be present, since it is present in the Ventura River. Non-native species such as channel catfish (*Ictalurus punctatus*) and sunfish (*Lepomis* sp.) are also present in the lake (M. Capelli, pers. comm.).

Downstream of the dam, Matilija Creek flows for approximately 0.6 miles before it joins with the North Fork of Matilija Creek and forms the mainstem Ventura River. The creek flows through a steep sided canyon for this distance with a narrow floodplain and riparian zone. The substrate is primarily cobbles and boulders, likely due to high velocities through the canyon. The Casitas Water District Los Robles Diversion Dam is located at RM 14 on the mainstem of the Ventura River. The Ventura River flows through several constricting canyons downstream of the Matilija Creek confluence interspersed with wider floodplain areas. The floodplain is never more than about 0.5 miles wide, except at the estuary where the floodplain is approximately 1.25 miles wide. The Ventura River substrate is mixed with areas of deposition of sands and wood and areas of gravel and cobble with pools and riffles which provide steelhead/rainbow trout habitat. Riparian zones are dominated by willows, alders (*Alnus rhombifolia*) and cottonwoods with an understory of mulefat (*Baccharis salicifolia*), California blackberry (*Rubus ursinus*), poison oak (*Toxicodendron diversilobum*), and grasses. A wide variety of mammals, waterfowl, songbirds, amphibians and reptiles are found along the Ventura River (Hunt, 1994). Species include previously mentioned species, plus striped skunk (*Mephitis mephitis*), house finch (*Carpodacus mexicanus*), southwestern pond turtle, southern alligator lizard (*Elegaris multicaeratus webbi*)

and other species. Fish species include those previously mentioned plus Pacific lamprey (*Lampetra tridentata*), partially armored three-spine stickleback (*Gasterosteus aculeatus microcephalus*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*) and other non-native species.

The Ventura River Estuary begins about 0.6 miles from the Pacific Ocean, where tidal influence begins. The substrate is a mix of muddy/sandy areas and gravels in the higher velocity channel. A sand bar at the mouth of the river cuts off tidal flows during the summer months when there is little freshwater outflow. Freshwater marshes exist at the upper end of tidal influence and are dominated by narrow-leaf cattail (*Typha domingensis*), duckweed (*Lemna minor*), ditchgrass (*Ruppia cirrhosa*), and enteromorpha (*Enteromorpha intestinalis*). The riparian zone is typically dominated by willows. Saltmarsh occurs at the lower end of the river and is dominated by California bulrush (*Scirpus californica*), Pacific coast bulrush (*Scirpus maritimus*), pickleweed (*Salicornia virginica*) and saltgrash (*Distichlis spicata*). The estuary provides a diverse mix of habitats for primarily small mammals and a large number of migratory and resident birds. Additionally, saltwater fishes are found in the lower estuary such as tidewater goby (*Eucyclogobius newberryi*) and topsmelt (*Atherinops affinis*). (Mertes, et al. 1996)

Twenty-eight special status species may occur in the types of habitat found in the project area, near the dam and reservoir or in downstream areas and includes 14 listed species (federal or state) and 14 species of concern (USFWS, 2000).

**Table 1. Special Status Species**

<i>Common Name</i>	<i>Scientific Name</i>	<i>Status</i>	<i>Geographical Location</i>
<b>Listed Species:</b>			
Southern steelhead	<i>Oncorhynchus mykiss</i>	federal endangered	Ventura River, Matilija Creek
Tidewater goby	<i>Eucyclogobius newberryi</i>	federal endangered	Lower Ventura River
Least Bell's vireo	<i>Vireo bellii pusillus</i>	federal/state endangered	Lower Ventura River
Southwestern willow flycatcher	<i>Empidonax traillii extimus</i>	federal/state endangered	Scrub/Chaparral/Matilija Creek
Brown pelican	<i>Pelecanus occidentalis californicus</i>	federal/state endangered	Ventura River Estuary
California least tern	<i>Sterna antillarum browni</i>	federal/state endangered	Ventura River Estuary
California condor	<i>Gymnogyps californianus</i>	federal/state endangered	Santa Ynez Mountains
Western snowy plover	<i>Charadrius alexandrinus nivosus</i>	federal threatened	Ventura River Estuary, Coastal Dunes
California red-legged frog	<i>Rana aurora draytonii</i>	federal threatened	Matilija Creek
Peregrine falcon	<i>Falco peregrinus</i>	state endangered	Ventura River Estuary
Belding's savannah sparrow	<i>Passerculus sandwichensis beldingi</i>	state endangered	Ventura River Estuary
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	state endangered	Ventura River Riparian Areas, Not Confirmed
Ringtail	<i>Bassariscus astutus</i>	state fully protected	Matilija Reservoir, Ventura River
Black-shouldered kite	<i>Elanus caeruleus</i>	state fully protected	Ventura River Estuary
<b>Species of Concern:</b>			
Arroyo chub	<i>Gila orcutti</i>		Matilija Creek, Ventura River
Southwestern pond turtle	<i>Clemmys marmorata pallida</i>		Ventura River and all Tributaries
Silvery legless lizard	<i>Anniella pulchra pulchra</i>		Coastal Dunes
Two-striped garter snake	<i>Thamnophis hammondi</i>		Ventura River
Tricolored blackbird	<i>Agelaius tricolor</i>		Lower Ventura River Riparian Areas
White-face ibis	<i>Plegadis chihi</i>		Ventura River Estuary
Osprey	<i>Pandion haliaetus</i>		Lower Ventura River
Black swift	<i>Cypseloides niger</i>		Lower Ventura River
Cooper's hawk	<i>Accipiter cooperi</i>		Lower Ventura River
Yellow warbler	<i>Dendroica petechia brewsteri</i>		Ventura River Estuary
Blue grosbeak	<i>Guiraca caerulea</i>		Ventura River Riparian Areas
Yellow-breasted chat	<i>Icteria virens</i>		Ventura River Estuary
Pallid bat	<i>Antrozous pallidus</i>		Lower Ventura River
Western spadefoot toad	<i>Scaphiopus hammondi</i>		Ventura River, Not Confirmed

## ALTERNATIVE 1BB AND COST ESTIMATES

This section addresses the technical feasibility and preliminary cost of transporting the sediment accumulated behind Matilija Dam to a downstream point of disposal by means of a slurry pipeline or conveyor belt. The alternative is designated "Alternative 1BB" within the framework of the USBR's Appraisal Investigations Report (2000a and b). While the optimal approach may be a combination of several alternatives, this analysis assumes that Alternative 1BB will be used exclusive of the other alternatives (1A, 1B, and 2-6) proposed in the report.

Alternative 1BB can be broken down into four potential sub-alternatives:

- Conveyor belt transport of sediment to a land disposal site
- Conveyor belt transport of sediment to the ocean
- Slurry pipe transport of sediment to a land disposal site
- Slurry pipe transport of sediment to the ocean

Each sub-alternative could be broken down further by sediment interval (i.e., conveyor belt transport of fines to the ocean, conveyor belt transport of gravels to the ocean, etc.) Most of these sub-alternatives can be ruled out from the start. The first sub-alternative, conveyor-belt transport to a downstream land disposal site, is technically viable, but the costs are highly dependent on the site location. Two potential land disposal sites were called out in USBR (2000b), the former S.P. Milling site and an unspecified site location on the Ventura River approximately ½ mile downstream of the Los Robles diversion structure. Conveyor belt transport to the S.P. Milling site can be ruled out on the basis of distance (i.e., cost) and the fact that the conveyor alignment would cross through developed areas. Conveyor belt transport of coarse material (that cannot be slurried) over a much shorter distance to a land disposal site downstream of the Los Robles Diversion Dam may be cost effective and is considered in this analysis. The second sub-alternative, conveyor-belt transport for 16.5 miles to the ocean, is also considered briefly in this section.

The third sub-alternative, slurry pipe transport to a downstream disposal site on the Ventura River or elsewhere is technically viable but is ruled out since it would require additional processing costs at the outlet and have unacceptable environmental impacts. Other possibilities might be to combine the slurry with natural transport, either by allowing sediment to accumulate naturally in a debris basin above the Los Robles Diversion and slurrying from there to the ocean or by slurrying from Matilija Reservoir to just beyond the Los Robles structure and allowing natural transport from there to the ocean. These alternatives would most likely result in excessive environmental problems, such as deposition of fine-grained material over existing spawning grounds. The final sub-alternative, slurry pipe transport of sediment to the ocean, is a viable means to transport fine sediment fractions and is included as an alternative herein. The slurry pipe alternatives are considered for the fine material only (see *Sediment Composition* below.)

In summary, this section considers a combination of transport methods: Slurry pipe transport of fine sediment from the dam to the ocean and conveyor belt transport of coarse fractions to a disposal site downstream of the Los Robles Diversion Dam. This combination can be compared with Alternatives 1A and 1B developed by the USBR (2000b). The unit costs of transport by conveyor could be compared with the unit costs of trucking by factoring by the relative distances.

In USBR (2000b), it is assumed that the dam will be demolished in stages and that the crest will be lowered to the level at which sediment is removed. For purposes of comparing Alternative 1BB with Alternatives 1A and 1B, this assumption is carried forward. However, if the dam were left in place for the duration of the sediment removal, it would continue to capture flood flows and could significantly increase the availability of stream water for use in the slurry pipeline. This could 1) reduce the overall time required if stream flow is the only water source, or 2) reduce the cost of purchasing water if other sources are considered. If this option were pursued, excavation of the sediment could be done by means of a hydraulic dredge from a floating barge. The work would initially start in the existing pool near the dam, progressing upstream as material is removed and the water surface is expanded. Dredging costs increase with the depth of water, so this factor would need to be considered along with the cost of water supply.

Advantages to this approach might include:

- Storage capacity would increase as sediments are removed, allowing more flood water to be captured.
- Excavation from the barge could continue through the winter months when stormwater is most available.

Disadvantages to this approach might include:

- The trapping efficiency of the dam would increase, so the reservoir could potentially capture an increasing amount of the incoming sediment from the watershed each year. Major floods could deposit large amounts of debris in the reservoir, which might have been passed through had the dam been notched to the same elevation as the sediment.
- Dredging could be significantly reduced during drought years

The following sections describe the development of the conceptual design and preliminary cost estimate for Alternative 1BB. These sections are outlined as follows for comparison with Alternatives 1A and 1B:

1. Streamflow and Diversion
2. Structural Removal
3. Sediment Removal
  - a. Sediment composition
  - b. Water supply
  - c. Pipeline design and cost
  - d. Conveyor design and cost
4. Site Restoration
5. Summary

## **Streamflow and Diversion**

Streamflows into and out of Matilija Reservoir have been characterized by USGS gages located upstream and downstream of the area. Details on the gage locations and available data can be found in USBR, 2000b. Monthly statistics for the average daily flows are listed in Table 2 below. Flows below the dam are noticeably affected by reservoir operations. The USBR has called out a stream diversion structure with a capacity of 3-5 cfs. Only the minimum flows would be diverted



by this structure, and discharges in excess of 5 cfs would overtop the structure and temporarily flood the work site. For purposes of comparison, this assumption is carried forward.

**Table 2. Monthly Streamflow Statistics – Average Daily Flow (cfs)**

Matilija Creek Above Reservoir Near Matilija Hot Springs, Station #11114500, DA = 50.7 square miles, 1948 - 1969												
	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	1.7	2.3	2.6	1.7	1.4	0.6	0.5	0.4	0.4	0.3	0.6	1.1
Ave.	70	92	49	48	17	9	5	4	3	2	16	25
Max	8610	6210	1410	2530	126	46	23	21	14	9.1	1820	2890
Matilija Creek At Matilija Hot Springs, Station #11115500, DA = 54.6 square miles, 1927 - 1988												
	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	0.1	0.2	0.1	0.1	0.2	0.3	0.6	0.3	0.3	0.2	0.1	0.1
Ave.	48	103	106	52	22	12	8	5	5	4	10	22
Max	8340	6250	7740	2390	332	431	239	80	187	242	1180	2900

## Structural Removal

This alternative utilizes the structural removal process outlined in Alternative 1A: removing the dam in phases concurrent with the sediment removal. If the dam is left in place during sediment removal, demolition could occur in one step at the end of the project. For the appraisal-level design estimates, controlled blasting will be used as the concrete excavation technique. The concrete will be hauled by highway trucking to commercial concrete recycling plants to be recycled. For proposed haul routes from the dam to the recycling plants see Haul Routes, Appendix A-3 (USBR, 2000b).

## Sediment Removal

This alternative examines mechanical removal of the sediment downstream by slurry or conveyor. Two primary variables that affect the pipeline and conveyor design are the sediment composition within the reservoir and the available water supply.

### *Sediment Composition*

The total sediment volume and characteristics are outlined in USBR, 2000a. Large material can damage or clog a slurry pipe. This risk increases with the length of the pipeline; therefore, in order to ensure the optimal operation of the pipeline, a detailed analysis should be performed to determine the maximum sediment size that can be handled by the pipeline. An analysis of the portion of the sediment in the reservoir usable as slurry material would consider a range of particle sizes and sediment concentrations. The ASCE Sedimentation Engineering Manual states, "Little is known about the transportation of graded sediments having a wide range of particle sizes. Previous investigations have concentrated their efforts on the determination of a

characteristic size that will represent the entire range of sediments" (ASCE, 1975.) This alternative assumes a single sediment gradation for use in the slurry mix. Precise separation of the material for slurry may not be practical, so a more detailed design would need to account for the behavior of the pipe under various overload scenarios, such as exceeding the design slurry concentration or gradation.

For this analysis, it is assumed that it would not be economical to transport particle sizes larger than 1mm in diameter by pipeline as slurry over the given distance. Larger particle sizes can be transported using higher velocities; however, the head losses along the pipe (and therefore the pumping costs) would increase accordingly. For the purposes of this study, the sediment in the reservoir is divided into two general categories: the fraction with grain sizes larger than 1mm (coarse) and the fraction with grain sizes smaller than 1mm (fine). The slurry pipeline will be assumed to carry the fine sediment only (silt, clay, and sand fraction smaller than 1.0 mm). USBR (2000b) breaks down the sediment in the reservoir using a historical simulation as follows:

- 38% silt and clay (.00024 - .062 mm)
- 54% sand (.062 - 2 mm)
- 8% gravel and cobbles (2 - 64 mm)

A gradation plot based on the historical simulation (Attachment A, Figure 1) shows that approximately 85% of the sediment by weight has a diameter less than 1mm. The total sediment volume behind the dam is estimated at 6 million CY (USBR, 2000a). Based on the historical simulation, there are roughly 5 million CY of fines (particle diameter smaller than 1 mm). This breakdown assumes that the densities are fairly consistent, i.e., the percent finer by weight is approximately equal to the percent finer by volume. The estimated dry bulk density of the fines is 94 lbs/ft<sup>3</sup> (about 40% voids), giving 6.3 million tons of sediment in 5 million CY. Soil density would presumably increase with depth, and in-situ density tests would be required for the full depth of sediment to refine this value. Figure 1 includes composite curves based on samples taken at the reservoir, which also show about 85% of the material by weight to be finer than 1 mm.

It must be noted that all samples were taken within about 2,000 feet of the dam (USBR 2000b). No samples were taken in the upstream portion of the reservoir, where more gravel is reportedly present. For calculation purposes, 85% will be assumed as the fraction of the sediment that is to be transported through the pipeline. Pebble counts and gradation curves in the upstream portion of the reservoir and deeper samples throughout would result in a better estimate of the existing sediment properties. Boulders in excess of the maximum particle sizes for conveyor systems could be left on site and used as natural bank protection or crushed at the sorting facility.

Based on Table 9 and Figure 18 in USBR (2000b), long-term average sediment inflow to Matilija Reservoir is approximately 110 af/yr, of which 78 af/year has historically been trapped behind the dam. Low inflows occurred from 1964-65 (0 af/yr) and from 1978-86 (25 af/year). High inflows occurred in 1965-70 (248 af/yr) and 1970-78 (223 af/yr). The project schedule will need to account for an increasing volume of sediment, especially if the dam is to be left in place during the sediment removal process.

### *Water Supply*

The slurry mixture will require a large volume of water. Typical slurry concentrations for sand-water mixtures can range from 2% to 20% by volume, where concentration is given as  $Q_s/(Q+Q_s)$  (ASCE, 1975.) High sediment concentrations in slurry mixtures tend to cause deposition and backup problems in pipelines. Given the distance from the reservoir to the ocean, head losses in the pipe would be high. Higher sediment concentrations in a slurry mix result in higher head losses. Head losses can be assumed to increase proportionally to the specific gravity of the mixture (Fairbanks, 1988.) A more detailed analysis of slurry pipe sizes would account for a range of concentrations in various pipe sizes to determine an optimal solution. The optimal solution would balance the cost of providing more energy to pump higher sediment concentrations with the cost of water saved.

For this study, a relatively low slurry concentration of 5% by volume or 13% by weight will be assumed. Given 6.3 million tons of fines, 50 million CY (approximately 31,000 acre-feet) of water would be needed to transport the sediment to the ocean. Historical streamflow records (see Table 2) show an annual average flow of about 40 cfs in Matilija Creek (about 45 million CY). Theoretically, if all of the flow in Matilija Creek were available to mix with the slurry in the pipeline, it could transport 5.8 million tons of sediment per year, or just over 12 months to remove the sediment from the reservoir in an average flow year.

Unfortunately, the reservoir does not have the capacity to store water even from a single major storm event, and average daily wet season flows would fill the reservoir in a matter of days. The USBR estimates the current reservoir capacity at 500 acre-feet (USBR, 2000b). This translates to 0.8 M CY of water storage, barely enough to transport 1% of the sediment in the reservoir down the slurry line at the assumed concentration.

Most of the flow in Matilija Creek occurs during infrequent events in the winter months (USBR, 2000b). Dry weather flows are minimal and are generally not available for diversion. In fact, the Los Robles diversion structure 2 miles downstream of Matilija Dam has a minimum bypass requirement of approximately 20 cfs (USBR, 2000b). The actual water rights are somewhat more complex (USBR, 2000b), but 20 cfs will be used as the assumed minimum flow for this alternative. Attachment C shows the historical diversion at Los Robles and gives a good indication of times when water is available for diversion. The Department of Fish and Wildlife and the National Marine Fisheries Service do not have specific minimum flow requirements for steelhead above Los Robles Diversion, but these needs should be addressed in any plan to divert water at the dam. The majority of the basin area above the Los Robles diversion is tributary to Matilija Creek, so any diversion at Matilija Dam would dramatically affect the available water at Los Robles. Table 3 shows the basic assumptions and constants used in this analysis for sediment and slurry characteristics.

**Table 3. Summary of Sediment and Slurry Characteristics**

Total Volume of Sediment in Reservoir:	6M CY
Fraction of Fines (<1mm):	85%
Total Volume of Fines in Reservoir:	5M CY
Total Volume of Gravel & Sand (>1mm):	1M CY
Bulk Dry Density of Fine Sediment:	94Pcf
Specific Gravity of Solids:	2.65
Percent Voids in Fines:	43%
Dry Weight of Fines:	6.5M tons
Slurry Sediment Concentration by Volume:	5%
Slurry Sediment Concentration by Weight:	13%
Slurry Sediment Concentration:	130,000Ppm
Minimum Bypass Flow in Matilija Creek:	20Cfs
Average Annual Total Sediment Inflow:	70Acre-feet
Volume of Water Required to Remove Fines:	31,000Acre-feet

Table 4, below, shows various potential slurry line sizes along with the approximate time required to transport the fine sediment in the reservoir. Attachment D shows the complete spreadsheet. In Table 4 it was assumed that the first 20 cfs is bypassed, and the remainder could be used in the slurry line. Time estimates are derived from the flow frequency curve in the USBR report (2000b) with a 5% by volume slurry and assume that all slurry water is supplied by runoff. It appears that the minimum time to empty the reservoir is 4 years, regardless of pipe size.

**Table 4. Pipe Flow Using Variable Runoff**

Q water in Matilija Creek (cfs)	Exceedence Frequency (%)	Days per year exceeding Flow (days)	PIPE SIZE Pipe Flow after bypass (cfs)	Sediment Flow in Pipe (cfs)	Daily Sediment Load for given Q (CY)	Net Annual Sediment Removal after Inflow (CY)	Years to Remove Sediment in Reservoir (yrs)
0	100	365	0	0	0	-54568	-
10	35	128	0	0	0	-54568	-
20	20	73	0	0	0	-54568	-
25	17	62	5	0.3	842	-2315	-
30	15	55	10	0.5	1684	43790	66
35	13	47	15	0.8	2526	83748	35
40	12	44	20	1.1	3368	120632	24
<b>45</b>	<b>11</b>	<b>40</b>	<b>25</b>	<b>1.3</b>	<b>4211</b>	<b>154442</b>	<b>19</b>
50	10.5	38	30	1.6	5053	186716	16
60	10.0	37	40	2.1	6737	248190	12
80	7.5	27	60	3.2	10105	340400	9
100	6.5	24	80	4.2	13474	420316	7
120	6.0	22	100	5.3	16842	494085	6
140	5.5	20	120	6.3	20211	561706	5
160	5.0	18	140	7.4	23579	623179	5
180	4.5	16	160	8.4	26947	678506	4
200	4.0	15	180	9.5	30316	727685	4
220	3.5	13	200	10.5	33684	770716	4

Given the small reservoir capacity, most of the slurring would need to be done during the wet season for the runoff to be fully utilized. Sizing the pipe to pass flood flows, however, would not be economical. The expected annual runoff volume varies a great deal year to year, which would make the project schedule highly dependent on the weather. The dry season flow could transport up to 300,000 CY of sediment per year, requiring about fifteen years to empty the reservoir. If the dam were to be left intact during sediment removal, the additional capacity could be used to store runoff.

Another alternative would be to import water to the site. Water rights issues are beyond the scope of this report, but Attachment B shows a rate table for Casitas Municipal Water District. In addition to the meter fee, water rates range from about \$ 0.30 to \$2 per one hundred cubic feet (ccf), or about \$130 to \$870 per acre-foot. The availability of water supply and the viability of transporting water to the dam need to be examined in more detail. The nearest substantial volume of surface water is at Lake Casitas approximately five miles downstream. Groundwater levels at the wells above Los Robles Diversion have historically been fairly stable at an elevation of around 800 ft (over 300 ft below the reservoir bed.) Several 100' to 200' deep domestic wells are operating in the vicinity of the dam; however, these levels may be artificially high due to the reservoir. Pumping costs for providing groundwater to the elevation of the dam crest would also need to be examined in more detail. At this point it does not appear feasible to pump the entire amount of water from underground aquifers due to potential subsidence and effects on surrounding wells. For example, a 25 cfs capacity slurry line would require the equivalent of over 10,000 gpm of water, which far exceeds conventional submersible pump capacities. Wells within Matilija Reservoir, however, could potentially supplement the runoff.

A more detailed analysis would examine various scenarios of supplemental water supply throughout the year. The analysis could make use of a statistical prediction of available runoff based on historical streamflow records. Table 5 shows the time required to remove the fine sediment based on a constantly-available water supply. The time is calculated using 6, 9, and 12 months per year as an operating schedule.

**Table 5. Pipe Flow Using Constant Runoff**

Q			Operating 12 months per year		Operating 9 months per year		Operating 6 months per year	
Slurry Pipe Capacity	Water Supply Rate	Sediment Flow in Pipe	Net Annual Sediment Removal after Inflow	Years to Remove Sediment	Net Annual Sediment Removal after Inflow	Years to Remove Sediment	Net Annual Sediment Removal after Inflow	Years to Remove Sediment
(cfs)	(cfs)	(cfs)	(CY)	(yrs)	(CY)	(yrs)	(CY)	(yrs)
0	0.0	0.0	-54,568	-	-54,568	-	-54,568	-
5	4.7	0.3	252,800	11.5	175,958	16.5	99,116	29.2
10	9.5	0.5	560,169	5.2	406,485	7.1	252,800	11.5
15	14.2	0.8	867,537	3.3	637,011	4.6	406,485	7.1
20	18.9	1.1	1,174,906	2.5	867,537	3.3	560,169	5.2
<b>25</b>	<b>23.7</b>	<b>1.3</b>	1,482,274	2.0	1,098,064	2.6	<b>713,853</b>	<b>4.1</b>
30	28.4	1.6	1,789,642	1.6	1,328,590	2.2	867,537	3.3
40	37.9	2.1	2,404,379	1.2	1,789,642	1.6	1,174,906	2.5
60	56.8	3.2	3,633,853	0.8	2,711,748	1.1	1,789,642	1.6
80	75.8	4.2	4,863,327	0.6	3,633,853	0.8	2,404,379	1.2
100	94.7	5.3	6,092,800	0.5	4,555,958	0.6	3,019,116	1.0
120	113.7	6.3	7,322,274	0.4	5,478,064	0.5	3,633,853	0.8
140	132.6	7.4	8,551,748	0.3	6,400,169	0.5	4,248,590	0.7
160	151.6	8.4	9,781,221	0.3	7,322,274	0.4	4,863,327	0.6
180	170.5	9.5	11,010,695	0.3	8,244,379	0.4	5,478,064	0.5
200	189.5	10.5	12,240,169	0.2	9,166,485	0.3	6,092,800	0.5

For the remainder of this alternative, a slurry pipe capacity of 25 cfs will be assumed (shown in bold in the above Tables 4 and 5). This would give a 19-year removal schedule if one were to rely solely on incoming runoff. Assuming the runoff could be supplemented to provide 25 cfs six months out of each year, the reservoir could be emptied in 4 years. This is the schedule that will be carried forward in the cost estimate.

*Slurry Pipe Design*

Pipeline Alignment

The pipeline will be considered to extend 16.5 miles from Matilija Dam to an ocean outfall. At the outlet, the slurry could either be dumped on the beach and spread with bulldozers or discharged beyond the tidal zone. If the slurry is to be discharged offshore, the outfall would need to be located in water with a depth of at least 20 feet to avoid the most productive intertidal and shallow subtidal zone. Multiple or movable outlet pipes would most likely be required to avoid creating an enormous pile of material offshore. The location would need to be selected to optimize the littoral transport to nearby beaches. Due to the long project schedule and environmental concerns, the alternative of dumping the slurry on the beach is ruled out for this alternative. The preliminary alignment for the pipeline is shown in Figures 2A-2C (Attachment A). A profile of the selected alignment is shown in Figure 3. Portions of the pipeline will be located within the 100-year floodplain. Detailed flow depth, velocity, and duration analyses will be required to determine the expected effects of river flows on the pipe. Anchoring to prevent flotation or dislodgement will have to be considered.

### Slurry Makeup (see *Sediment Composition* above)

For calculation purposes, the slurry is assumed to be 13% sediment and 87% water by weight. The sediment in the slurry would have a  $D_{85}$  value of 1 mm. A sluicing operation or other facility to control the mixture would be required at the pipe inlet. Given the relatively high silt and clay content, much of the sediment may simply disperse once it reaches the ocean – the fraction of the fines usable as beach sand would need to be examined further, but is described briefly in the beneficial use section.

### Pipe Size

The slurry pipe capacity is assumed to be 25 cfs. To maintain sufficient velocities to keep the slurry in suspension, the pipeline will be an 18" high-density polyethylene smooth wall pipe fused in the field. A more detailed analysis would show minimum velocities versus maximum particle sizes for a range of pipe diameters.

Some of the assumptions used in the pipe design are:

- Pumping efficiencies of 75%
- 15 fps minimum velocity to keep solution in a suspended state
- Vacuum control to alleviate potential negative pressures
- Steel connections for significant bends or spans
- A specific gravity of 1.2 was used to account for head losses from the slurry
- 3500' of friction and minor head loss
- Friction slope of .041
- 13,300 Horsepower required
- 30 psi at suction side of pump station
- 8 pump stations at 1125 HP each
- 150 psi normal operating range

Calculations are based on Cybernet Water Modeling software and Fairbanks Morse Hydraulics Handbook. Figure 4 (Attachment A) shows that the required energy input could be reduced by half if the minimum velocity requirement of the pipeline were lowered to 12 fps. Typical details of the slurry pipe, vacuum control, and supports are shown in Figure 5 (Attachment A).

### Operations

A typical operation schedule would involve dredging or trucking the material from within the reservoir to a sluicing facility, where the fines would be mixed with the water supply at the desired concentration. Lift stations approximately every two miles would keep the pressure in the pipe within normal operating range. Extensive monitoring of the pipeline would be necessary to minimize damages from potential backups. Mechanical dispersion may be required to prevent the outlet from blocking itself.

### Real Estate

An overlay of the preliminary pipeline alignment on a Ventura County parcel map shows the alignment crossing 117 parcels, of which 35 are publicly-owned and 82 are privately-owned.

Total acreage of the affected parcels is 4400, and the assessor's office lists the combined land value at \$9.5 million (excluding improvements on 31 parcels with a combined value of \$3.5 million.) The actual land area required for the pipeline would be approximately 40 acres (16 mile long by 20 foot wide easement.) A more detailed analysis of leasing costs or acquisition prices would be required to determine the costs associated with an easement along the proposed alignment. The cost estimate for the pipeline assumes \$1,000,000 in real estate costs as a temporary placeholder.

#### Pipeline cost:

The expected cost of the pipeline is broken down in Attachment E. The total cost of the pipeline before contingency is roughly \$78 million, including the cost of water supply for the slurry. The cost of water conveyance will vary significantly depending on availability and would most likely be a combination of groundwater and surface water. For the purpose of this estimate, water is assumed to be available within 1 mile of the site. Mechanical excavation costs up to the slurry processing facility are used from the USBR (2000b) for comparison purposes, but that cost could be higher if the dam is left intact during sediment removal (due to the depth of water during excavation).

#### Schedule

USBR (2000b) uses a 4-year demolition plan for Alternative 1A and a 2-year plan for Alternative 1B. For the slurry operations, the schedule for Alternative 1B in Appendix C can be used, substituting "excavate and slurry" for "excavate and stockpile." (USBR, 2000b). The total time required to remove the sediment using the slurry pipeline alternative could vary from a minimum of two years, if the required water is available, to 25 years if the water supply is limited to the natural stream flow available after downstream commitments. It is assumed here that 25 cfs will be available six months out of the year. In addition, approximately one year would need to be added to the beginning of the project schedule for installation of the slurry line. Prior to the commencement of sediment removal, approximately three months would be required to lay the pipe (assuming 1000 ft per day of pipe production). An additional six months of sitework may be required to prepare a base for the pipeline. Therefore, assuming a nine-month construction season as noted in the USBR report (2000b), the first construction season would be lost to mobilization efforts. To save time, the sitework could be phased to occur with the initial blasting of the first phase dam removal.

The time schedule presented above assumes that the dam will be lowered as the sediment is removed. However, if the dam is left in place to store flood flows during the project, demolition could revert to the USBR's 2-year plan, and would take place at the end of the sediment removal phase. The time schedule for the case in which the dam is left in place until the after the sediment is removed could utilize year-round operations. This would take advantage of flows during the wet season, with the risk that large floods could bring more debris into the reservoir.

#### *Conveyor Design*

#### Conveyor Alignment

Figure 6 shows a preliminary alignment of the conveyor system. Near the dam, the alignment generally follows the existing road. Further downstream, the alignment follows the edge of the



river until it reaches the temporary disposal site. Any portion of the conveyor within the 100-year floodplain would need to be raised above an assumed water surface elevation. Risk analyses that determine this level would be part of a future study.

This alternative would most likely need to be combined with trucking, as the costs of constructing a conveyor system all the way to the ocean are prohibitively high. An intermediate temporary stockpiling area must therefore be selected for this approach. For consistency with the analyses of Alternatives 1A & 1B, the stockpiling area will be selected as the site just downstream of the Los Robles Diversion Dam. The haul distance is estimated as 30 mi. for comparison with Alternative 1B. The coarse sediment from the reservoir will be conveyed via conveyor belt from the reservoir to the temporary stockpiling area, where it will be sorted and used for sand and gravel operations or other beneficial use. Sorting and hauling costs from the temporary location will vary significantly, depending on the selected location. To save costs, the conveyor could follow the same alignment as the pipeline. The 20' base cleared for the pipeline would need to be widened to approximately 30'. Above Los Robles, the conveyor would follow the same profile as the pipeline above Los Robles in Figure 3 (Attachment A).

#### Makeup of material (see *sediment composition* above)

The material transported by conveyor is assumed to be the coarse-grained material only, as the fine-grained material would be transported in the slurry line. The cost could also be factored, however, to include the entire volume of sediment from the reservoir. The capacity of the conveyor is limited by the maximum particle size (6" maximum particle size for a 36" conveyor), so the same conveyor system could convey the fines along with the coarse material.

#### Conveyor Capacity

A 36" conveyor could transport approximately 1000 tons of sediment per day. For 2.2 million tons of coarse material, the conveyor would need to operate for 2200 hours. If the fines were to be added, 12,000 hours would be required to transport the entire volume of sediment. A typical detail for a conveyor system is shown in Figure 7. Following are assumptions used in the cost estimate:

- 8 drives at 300 hp each
- 10' modules
- 1000 tons per hour capacity
- 500' per minute conveyor speed
- Multiple segments to account for bends
- Maximum particle size 6"

#### Operations

A typical operation would consist of transporting the sediment in the reservoir to a sorting plant or sluicing facility by dredge or tracked vehicles. After initial dewatering, the conveyor would transport the coarse sediment 2.5 miles downstream to a temporary stockpiling site. Sorting and hauling would need to occur concurrently with conveyor operations, since the temporary site would probably not be able to accommodate the entire estimated 1,000,000 CY of coarse material from the reservoir. If the material dries, water would need to be added to control dust. Monitoring of the system is extremely important to prevent breakdown of the line.

### Real Estate

Property values can be factored based on the estimate for the 16-mile pipe alignment. The conveyor belt could utilize the same easement as the slurry pipeline, so costs are not separated. For a rough estimate here, the real estate cost from the pipeline is factored based on the relative area in question.

### Conveyor Cost

The total cost of the conveyor system is broken down in Attachment E. A preliminary cost estimate for a 2.5-mile conveyor system with a capacity of 1,000 tons per day is \$21 million before contingencies. This figure includes final disposal, but excludes duplicate costs already covered by the slurry pipeline. Removal costs from the reservoir to the sorting plant are used for comparison purposes (USBR, 2000b), but that cost could be higher if the dam is left intact during sediment removal. For comparison to Alternative 1B, Attachment E also breaks down the cost of conveying the entire 6 million CY of sediment with the conveyor system. Removal costs are assumed to be offset by the salvage value of the system. Total field cost for this breakdown is \$149 million, about half of which is the cost of hauling from the temporary site.

### Schedule

The conveyor could utilize the base prepared for the slurry pipeline, although the base would need to be wider to accommodate both. After site work, assuming 500' per day of production, the conveyor could be installed in one month. The conveyor operation schedule will be limited by the removal of fines, since the coarse material would not be available for conveyance until the sediment in the reservoir has been sorted. 2000 hours of operation would be required to move the coarse sediment. It is assumed that this operation would take place as needed rather than continuously. 12,000 hours of operation would be required to move all of the sediment (coarse and fine).

## 4. SITE RESTORATION AND MITIGATION

The new streambed and surrounding area at the reservoir will be restored to pre-dam conditions wherever feasible, as outlined in USBR (2000b). The project will also likely require compensatory mitigation for such project elements as the pipeline and conveyor corridor(s), and wetland mitigation for loss of the reservoir. Costs cannot be calculated for these mitigation elements at this time because of limited information.

## 5. SUMMARY

The total field cost of this alternative is \$161 million. This cost assumes a 16.5-mile slurry pipeline for the fine sediment and a 2.5-mile conveyor system for the coarse sediment. The cost can be broken down without contingencies or unlisted items as follows:

- \$18 million for dam demolition, diversion, and dewatering (Attachment E, Sheet 1)
- \$78 million for 16.5-mile slurry pipeline, pumping, and water supply (Attachment E, Sheet 2)
- \$21 million for 2.5-mile conveyor system and hauling operations (Attachment E, Sheet 3)

The total cost of \$161 million includes dam demolition, excavation, sediment processing, water supply and conveyance, pumping, operation and maintenance, revegetation, and contingencies. This alternative may be combined with others for an optimal solution. The conveyor cost and slurry line costs can be factored and considered separately if they are to be combined with other alternatives. A separate analysis of transporting all sediment (coarse and fine) with the conveyor system to Los Robles, gave a total field cost of \$149 million, including the cost of hauling to a final disposal site (Attachment E, Sheet 4).

For a rough comparison of the costs of the slurry pipe to the conveyor system, unit costs of the pipe can be compared with unit costs of the conveyor over the entire 16.5-mile distance. Assuming the site work for both alternatives is the same, the cost of purchasing and installing the 18" pipeline is estimated at \$150 per lineal foot (\$13 million total). The cost of purchasing and installing the conveyor is estimated at \$300 (\$26 million total). The additional cost of the conveyor would need to be considered against the cost and availability of water supply to determine the most cost-effective alternative.

## POTENTIAL ENVIRONMENTAL IMPACTS OF ALTERNATIVES 1 AND 2

### Geology/Soils/Sediments

*All Alternatives:* The USBR has proposed to place coffer dams upstream and downstream of the sediment excavation zone and divert the creek around in pipes or ditches (no other details available). With ditches there is a high potential for eroding the sediment in the ditches unless they are tightlined. The sediment is also proposed to be dewatered using wells or pumps with the water transported downstream of the dam to a settling pond. The settling pond would likely have to be quite large to effectively settle out the very fine materials present in the sediment (see Attachment F for information on sizing settling ponds). The sediments would likely be primarily less than 1 mm (fine sands and silts) which could be transported downstream of the dam into Matilija Creek and the Ventura River, and would likely be deposited in pools or spawning gravels at low flows (although flushed out during high flows). Additionally, the Los Robles Diversion Dam could experience increased sedimentation and require maintenance to keep the intakes working correctly, and sediment may deposit in areas of the Ventura River causing localized elevated flood levels. There would likely be some continuing erosion of sediments and transportation downstream for some years following removal of the dam while the banks are being stabilized. The Matilija Creek channel upstream of the reservoir will also likely experience some downcutting and stability changes as a result of the gradient being steepened through the reservoir reach. Following removal of the dam, Matilija Creek will transport sediment that would have been held back by the dam (increased sediment load), but this will recreate the natural sediment transport process and is not expected to have adverse effects on Matilija Creek or the Ventura River.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The mechanical removal of sediments would have the potential for sloughing sediments into the creek which would also be transported downstream. The sediments removed in each increment would be placed along the right half of where the reservoir currently exists. The material would be placed in a large pile in the range of 10-20 feet high alongside about 6000 linear feet of new creek channel. This pile

would fill in the existing floodplain of the creek creating a narrower more canyon-like channel, but with an erodable bank adjacent to the creek. The USBR has proposed to stabilize the pile with a combination of rock, gabions and geogrids with plantings. This will reduce the potential for erosion, but will require maintenance over the long term. Some erosion and piping through the rock or other stabilizers is to be expected. Additionally, the material would reduce the potential area of riparian restoration that could occur along this reach of Matilija Creek.

*Alternative 1B, Mechanical Removal and Placement Downstream.* The mechanical removal of sediments would have the potential for sloughing sediments into the creek which would also be transported downstream. The sediments would be placed in a disposal site(s) downstream of Los Robles Diversion Dam or Vineyard Avenue. The Vineyard Avenue site is east of the Ventura River floodplain so there would be no danger of further erosion into the river after removal is complete, but the site downstream of Los Robles Diversion Dam could be subject to erosion since it will be in the floodplain. The remaining reservoir bottom would need to be revegetated to prevent further erosion (approximately 70 acres).

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The mechanical removal of sediments and the slurry and conveyor activities would have the potential for sloughing sediments into the creek which would also be transported downstream. The slurry arriving at a downstream disposal site would require a significant period of settling or dewatering to avoid discharging highly turbid water into the Ventura River. The discharge of slurry into the ocean would place sediments < 1 mm in size in the coastal zone for beach nourishment purposes; however, the fine materials are not the most suitable material for beach nourishment. The Vineyard Avenue site is out of the Ventura River floodplain so there would be no danger of further erosion into the river after removal is complete, but the site downstream of Los Robles Diversion Dam could be subject to erosion since it will be in the floodplain. The pipeline and conveyor alignments could require the removal of significant amounts of vegetation adjacent to the river which could also be subject to erosion. The remaining reservoir bottom would need to be revegetated to prevent further erosion (approximately 70 acres).

*Alternative 2, Phased Natural Transport of Sediment.* The dam would be lowered in increments and the majority of the sediment would be allowed to sluice over the dam and downstream. This could be on the order of several hundred thousand CY of material per year, depending on storm events. This material, composed primarily of sands and finer materials, would be transported downstream of the dam into Matilija Creek and the Ventura River. This large volume of material would deposit in numerous locations of slower water (pools, behind woody debris, bridges, etc.) and also bury the existing substrate. There would be a great chance of causing flooding in several locations.

## **Surface Water/Water Quality/Groundwater**

*All Alternatives.* The lowering of the reservoir will eliminate the open water reservoir area which currently exists and dewater the associated wetlands at the upstream end of the reservoir (up to 35 acres). The groundwater table would be lowered along with the reservoir and creek lowering, likely for several miles upstream of the reservoir as a result of the steepening of the gradient and subsequent downcutting of the creek bed. Although the surface sediments do not contain metals in levels of any concern, there is the potential for some of the deeper sediments to have contaminants which could become dissolved in the water column. The mechanical excavation,

creek diversion and dewatering activities have the potential to discharge turbid water downstream of the dam, even after going through a settling pond.

*Alternative 1A, Mechanical Removal and Placement Upstream.* During mechanical removal of sediments there is a strong likelihood of discharging sediment into the creek causing additional turbidity throughout construction. The material would be placed in the left half of where the existing reservoir is located. There is the potential for further erosion following dam removal and stabilization of sediment, so there may be elevated turbidity and transport of sediment after dam removal.

*Alternative 1B, Mechanical Removal and Placement Downstream.* During mechanical removal of sediments there is a strong likelihood of discharging sediment into the creek causing additional turbidity throughout construction. Following dam removal, there should not be any continuing water quality issues.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* During mechanical removal of sediments there is a strong likelihood of discharging sediment into the creek causing additional turbidity throughout construction. Depending on the pipeline/conveyor alignments, this alternative may require the removal of riparian vegetation which could cause soil erosion and sediment to enter the river. It would be possible to place the pipeline or conveyor on unvegetated bars next to the river, but there would be some risk of flood or debris damage. The discharge of slurry into the ocean would create a large plume of turbidity, and the dewatering process at another disposal site could discharge turbid water into the river. Following dam removal, there should not be any continuing water quality issues.

*Alternative 2, Phased Natural Transport of Sediments.* As a result of the sediment sluicing out of the dam there will be continual very high levels of turbidity, likely whenever there is water passing over the dam. The high volumes of sediment moving downstream could fill in pools and wetlands in the Ventura River or its estuary.

## Vegetation

*All Alternatives.* Existing wetland and riparian vegetation (including non-native arundo) in the delta area of the reservoir and riparian vegetation some distance upstream of the reservoir will die as a result of lack of water when the reservoir (and water table) is lowered. New riparian vegetation could be planted or will recolonize the new creek channel and floodplain following completion of the dam removal. It will take several years for this vegetation to provide equivalent riparian functions, but should be a much larger area of riparian zone than currently exists. Invasive non-native species such as arundo should be removed prior to dam removal activities to prevent recolonization of the disturbed reservoir area and seed migration downstream.

*Alternative 1A, Mechanical Removal and Placement Upstream.* Any vegetation growing on the proposed disposal site would be removed or buried. It is likely that there are several acres of wetlands and riparian zone which would be filled over with sediment. After the placement of sediment is complete, the site would be stabilized with rock, gabions and geogrids and revegetated with chaparral and riparian species as appropriate relative to the water table (willow,

alder, mulefat, laurel sumac, etc.) to stabilize the sediment and replace natural habitat functions. It may take 5-10 years or more to begin to replicate riparian habitat values.

*Alternative 1B, Mechanical Removal and Placement Downstream.* Vegetation may have to be removed from the disposal site(s) prior to placement of sediment. If the material was taken to commercial operations, no removal of vegetation would be necessary.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* Vegetation will likely be removed from the pipeline/conveyor alignment and may also have to be removed from the disposal site(s) prior to placement of sediment. Placement on eroding beaches may bury existing marine algae/kelp or eelgrass on the site. Kelp or eelgrass would likely quickly recolonize the new substrate after the four year slurry process. The pipeline and conveyor alignment should be restored following completion of dam removal.

*Alternative 2, Phased Natural Transport of Sediments.* Riparian and wetland vegetation downstream of the dam may be buried by the large volume of sediment moving downstream. Vegetation would seasonally recolonize the new substrate, but there would be a lot of instability in the river channel (braiding) for many years.

## **Aquatic Habitat**

*All Alternatives.* Removal of the dam will eliminate the relatively small amount of deep water lake habitat which currently exists in the reservoir. This habitat will be replaced over time by a natural creek channel and habitats. Creek habitats include pools, riffles, glides, and cascades. This would favor creek dwelling fish and invertebrate species and eliminate habitat for lake dwelling fish (mostly non-native) and invertebrates. Additionally, many acres of wetlands in the delta area of the reservoir would be dewatered. Some wetland areas will likely develop in the floodplain and side channels of the new creek channel, but they will likely be much smaller and have different plant communities and functions. During construction of all alternatives there will be transport of some volume of sediments downstream of the dam which could fill in aquatic habitats such as pools and wetlands in Matilija Creek and the Ventura River.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding and it will prevent the formation of a relatively large riparian/floodplain zone adjacent to the new creek channel. This material could be transported downstream and could fill in aquatic habitats such as pools and wetlands in Matilija Creek and the Ventura River.

*Alternative 1B, Mechanical Removal and Placement Downstream.* Material placed in the floodplain could erode and enter the Ventura River filling in pools or wetlands. Following removal of the dam, there should be no effects on aquatic habitat downstream of the dam.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* Material placed in the floodplain could erode and enter the Ventura River filling in pools or wetlands. The slurry entering marine waters could bury existing subtidal habitats. The material would quickly be redistributed by wave action and long-shore currents and some of the material could nourish beaches. Following removal of the dam, there should be no effects on aquatic habitat downstream of the dam.

*Alternative 2, Phased Natural Transport of Sediments.* The material transported downstream will fill in or bury most of the existing aquatic habitat in the lower reach of Matilija Creek and the Ventura River and estuary. Over a time period of many years, the large pulse of sediment will be transported into the ocean by high flows, but will likely cause channel instability (braiding) for a long time.

## **Fish**

*All Alternatives.* Removal of the dam will eliminate deep water lake habitat which is currently inhabited by rainbow trout, smallmouth bass, channel catfish and sunfish (USFWS, 2000; M. Capelli, pers. comm.). The new creek channel should be suitable for rainbow trout and steelhead and the arroyo chub, and have a variety of habitats including pools, riffles and glides. Removal of the dam will provide access to 20 miles of spawning and rearing habitat for anadromous steelhead upstream of the dam, likely increasing the production and overall population; perhaps by as much as 1100 adults per year (Chubb, 1997). Smallmouth bass is a non-native species which can be a significant predator on juvenile salmonids and other native fish, it would likely be reduced in population after removal of the lake because it prefers lacustrine or other slow-moving habitats, but many of those fish (and catfish and sunfish) will probably re-establish themselves in the lower reaches of the Ventura River, where bass currently exist. Downstream of the dam, the increased sediment load could damage fish habitat, especially by armoring gravel or filling in pools (especially during low flows when pools are the primary habitat for steelhead/rainbow trout) and could smother eggs if they were in the gravel during construction activities. Turbidity can reduce visibility and primary production, abrade fish gills and even cause mortality of fish if the concentrations are very high or over a prolonged period of time. The sediment build-up could also cause localized fish barriers. Over time, the sediments transported during dam removal and following dam removal from creek bed downcutting would be transported all the way down the Ventura River to its estuary and mouth. Fish species in the estuary include tidewater goby, topsmelt, common carp, largemouth bass, arroyo chub, and partially armored three-spine stickleback. These species could be adversely affected by turbidity and larger volumes of sediment moving through the estuary, although mud and sand substrates are important habitats for tidewater gobies (Hunt, et al; 1992). Removal of the dam will restore a natural flood and sediment regime to Matilija Creek and incrementally the Ventura River, allowing the river to naturally create aquatic habitat.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This could bury aquatic habitat or smother eggs of fish downstream in Matilija Creek or the Ventura River even following dam removal.

*Alternative 1B, Mechanical Removal and Placement Downstream.* Once dam removal is complete, there should not be any further adverse effects on fish or fish habitat.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* Once dam removal is complete, there should not be any further adverse effects on fish or fish habitat.

*Alternative 2, Phased Natural Transport of Sediments.* If the yearly volumes of material were large (>100,000 CY) resultant effects of burying fish habitat, turbidity and smothering of eggs would be a very significant impact. This would dramatically affect the quality and quantity of fish habitat in each reach of the river which the pulse of sediment moved through, until it was

transported into the ocean. When the sediment reached the ocean, it would be transported naturally along the shoreline and may renourish eroding beaches and other nearshore habitats.

## Wildlife

*All Alternatives.* Removal of the dam will eliminate open water reservoir habitat and the associated wetlands and riparian zone in the delta area of the reservoir. Wildlife species observed or expected at the site include Pacific tree frog, California tree frog, western toad, common yellowthroat, yellow-rumped warbler, and various waterfowl, and possibly the southwestern pond turtle. A non-native species, the bullfrog also utilizes this habitat. The bird species could likely range upstream and downstream of the construction site without significant impact and the waterfowl could migrate over to other lakes such as Lake Casitas. The native frogs will benefit from an increased riparian zone, and the non-native bullfrog will lose habitat. A survey for southwestern pond turtles should be conducted to determine if loss of lake habitat will be detrimental to this species. Large mammals such as black bear which are found in the Matilija Creek watershed could benefit if an increased steelhead population provided increased foraging opportunities. There will be some volume of sediment transported downstream during dam removal operations which could partially fill in wetlands adjacent to the Ventura River reducing their value for amphibians and other wildlife.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This material could be transported downstream and fill in some wetlands adjacent to the Ventura River and its estuary. This could change the plant communities by providing more high marsh area at the expense of low marsh or mudflat area. This material could continue to be transported even after dam removal.

*Alternative 1B, Mechanical Removal and Placement Downstream.* Vegetation may have to be removed from the disposal sites and may eliminate several acres of habitat which could be utilized by many wildlife species.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* Vegetation will have to be removed from the pipeline/conveyor alignments and will eliminate several acres of habitat and possibly disturb migration corridors for many species of wildlife.

*Alternative 2, Phased Natural Transport of Sediments.* If the yearly volumes of sediment were large (>100,000 CY) it would fill in or bury wetlands and riparian areas adjacent to the Ventura River and estuary. This could dramatically change the plant communities and associated wildlife habitat for many species. The channel would be very unstable (braiding) for many years and eliminate many of the riparian and wetland plant species. The sediment would seasonally recolonize, but likely with weedy species such as arundo and other herbaceous plants.

## Threatened and Endangered Species

*All Alternatives.* Removal of the dam will eliminate open water reservoir habitat and the associated wetlands and riparian zone in the delta area of the reservoir. Species which may utilize this habitat include several listed species or species of concern including: southwestern willow flycatcher, ringtail, California red-legged frog, yellow-billed cuckoo, southwestern pond turtle, and blue grosbeak. The bird species could likely range upstream and downstream of the



construction site without significant impact and the waterfowl could migrate over to other lakes such as Lake Casitas. The red-legged frog will benefit from an increased riparian zone, and the non-native bullfrog which preys on native frogs will lose habitat. A survey for southwestern pond turtles should be conducted to determine if loss of lake habitat will be detrimental to this species. The new creek channel could be revegetated or naturally recolonize with riparian species to provide a new riparian zone in 5-10 years. This would provide approximately equivalent habitat for riparian dependant species, over time. During dam removal, transport of sediments downstream could fill in aquatic, wetland and riparian habitats in and adjacent to Matilija Creek and the Ventura River and estuary. This could temporarily reduce habitat available for steelhead, tidewater goby, arroyo chub, southwestern pond turtle, least Bell's vireo, California least tern, Belding's savannah sparrow, ringtail, western snowy plover, yellow-billed cuckoo, tricolored blackbird, white-faced ibis, osprey, yellow warbler, blue grosbeak, yellow-breasted chat and western spadefoot toad. However, once the dam is removed, steelhead will have access to 20 miles of spawning and rearing habitat upstream of the dam.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This could cause additional transport of sediments downstream and fill in or bury aquatic, wetland and riparian habitats adjacent to the Ventura River and estuary. This could further reduce habitat available for steelhead, tidewater goby, arroyo chub, southwestern pond turtle, least Bell's vireo, California least tern, Belding's savannah sparrow, ringtail, western snowy plover, yellow-billed cuckoo, tricolored blackbird, white-faced ibis, osprey, yellow warbler, blue grosbeak, yellow-breasted chat and western spadefoot toad.

*Alternative 1B, Mechanical Removal and Placement Downstream.* Following dam removal, there should be no other significant effects from sedimentation on Matilija Creek and the Ventura River. Removal of vegetation and placement of material at the disposal site(s) could have effects on threatened or endangered species which might utilize those sites.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The removal of vegetation for the pipeline/conveyor alignment could temporarily reduce habitat available for and cause a disturbance to yellow-billed cuckoo, ringtail, southwest willow flycatcher, two-striped garter snake, tricolored blackbird, osprey, black swift, Cooper's hawk, blue grosbeak, and pallid bat. The potential erosion of sediment from the denuded alignment could also temporarily damage aquatic habitat for steelhead, tidewater goby, arroyo chub, and southwestern pond turtles. The alignment(s) should be revegetated following dam removal.

*Alternative 2, Phased Natural Transport of Sediments.* The downstream transport of large volumes of sediment will fill in or bury aquatic, wetland and riparian habitats in and adjacent to Matilija Creek and the Ventura River and estuary. This could significantly reduce habitat available for steelhead, tidewater goby, arroyo chub, southwestern pond turtle, least Bell's vireo, California least tern, Belding's savannah sparrow, ringtail, western snowy plover, yellow-billed cuckoo, tricolored blackbird, white-faced ibis, osprey, yellow warbler, blue grosbeak, yellow-breasted chat and western spadefoot toad.

## **Air Quality/Noise/Light**

*All Alternatives.* During removal activities at the dam, there will be smog and other pollutants generated from the use of heavy equipment and trucks as well as noise, in the immediate dam

area. If the sediments are dry during removal, there could be dust generated. These effects will continue throughout the construction period, but will stop following dam removal. The concrete dam structure will be transported to a commercial source for recycling. This will require many truck trips along the haul route (highway 33 and other roads). There will be no long-term effects on air quality, noise or light.

*Alternative 1A, Mechanical Removal and Placement Upstream.* Additional smog, other pollutants and noise could be generated due to rehandling of material to place at upstream disposal site. Grading and shaping the new bank slope could generate dust. Following final site work there will be no long-term effects on air quality, noise or light.

*Alternative 1B, Mechanical Removal and Placement Downstream.* The transport of sediment via truck to the downstream disposal site(s) will necessitate up to 600,000 truck trips over a 48-64 kilometer haul route. This will generate significant quantities of smog, other pollutants and noise for residents adjacent to highways 33, 150 101, Vineyard Avenue or Toland Road. If the material is moved again from the disposal site to a beach nourishment site, there will be additional temporary air quality, noise and light impacts during placement. Following completion of all sediment transport and site work there will be no long-term effects on air quality, noise or light.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The pipeline and conveyor systems and their associated pumps will create noise that could disturb wildlife and people within about 1/2 mile of the alignment. There would not be any significant effects on air quality or light. If the material is moved from a temporary disposal site to the beach nourishment or other permanent location, there will be temporary air quality, noise and light impacts. Following final site work there will be no long-term effects on air quality, noise or light.

*Alternative 2, Phased Natural Transport of Sediments.* Dust could be generated from depositions of fine materials downstream of the dam in Matilija Creek or the Ventura River, if the deposits were not quickly colonized by plant species. Otherwise, there would be no effects on air quality, noise or light beyond the construction activities describe above for all alternatives.

## **Cultural Resources**

*All Alternatives.* A nine acre historic site is located downstream of the dam (Matilija Hot Springs). Construction activities will need to be planned to avoid effects on this site. An investigation of other potential cultural resource sites will need to be conducted to determine if there is any likelihood of pre-settlement cultural resources (Chumash Indian artifacts, etc.).

## **Socioeconomics**

*All Alternatives.* Dam removal activities will provide employment for a number of various construction industry companies and personnel for up to several years.

## **Public Health and Safety**

*All Alternatives.* Sediments transported downstream of the dam during construction activities have the potential to deposit in areas of Matilija Creek and the Ventura River. This could cause localized flooding. Following removal of the dam, there will be a future increased sediment load coming from Matilija Creek, since the dam will no longer be trapping sediment. This will

increase the volume of sediment moving through the Ventura River and could cause localized flooding in perpetuity. During dam removal activities there is an increased risk of spills of fuels and oils or other hazardous materials.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This could cause additional transport of sediments and increase localized flooding following dam removal.

*Alternative 1B, Mechanical Removal and Placement Downstream.* There could be an increased risk of traffic accidents from the large number of trucks that would be transporting sediment to the downstream disposal site(s) or beach nourishment locations.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The slurry entering marine waters could require beach closures during dam removal activities. If the material is moved from a temporary disposal site to a beach nourishment location there could be an increased risk of traffic accidents from the trucks that would be transporting the sediment to the beach nourishment location.

*Alternative 2, Phased Natural Transport of Sediments.* There will likely be large volumes of sediment moving downstream through lower Matilija Creek and the Ventura River and estuary. This could cause localized flooding in many areas. Bridges and other structures could accumulate sediments and be damaged during high flows.

## **Transportation**

*All Alternatives.* Construction equipment operating around the dam may cause traffic disruptions during dam removal. The concrete dam structure will be transported to a commercial source for recycling. This will require many truck trips on the haul route (highway 33 and other roads).

*Alternative 1A, Mechanical Removal and Placement Upstream.* This alternative should not have any effects on transportation other than those identified above for all alternatives.

*Alternative 1B, Mechanical Removal and Placement Downstream.* The transportation of sediment to the downstream disposal site(s) will require up to 600,000 round-trip truck trips. This could dramatically affect traffic conditions along the haul routes (highways 33, 150, 101, Vineyard Avenue or Toland Road), and cause significant damage to the roadways. If the material is moved from the disposal site(s) to a beach nourishment or other permanent location, there will be additional impacts to traffic and roadways.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* This alternative should not have any effects on transportation other than those identified above for all alternatives, unless the material is temporarily stored downstream of Los Robles Dam and then transported to a beach nourishment or other location. The secondary transport could cause impacts to traffic and roadways.

*Alternative 2, Phased Natural Transport of Sediments.* The deposition of sediment behind bridge abutments and other structures could cause damage during high flows. This could require maintenance or replacement of bridges and other transportation facilities.

## Recreation

*All Alternatives.* Currently the dam and reservoir are not accessible by the public. The removal of the dam and creation of a new Matilija Creek channel could provide additional recreational area for public use. Since steelhead are a listed species, this could pose new restrictions on trout fishing in Matilija Creek and its tributaries upstream of the dam, which would become accessible to steelhead. If the restoration and access to new habitats increases steelhead populations to the point they are no longer listed then recreational fishing opportunities could be dramatically enhanced.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This could be a public safety hazard, or could be exacerbated by public use (could prevent vegetation establishment).

*Alternative 1B, Mechanical Removal and Placement Downstream.* There would be no effects on recreation unless the proposed disposal site(s) are currently utilized for recreation.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The pipeline/conveyor alignment could restrict public access to the Ventura River and the placement of slurry in marine waters could require beach closures.

*Alternative 2, Phased Natural Transport of Sediments.* The sediment transported downstream to Matilija Creek and the Ventura River and estuary could bury or fill in wetland and riparian habitats reducing the passive recreational opportunities (birdwatching, education, etc.) in these areas. The dam removal process would also be much longer, eliminating the possibility of public use of the existing reservoir area for a much longer time period.

## Land Use/Aesthetics

*All Alternatives.* The removal of the dam could provide opportunities for public access to the site that is currently inaccessible. The County may designate the site for public open space and recreation or the Forest Service may purchase the land for recreation purposes. The former reservoir area will appear highly disturbed for a few years until the vegetation/restoration of the new creek channel has taken hold. At that point, the area will likely be much more aesthetically pleasing as a natural creek channel. The increased sediment load coming down Matilija Creek (which will not be held back by the dam) could cause increased flooding along the Ventura River, making floodplain areas even less suitable for development.

*Alternative 1A, Mechanical Removal and Placement Upstream.* The material placed in the existing reservoir area has the potential for eroding. This could create a public safety hazard or make the site unavailable for recreation activities. Also, an eroding pile of sediment may be aesthetically unattractive.

*Alternative 1B, Mechanical Removal and Placement Downstream.* The downstream disposal site(s) will have their use changed by placement of sediments. Vegetation may have to be removed from the site(s). Also, piles of sediment stored at the disposal site(s) may be aesthetically unattractive.

*Alternative 1BB, Mechanical Removal and Slurry/Conveyor.* The placement of beach nourishment materials could protect existing buildings and other structures or facilities near the shoreline.

*Alternative 2, Phased Natural Transport of Sediments.* The transport of large volumes of sediment downstream in Matilija Creek and the Ventura River and estuary could raise flood elevations and cause additional lands to become part of the floodplain. This would make more area less useful for development. The unstable channel and loss of wetlands and riparian zones could be aesthetically unattractive.

### **Environmental Justice**

*All Alternatives.* None of the alternatives would cause more effects to low-income or subsistence populations than to middle or upper income populations. If any low-income housing is located low in the floodplain of the Ventura River it could experience higher flood elevations.

**Table 6. Summary Table of Environmental Impacts and Scale of Effect.**

- Slightly to moderately negative
- Strongly negative
- + Slightly to moderately positive
- ++ Strongly positive

Elements of the Environment	Alternative 1A, Mechanical Removal and Placement Upstream	Alternative 1B, Mechanical Removal and Placement Downstream	Alternative 1BB, Mechanical Removal and Slurry/Conveyor	Alternative 2, Phased Natural Transport of Sediments
Geology/Soils/Sediments	1) Transport of fines during dam removal. - 2) Upstream downcutting. - 3) Erosion of disposal site. -- 4) Filling in floodplain of Matilija Creek. --	1) Transport of fines during dam removal. - 2) Upstream downcutting. - 3) Potential erosion of disposal site in floodplain. -- 4) Filling in floodplain of Ventura River. --	1) Transport of fines during dam removal. - 2) Upstream downcutting. - 3) Potential erosion of disposal site in floodplain. -- 4) Covering up marine substrates. - or +	1) Transport of large volumes of sediment downstream during lengthy dam removal process (25 years). -- 2) Upstream downcutting. -
Surface Water/Water Quality/Groundwater	1) Loss of lake/wetlands. - 2) Lowering of groundwater table upstream. - 3) Turbidity during dam removal. - or -- 4) Turbidity from disposal site until stabilized with vegetation. - or --	1) Loss of lake/wetlands. - 2) Lowering of groundwater table upstream. - 3) Turbidity during dam removal. - or --	1) Loss of lake/wetlands. - 2) Lowering of groundwater table upstream. - 3) Turbidity during dam removal. - or --	1) Loss of lake/wetlands. - 2) Lowering of groundwater table upstream. - 3) Very high turbidity during lengthy dam removal process (25 years). -- 4) Loss of wetlands downstream due to filling. - or --
Vegetation	1) Loss of wetland/riparian vegetation at delta. - 2) New riparian vegetation planted to restore site. +	1) Loss of wetland/riparian vegetation at delta. - 2) New riparian vegetation planted to restore site. ++ 3) Loss of vegetation at disposal site(s). -	1) Loss of wetland/riparian vegetation at delta. - 2) New riparian vegetation planted to restore site. ++ 3) Temporary loss of vegetation along pipeline and conveyor. -	1) Loss of wetland/riparian vegetation at delta. - 2) New riparian vegetation planted to restore site. ++ 3) Loss of downstream wetland/riparian vegetation due to burial in sediment. - or --

Elements of the Environment	Alternative 1A, Mechanical Removal and Placement Upstream	Alternative 1B, Mechanical Removal and Placement Downstream	Alternative 1BB, Mechanical Removal and Slurry/Conveyor	Alternative 2, Phased Natural Transport of Sediments
Aquatic Habitat	1) Loss of lake/wetland habitat. - 2) New creek habitat. ++ 3) Accessible to upper 20 miles of creek. ++ 4) Downstream loss of habitat during dam removal (sedimentation). - 5) Downstream loss of habitat from erosion of disposal site. - or --	1) Loss of lake/wetland habitat. - 2) New creek habitat. ++ 3) Accessible to upper 20 miles of creek. ++ 4) Downstream loss of habitat during dam removal (sedimentation). - 5) Potential erosion of disposal site in floodplain. -	1) Loss of lake/wetland habitat. - 2) New creek habitat. ++ 3) Accessible to upper 20 miles of creek. ++ 4) Downstream loss of habitat during dam removal (sedimentation). - 5) Potential erosion of disposal site in floodplain. - 6) Covering up marine aquatic habitat. -	1) Loss of lake/wetland habitat. - 2) New creek habitat. ++ 3) Accessible to upper 20 miles of creek. ++ 4) Significant downstream loss of habitat during lengthy dam removal process (sedimentation). --
Fish	1) Eliminate lake habitat for smallmouth bass. + 2) Increased stream habitat for rainbow trout/steelhead. ++ 3) Downstream loss of fish habitat during dam removal (sedimentation). - 4) Downstream loss of fish habitat from erosion of disposal site. - or --	1) Eliminate lake habitat for smallmouth bass. + 2) Increased stream habitat for rainbow trout/steelhead ++. 3) Downstream loss of fish habitat during dam removal (sedimentation). - 4) Potential erosion of disposal site in floodplain. -	1) Eliminate lake habitat for smallmouth bass. + 2) Increased stream habitat for rainbow trout/steelhead. ++ 3) Downstream loss of fish habitat during dam removal (sedimentation). - 4) Potential erosion of disposal site in floodplain. - 5) Covering up marine aquatic habitat. -	1) Eliminate lake habitat for smallmouth bass. + 2) Increased stream habitat for rainbow trout/steelhead. ++ 3) Significant downstream loss of fish habitat during lengthy dam removal process (sedimentation). --
Wildlife	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat along new creek channel. + 4) Downstream loss of wetland habitat from erosion of disposal site. - or --	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat along new creek channel. ++ 4) Potential loss of habitat at downstream disposal site(s). -	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat along new creek channel. ++ 4) Disturbance and loss of habitat along pipeline routes. -	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat along new creek channel. ++

Elements of the Environment	Alternative 1A, Mechanical Removal and Placement Upstream	Alternative 1B, Mechanical Removal and Placement Downstream	Alternative 1BB, Mechanical Removal and Slurry/Conveyor	Alternative 2, Phased Natural Transport of Sediments
Threatened & Endangered Species	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream deposition of fine sediments and loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat in 5-10 years along new creek channel. + 4) Downstream deposition of fine sediments and loss of wetland habitat from erosion of disposal site. - or -- 5) Additional 20 miles of creek accessible to steelhead. ++	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream deposition of fine sediments and loss of wetland habitat during dam removal (sedimentation). - 3) New riparian habitat in 5-10 years along new creek channel. ++ 4) Additional 20 miles of creek accessible to steelhead ++ 5) Placement of material at disposal site(s) may reduce habitat for T&E species. -	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream deposition of fine sediments and loss of wetland habitat during dam removal (sedimentation). - 3) Disturbance and loss of habitat along pipeline/conveyor routes. - 4) New riparian habitat in 5-10 years along new creek channel. ++ 5) Additional 20 miles of creek accessible to steelhead. ++	1) Eliminate open water/wetland/riparian habitat. - 2) Downstream deposition of large quantities of sediments and loss of wetland habitat during lengthy dam removal process (sedimentation). -- 3) New riparian habitat in 5-10 years along new creek channel. ++ 4) Additional 20 miles of creek accessible to steelhead after 25 years. +
Air Quality/Noise/Light	1) Smog/pollutants/dust generated at dam site during removal. - 2) Truck trips to haul concrete for recycling. -	1) Smog/pollutants/dust generated at dam site during removal. - 2) Truck trips to haul concrete for recycling. - 3) Significant number of truck trips to haul sediment to disposal site(s). --	1) Smog/pollutants/dust generated at dam site during removal. - 2) Truck trips to haul concrete for recycling. - 3) Potential noise from slurry pipeline and conveyor. - or --	1) Smog/pollutants/dust generated at dam site during removal. - 2) Truck trips to haul concrete for recycling. -
Socioeconomics	1) Increased employment for local construction industry during dam removal. +	1) Increased employment for local construction industry during dam removal. +	1) Increased employment for local construction industry during dam removal. +	1) Increased employment for local construction industry during dam removal. +



Elements of the Environment	Alternative 1A, Mechanical Removal and Placement Upstream	Alternative 1B, Mechanical Removal and Placement Downstream	Alternative 1BB, Mechanical Removal and Slurry/Conveyor	Alternative 2, Phased Natural Transport of Sediments
Public Health/Safety	1) Potential increased flooding risk from sediments released during dam removal. - 2) Potential increased flooding risk from natural transport of sediments following dam removal. - 3) Potential increased flooding risk from sediments eroded from disposal site. -	1) Potential increased flooding risk from sediments released during dam removal. - 2) Potential increased flooding risk from natural transport of sediments following dam removal. -	1) Potential increased flooding risk from sediments released during dam removal. - 2) Potential increased flooding risk from natural transport of sediments following dam removal. -	1) Significant chance of increased flooding risk from sediments released during lengthy dam removal process (25 years). - 2) Potential increased flooding risk from natural transport of sediments following dam removal. -
Transportation	1) Increased traffic from truck trips to haul concrete for recycling. -	1) Increased traffic from truck trips to haul concrete for recycling. - 2) Increased traffic from truck trips to haul sediments to disposal site(s). - or --	1) Increased traffic from truck trips to haul concrete for recycling. -	1) Increased traffic from truck trips to haul concrete for recycling. - 2) Potential increased risk of damage to bridges from transport of large volumes of sediments during lengthy dam removal process. - or --
Recreation	1) Increased opportunity for recreation at Matilija Creek after dam removal. + 2) Likely restrictions on trout fishing due to presence of steelhead upstream of dam site after removal. - 3) Increased beach nourishment from natural sediment transport following dam removal. ++	1) Increased opportunity for recreation at Matilija Creek after dam removal. ++ 2) Likely restrictions on trout fishing due to presence of steelhead upstream of dam site after removal. - 3) Increased beach nourishment from natural sediment transport following dam removal. ++	1) Increased opportunity for recreation at Matilija Creek after dam removal. ++ 2) Likely restrictions on trout fishing due to presence of steelhead upstream of dam site after removal. - 3) Restricted access to Ventura River and beaches during slurry/conveyor operations. - 4) Increased beach nourishment from natural sediment transport following dam removal. ++	1) Increased opportunity for recreation at Matilija Creek after dam removal. ++ 2) Likely restrictions on trout fishing due to presence of steelhead upstream of dam site after removal. - 3) Potential loss of recreation due to filling of wetlands in Ventura River during lengthy dam removal process. - 4) Increased beach nourishment from natural sediment transport following dam removal. ++

<b>Elements of the Environment</b>	<b>Alternative 1A, Mechanical Removal and Placement Upstream</b>	<b>Alternative 1B, Mechanical Removal and Placement Downstream</b>	<b>Alternative 1BB, Mechanical Removal and Slurry/Conveyor</b>	<b>Alternative 2, Phased Natural Transport of Sediments</b>
Land Use/Aesthetics	1) Dam removal activities and sediment disposal will be aesthetically unattractive. -- 2) Dam site could become public open space after removal. +	1) Dam removal activities and sediment disposal will be aesthetically unattractive. - 2) Dam site could become public open space after removal. ++	1) Dam removal activities and sediment disposal will be aesthetically unattractive. - 2) Dam site could become public open space after removal. ++	1) Dam removal activities and sediment deposition in the Ventura River will be aesthetically unattractive. - 2) Dam site could become public open space after removal. ++

## SUMMARY OF ENVIRONMENTAL IMPACTS

All of the dam removal alternatives will have temporary low to moderately adverse impacts during dam removal activities, which include: 1) erosion and transport of fine sediments to downstream areas; 2) loss of lake and wetland habitats at the reservoir; 3) upstream downcutting of creek bed; 4) loss of vegetation or other habitat at disposal site; and, 5) air quality and noise effects from demolition activities and transport of dam materials. Following removal of the dam, the natural sediment transport processes will be restored which could affect flood control along the Ventura River. The benefits from dam removal include: restoring access to 10-20 miles of spawning and rearing habitat for steelhead; restoring natural flood and sediment regimes in Matilija Creek and incrementally in the Ventura River; increased recreation opportunities at the dam site; and, increased sediment input to the marine environment to reduce erosion of coastal beaches. The long-term benefits appear to outweigh the temporary adverse impacts.

The major differences between the alternatives are in the level of sediment transport and water quality impacts which are allowed during and following dam removal. Alternative 1A would have the potential for much more significant sediment transport and water quality effects than the other mechanical removal alternatives due to the fact that the sediment will be in the floodplain of Matilija Creek and will be subject to erosion, even after the site has been stabilized with vegetation. The natural habitat forming processes in the floodplain will also be constrained as a result of the placement of the sediment (fill) in the floodplain. Alternative 2 would result in all of the sediment behind the dam moving downstream through the Ventura River and its estuary. The bulk of the sediment would move rapidly during high flow events, but there is a significant likelihood of fine sediments depositing in aquatic habitats during low flows. Since one of the primary goals of dam removal is to restore habitat for steelhead, the adverse effects on downstream habitat for many years (up to 25) could dramatically reduce the viability of the steelhead run before the upstream habitat is even accessible. So, in conclusion, alternatives 1B and 1BB appear to have less significant environmental effects, but differ in their level of effects on the human environment (traffic, public safety).

## POTENTIAL METHODS TO AVOID, MINIMIZE OR MITIGATE FOR ADVERSE ENVIRONMENTAL IMPACTS

- Diverting the creek around the entire dam site in a pipeline during removal activities would reduce the potential for fine sediments being transported downstream and armoring gravel or filling in aquatic/wetland habitats.
- Provide temporary erosion control measures during dam removal activities by placing straw or other protective materials on sediments that are not being actively worked.
- Provide sediment bypass at Los Robles Diversion Dam.
- Sample sediments during dam removal activities to ensure no contaminants are present. If contaminants are found, separate out that unit of sediment for separate landfill disposal.
- Protect the downstream historic site from equipment and dam removal activities.



- Avoid removing vegetation wherever possible, minimize footprint of dam removal staging, pipeline and disposal site(s).
- Survey for and remove native amphibians and reptiles from the reservoir site and transfer to other appropriate habitats.
- Provide water trucks as needed to reduce dust from dry sediments.
- Reduce volume of sediments moving downstream under all alternatives to avoid increased flooding risk.
- Seasonally revegetate disposal site(s) if they will be lying idle to prevent erosion.
- Revegetate riparian zone, as far upstream as appropriate, and disposal sites immediately upon completion of removal activities. Provide irrigation as necessary to ensure quick establishment and growth of plants.
- Revegetate the riparian zone upstream of the reservoir area, in later years, if downcutting of the channel occurs.
- Create replacement wetland/floodplain habitats adjacent to Matilija Creek or the Ventura River to replace wetland habitat lost from dam removal.
- Conduct dam removal activities during appropriate fish and wildlife “windows” outside of the nesting/breeding seasons and spawning/emergence seasons.
- Remove invasive non-native species from the reservoir area such as arundo, bullfrogs and smallmouth bass to avoid having them move into other habitats.
- If placing sediments for beach nourishment, place out of the intertidal area, either above MHHW or in subtidal water to avoid impacts to grunion and other intertidal species.

## **BENEFICIAL USES OF SEDIMENT**

### **Beach Nourishment**

A significant percentage of the material behind the dam is composed of sand. This would make ideal beach nourishment material and Ventura County considers several of its beach resources to be eroding and in need of nourishment. The removal of the dam will restore natural sediment transport processes for the future, but additional nourishment with the sediment removed from behind the dam could also provide benefits to coastal beaches. Intertidal beach habitat is inhabited by a variety of marine organisms including clams, sand dollars, anemones, crabs, starfish, eelgrass, and algae. Additionally, the California grunion utilizes beaches for spawning activities. Placement of beach fill should be done outside of the grunion spawning periods. It also may be less environmentally damaging to place beach fill above the mean higher high water (MHHW) line or into deeper subtidal water (>20 feet in depth).

### **Habitat Restoration**

A small percentage of the material behind the dam is small to large gravels. Gravels are the preferred substrate for steelhead spawning and egg incubation. Steelhead juveniles prefer riffle/pool complexes for rearing prior to migration out to sea. In areas that are starved for gravel it may be appropriate to place gravel near the ordinary high water (OHW) mark to allow natural redistribution into downstream reaches. Placement of relatively small quantities of gravel (<15,000 CM) should be conducted and then monitored to determine how well the gravel is retained in the system and if any adverse flooding effects occurred.

### **Floodplain Revegetation**

Some of the material behind the dam may be suitable as a planting medium (when mixed with organic material) and could be used in the revegetation efforts adjacent to the dam removal site and upstream reaches of Matilija Creek. The material could also be used in downstream areas where revegetation would be beneficial.

### **Commercial Reuse**

Most of the fine materials are most likely unsuitable for commercial reuse; however, the sand and gravel material would be suitable for commercial purposes. This would reduce the volume of sediment that would have to be disposed of in other locations and minimize removal of vegetation at disposal sites, etc. Also, it would provide a good source of material to a commercial source so they would not have to conduct gravel mining or such activities elsewhere for the volume of material that will be produced from the dam site.



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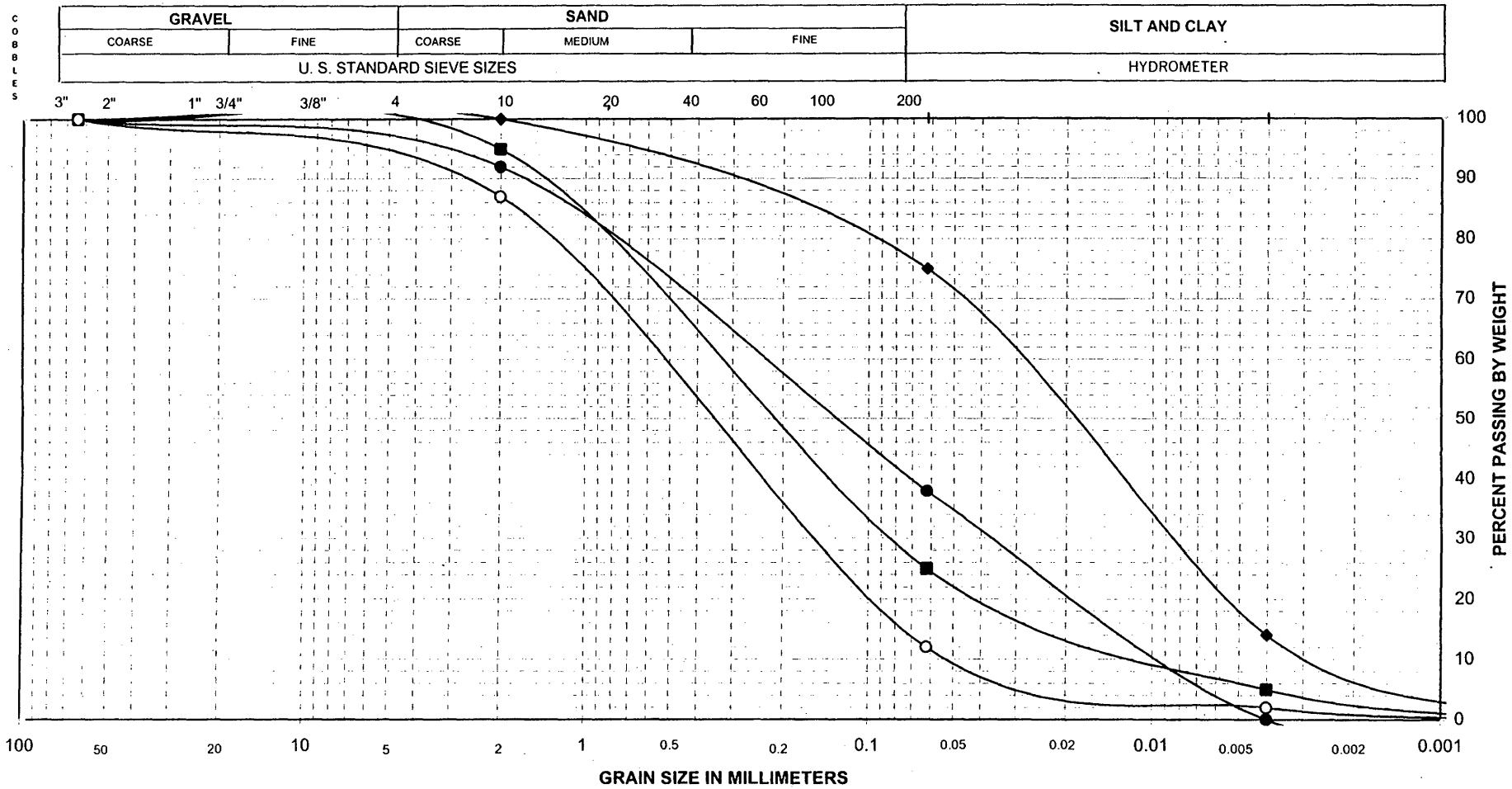


**ATTACHMENT A:**

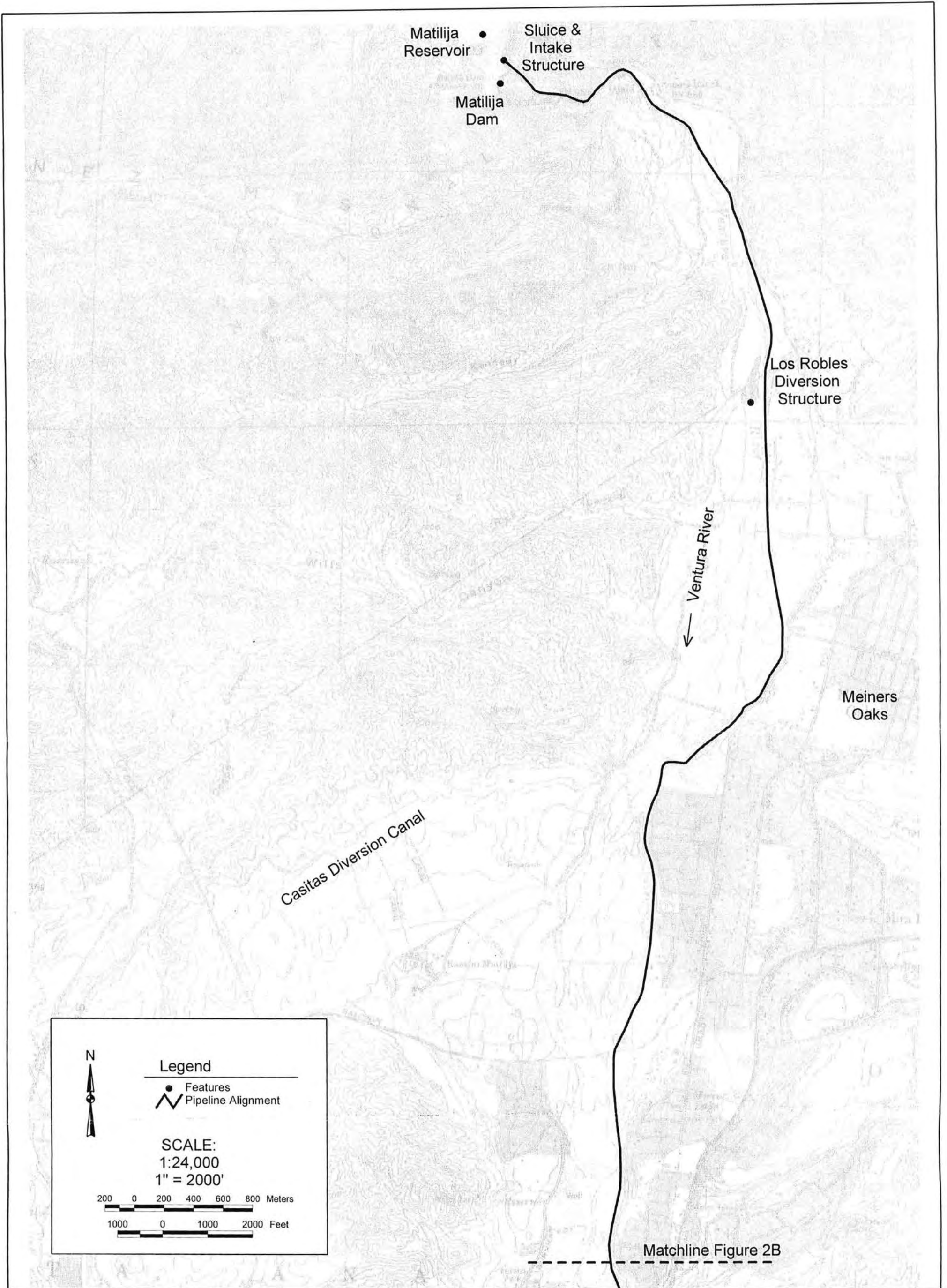
**FIGURES**



### UNIFIED SOIL CLASSIFICATION







**Legend**

- Features
- Pipeline Alignment

**SCALE:**  
1:24,000  
1" = 2000'

200 0 200 400 600 800 Meters  
1000 0 1000 2000 Feet

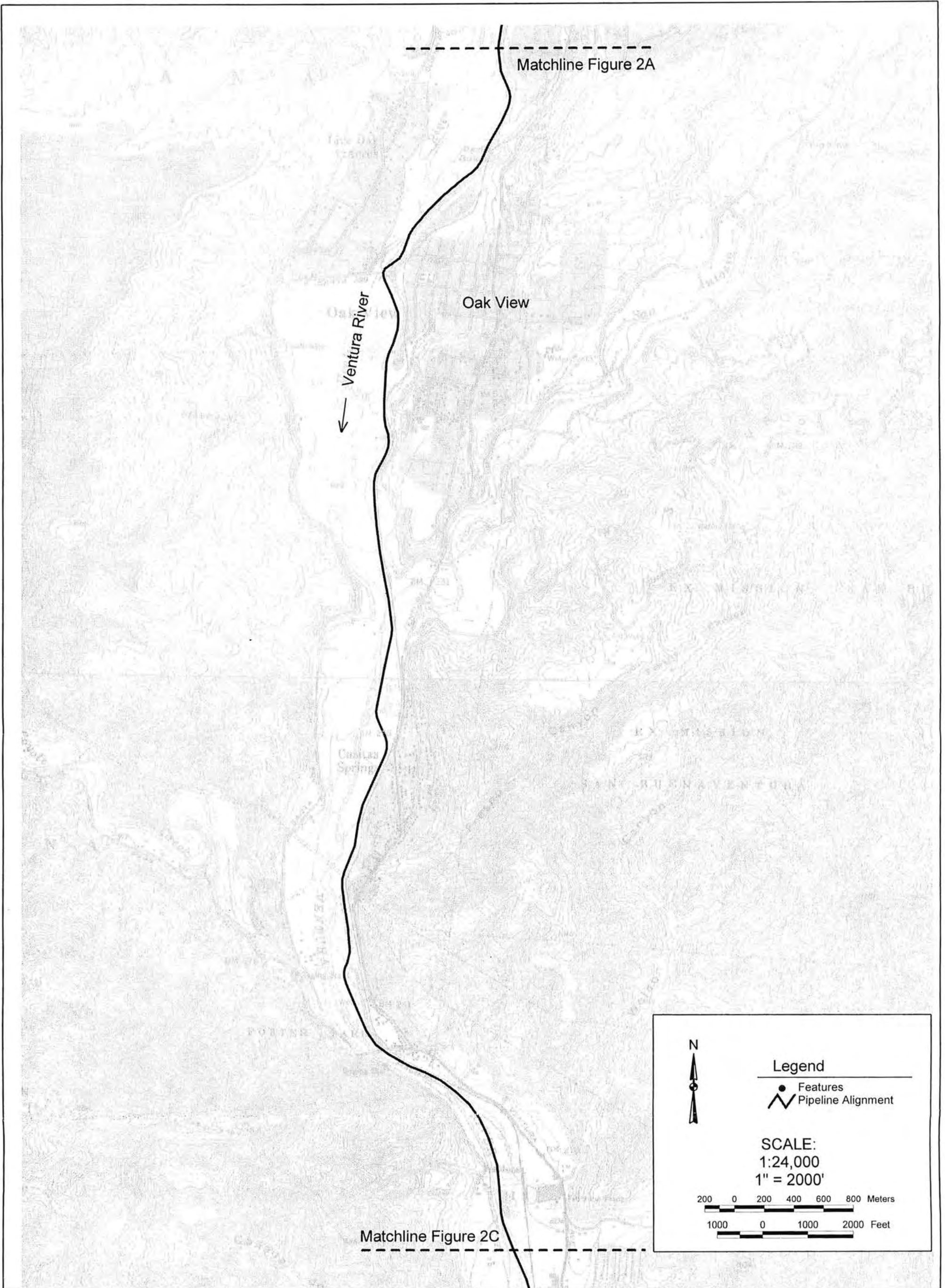


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Matilija Dam Decommissioning  
Appraisal Report Supplement

April 2000

Figure 2A  
Preliminary  
Slurry Pipe Alignment

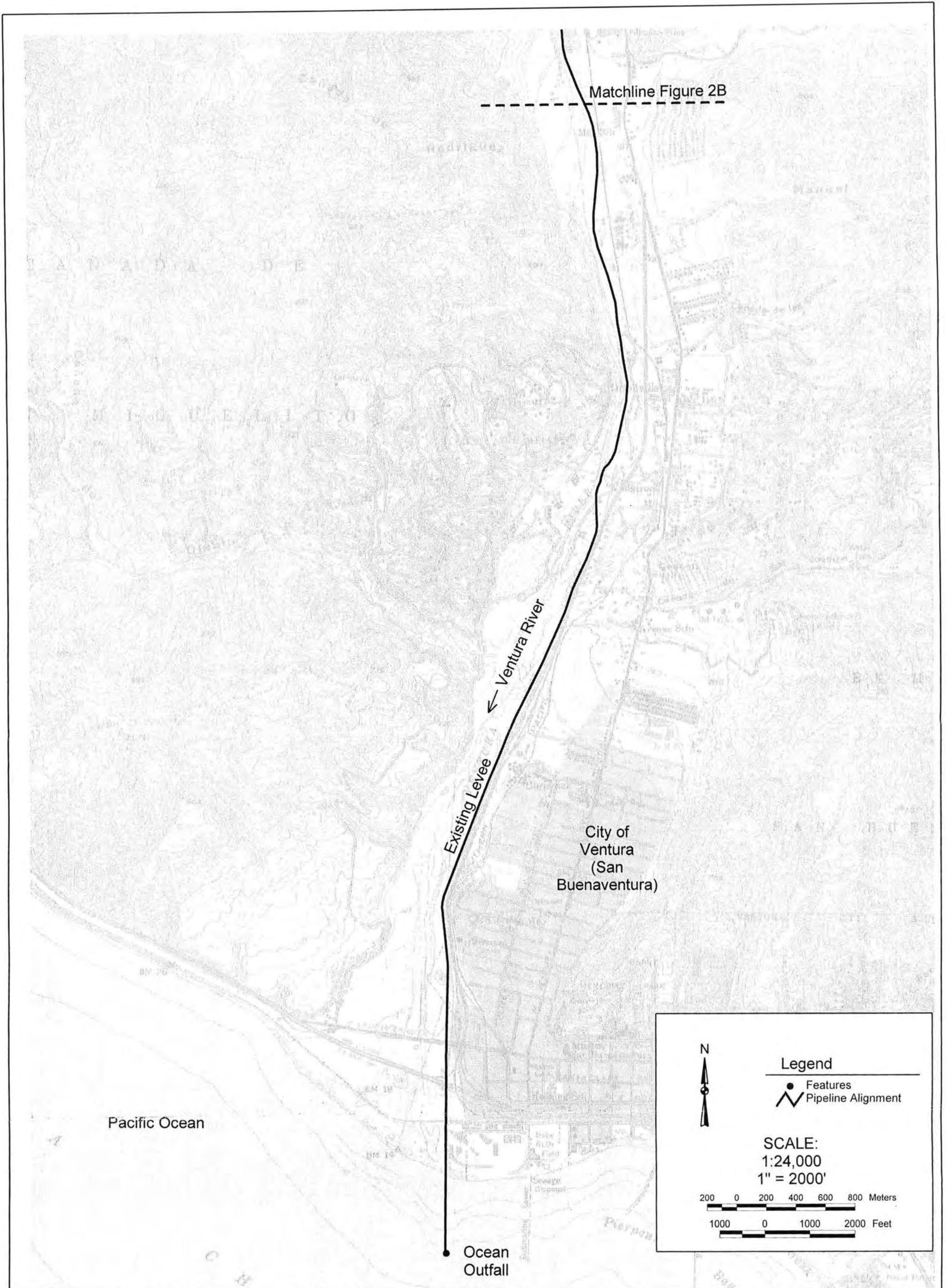


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Figure 2B  
 Preliminary  
 Slurry Pipe Alignment



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Figure 2C  
 Preliminary  
 Slurry Pipe Alignment

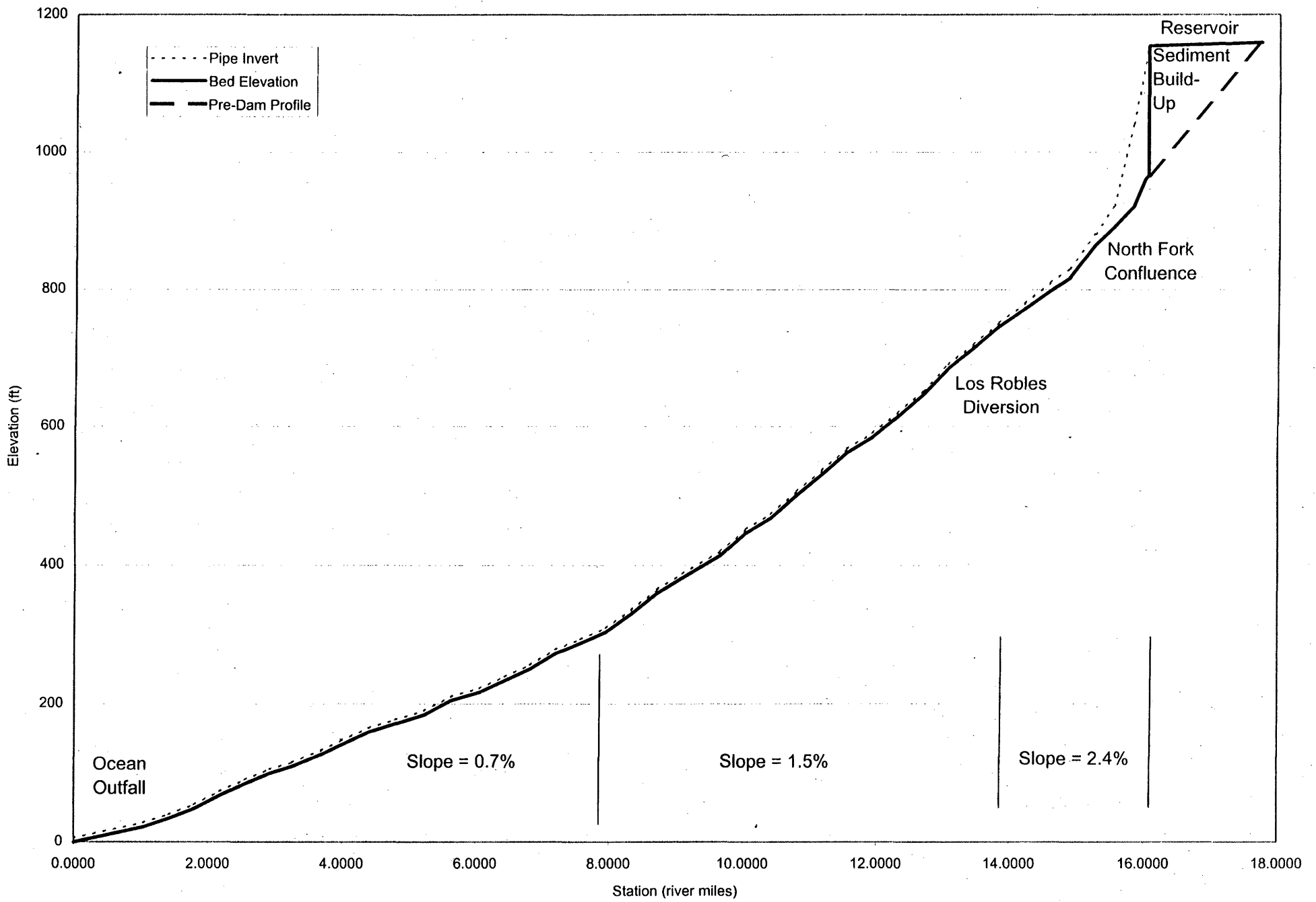


Figure 3: Proposed Slurry Pipe Profile



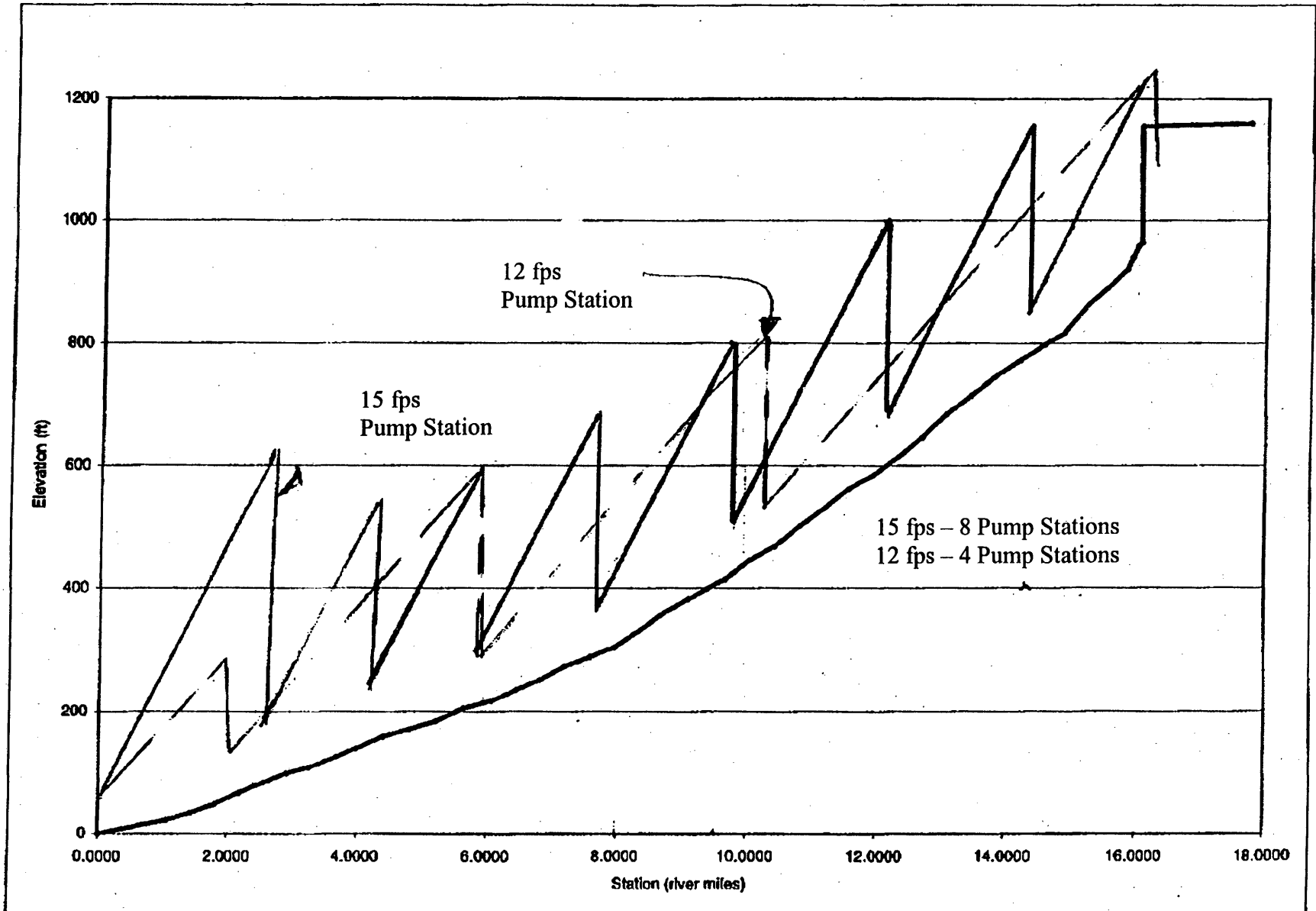
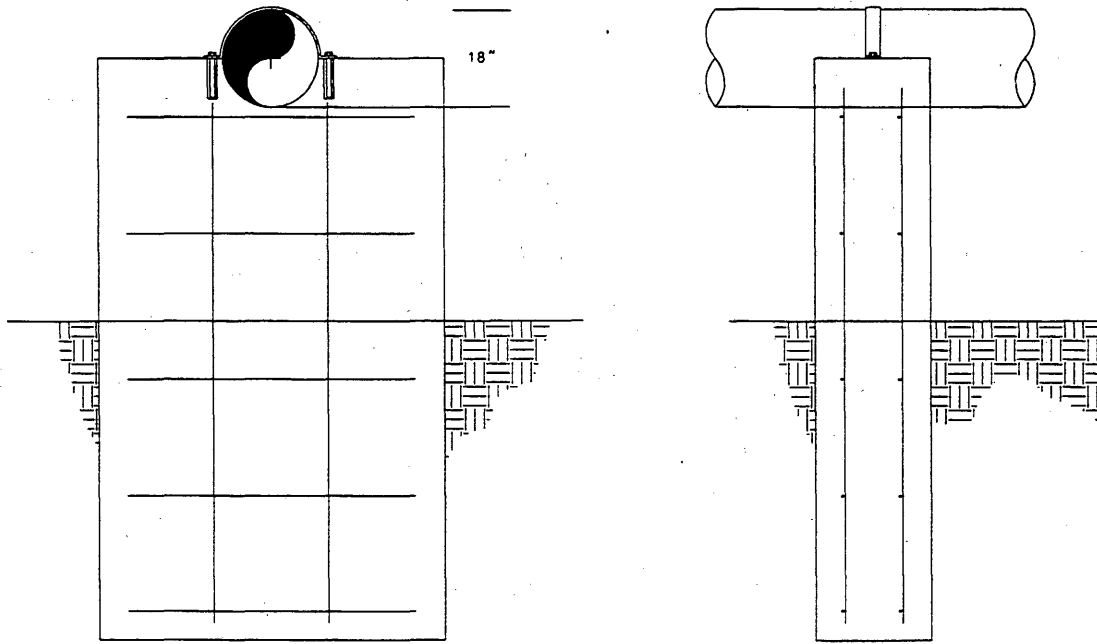
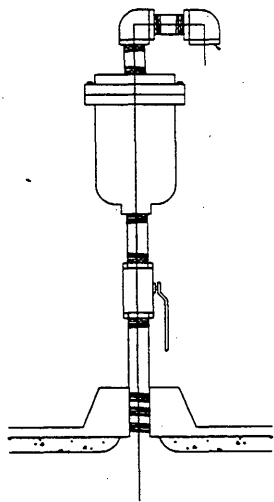


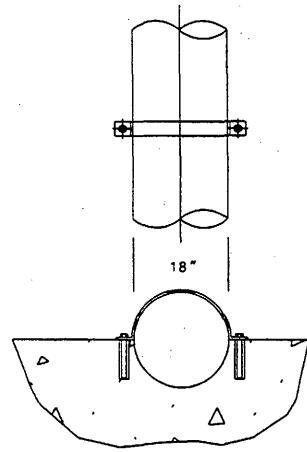
Figure 4: Pump Station Locations and Energy Head along Proposed Slurry Line



CONCRETE PIPE SUPPORT



AIR-VAC DETAIL



PIPE STRAP DETAIL



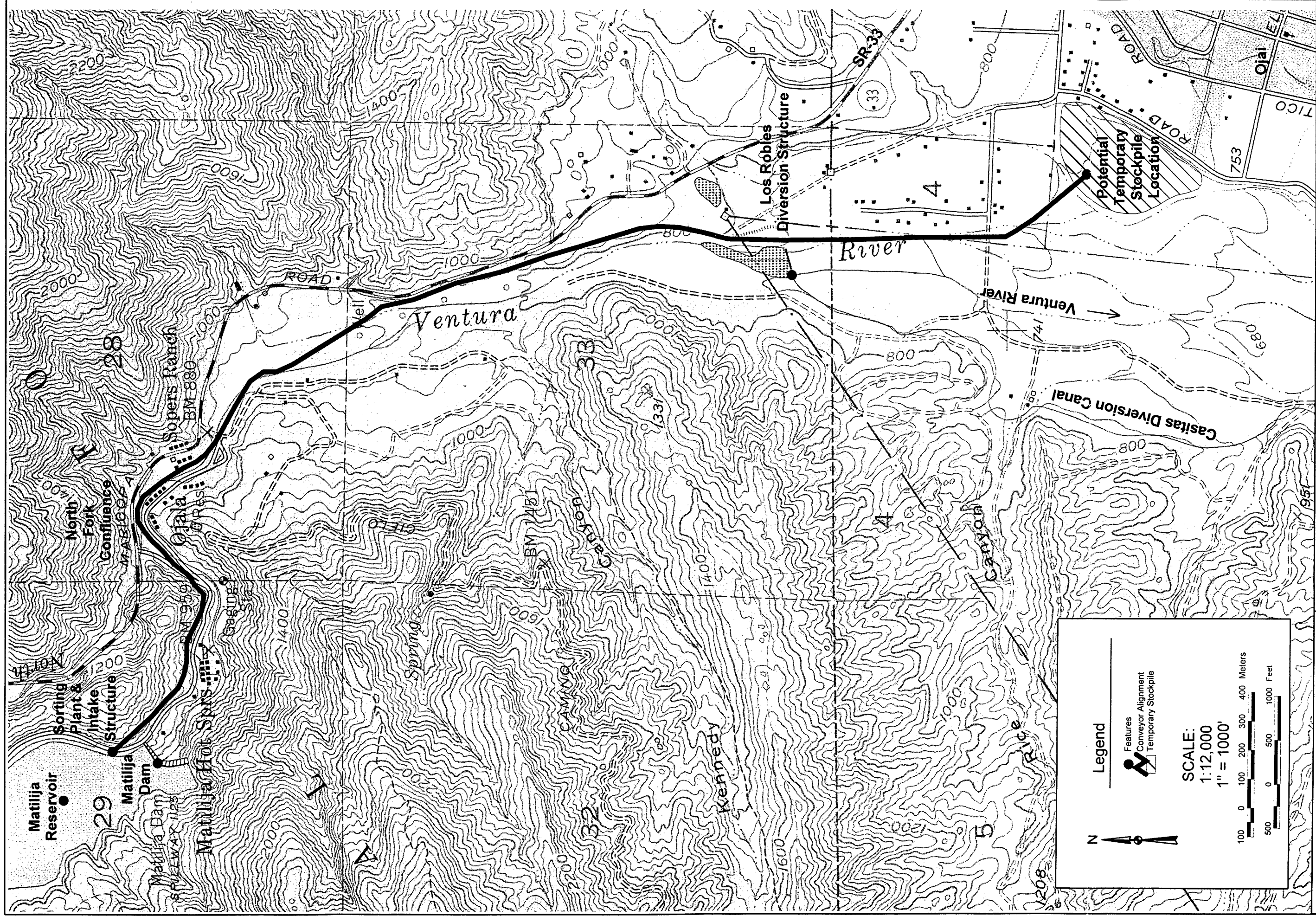
Tetra Tech, Inc.  
April 2000



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Los Angeles District

Matilija Dam Decommissioning  
Appraisal Report Supplement

Figure 5  
Typical  
Pipeline Details

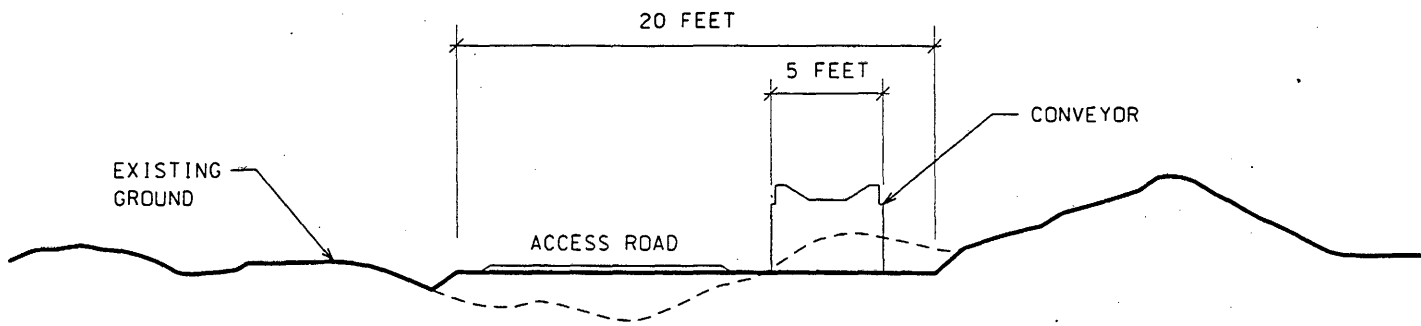


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Los Angeles District

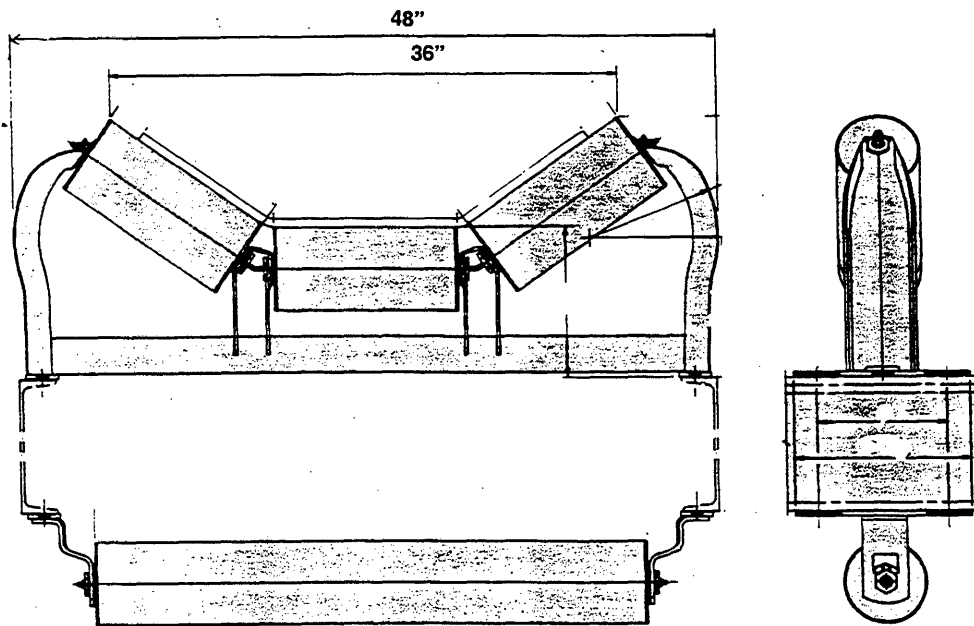
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Figure 6  
Preliminary  
Conveyor Alignment



TYPICAL SECTION  
CONVEYOR AND ACCESS ROAD



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Matilija Dam Decommissioning  
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Figure 7  
Typical  
Conveyor Details

**ATTACHMENT B:**

**CASITAS MWD WATER RATES**



EFFECTIVE: JANUARY 1, 2000

**CASITAS MUNICIPAL WATER DISTRICT  
EXCERPT OF RATES AND REGULATIONS FOR WATER SERVICE**

<b>9.3.1 RATE SCHEDULE - CLASS 1 SERVICE</b>	Rate per Unit **	
	Gravity Zone	Pumped Zone
Residential		
Monthly Lifeline 0-10 Units	\$ 0.640	\$ 0.871
Monthly Usage 11-17 Units	\$ 1.022	\$ 1.254
Monthly Usage Over 17 Units	\$ 1.420	\$ 1.652
Business	\$ 0.685	\$ 0.897
Industrial	\$ 0.626	\$ 0.858
Resale	\$ 0.385	\$ 0.871
Other	\$ 0.646	\$ 0.878
Temporary	\$ 2.017	\$ 2.249
Recreation	\$ 0.900	\$ 0.900

<b>9.3.2 RATE SCHEDULE - CLASS 2 SERVICE</b>	Rate per Unit **	
	Gravity Zone	Pumped Zone
Other	\$ 0.646	\$ 0.878

<b>9.3.3 RATE SCHEDULE - CLASS 3 SERVICE</b>	Rate per Unit **	
	Gravity Zone	Pumped Zone
Residential Lifeline 0-10 Units	\$ 0.640	\$ 0.871
Residential Lifeline 11-17 Units	\$ 1.022	\$ 1.254
Irrigation	\$ 0.307	\$ 0.307

\*\* One unit equals 100 cubic feet (748 gallons)

**9.3.4 COMBINATION (CLASS C) SERVICE.** Where more than one class of water service or use is provided through a single connection, the General Manager shall make an equitable proration of rates and fees, such proration shall be conclusive unless appealed within 30 days by the customer to the Board, in which case the determination of the Board shall be conclusive.

**9.4.1 Service Charges.** A service charge shall be paid by each customer for each billing period during which a service connection or allocation exists. Such charge for any billing period in which such a connection has existed for less than the whole of such period shall be prorated. Such charge shall not entitle the customer to any quantity of water and is in addition to the charges set forth in subsections 9.3.1, 9.3.2, and 9.3.3. The service charge shall be based on the meter manufacturer's recommended maximum flow capacity. The service charge for service shall be as set forth in the rate schedule in subsection 9.4.2.

**9.4.2 RATE SCHEDULE - SERVICE CHARGES**

METER SIZE		5/8"-3/4"-1"	1 1/2" - 2"	2 1/2" - 3"	4"	6"	Over
MAX CAPACITY	GPM	20-30-50	120 -160	TEMP - 350	1,000	2,000	Over 2,000
<b>RESIDENTIAL</b>	Monthly	\$ 11.04	\$ 33.90	\$ 72.18	\$ 153.21	\$ 452.29	
	Bi-Monthly	\$ 22.08	\$ 67.80	\$ 144.36	\$ 306.42	\$ 904.58	
<b>BUSINESS</b>	Monthly	\$ 20.00	\$ 61.35	\$ 130.74	\$ 277.47	\$ 819.05	
	Bi-Monthly	\$ 40.00	\$ 122.70	\$ 261.48	\$ 554.94	\$ 1,638.10	
<b>INDUSTRIAL</b>	Monthly	\$ 14.92	\$ 45.78	\$ 97.54	\$ 207.02	\$ 611.68	
	Bi-Monthly	\$ 29.84	\$ 91.56	\$ 195.08	\$ 414.04	\$ 1,223.36	
<b>IRRIGATION</b>	Monthly	\$ 24.60	\$ 75.40	\$ 160.64	\$ 340.96	\$ 1,006.49	
	Bi-Monthly	\$ 49.20	\$ 150.80	\$ 321.28	\$ 681.82	\$ 2,012.98	
<b>RESALE(G)</b>	Monthly	\$ 41.83	\$ 128.30	\$ 273.34	\$ 580.17	\$ 1,712.58	\$ 1.72932 per gpm
	Bi-Monthly	\$ 83.66	\$ 256.60	\$ 546.68	\$ 1,160.34	\$ 3,425.16	\$ 3.45864 per gpm
<b>RESALE(P)</b>	Monthly	\$ 18.18	\$ 49.62	\$ 105.67	\$ 224.29	\$ 662.09	
	Bi-Monthly	\$ 32.36	\$ 99.24	\$ 211.34	\$ 448.58	\$ 1,324.18	
<b>OTHER</b>	Monthly	\$ 16.70	\$ 51.21	\$ 109.08	\$ 231.51	\$ 683.37	
	Bi-Monthly	\$ 33.40	\$ 102.42	\$ 218.16	\$ 463.02	\$ 1,366.74	
<b>TEMPORARY</b>	Monthly		\$ 46.46	\$ 99.00			
	Bi-Monthly		\$ 92.92	\$ 198.00			
<b>RECREATION</b>	Monthly	\$ 21.34	\$ 65.48	\$ 139.52	\$ 296.09	\$ 874.06	
	Bi-Monthly	\$ 42.68	\$ 130.96	\$ 279.04	\$ 592.18	\$ 1,748.12	



**ATTACHMENT C:**

**HISTORICAL DIVERSION AT ROBLES**



**ROBLE-CASITAS CANAL  
HISTORICAL MONTHLY DIVERSIONS  
CASITAS MUNICIPAL WATER DISTRICT  
1959-1998**

YEAR	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		TOTAL			
	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.	days	a.f.		
1959	26	374	21	3645	23	928	3	158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	5105	
1960	0	0	2	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	24	
1961	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	23	2	32		
1962	0	0	20	13564	31	6882	30	1438	5	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	21915	
1963	0	0	23	2043	11	896	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	2939	
1964	2	10	0	0	0	0	1	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	176	5	354		
1965	0	0	0	0	0	0	29	4955	4	79	0	0	0	0	0	0	0	0	0	0	14	11676	28	4729	75	21439		
1966	31	11440	28	3754	12	418	0	0	0	0	0	0	0	0	0	0	0	0	3	821	2	108	28	8782	104	25323		
1967	20	6284	16	1170	23	5023	30	10488	31	8909	30	1571	15	478	0	0	0	0	4	454	9	291	18	504	196	35172		
1968	0	0	1	16	24	339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	715	0	0	29	1070		
1969	7	4924	20	11902	31	16623	30	8654	31	2685	30	1507	31	2710	5	360	0	0	0	0	5	76	10	908	200	50349		
1970	13	312	14	988	31	7347	11	404	0	0	0	0	0	0	0	0	3	365	0	0	1	575	19	5868	92	15859		
1971	31	3460	24	2011	3	24	0	0	0	0	9	861	0	0	0	0	0	0	0	0	4	550	7	4051	78	10957		
1972	20	1093	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	620	0	0	1	5	0	0	25	1718		
1973	15	3445	28	15331	31	14219	30	4274	23	1435	0	0	0	0	0	0	0	0	0	0	5	884	0	0	132	39588		
1974	23	6431	8	501	19	2437	4	539	0	0	0	0	0	0	0	0	0	0	0	0	3	397	3	1427	60	11732		
1975	0	0	7	1090	21	8876	17	1826	3	686	0	0	0	0	0	0	0	0	0	0	3	510	0	0	51	12988		
1976	0	0	9	2855	0	0	0	0	0	0	0	0	0	0	0	0	2	583	0	0	0	0	0	0	11	3438		
1977	0	9	0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	4	1044	5	1094		
1978	24	7290	28	13204	17	7834	0	0	0	0	4	1167	0	0	0	0	0	0	0	0	0	0	0	0	0	73	28695	
1979	0	0	26	4712	16	1796	0	0	3	670	0	0	5	1667	0	0	0	0	0	0	0	0	0	0	0	50	8845	
1980	20	1456	15	1127	2	134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	2717	
1981	4	203	0	0	31	5018	2	551	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	5772	
1982	3	599	0	0	11	1492	25	3582	28	494	15	74	0	0	0	0	0	0	0	0	7	657	14	3035	103	9933		
1983	10	8994	28	8791	0	0	0	0	0	0	17	1138	20	1430	4	218	11	536	0	0	0	0	14	1024	104	22131		
1984	0	0	8	1130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	957	17	2087		
1985	3	528	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1522	9	964	19	3015		
1986	2	1385	28	14926	31	14415	30	5430	22	1418	27	1742	0	0	0	0	0	0	0	0	0	0	0	0	140	39316		
1987	0	0	0	0	10	1034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	580	12	1614		
1988	10	1368	4	1533	15	4725	11	885	3	643	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	9154	
1989	0	0	7	524	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	524	
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	1	367	18	11776	30	4186	12	925	0	0	0	0	0	0	0	0	0	0	0	0	2	366	63	17620		
1992	5	1026	23	14826	31	15898	30	7228	31	2460	9	413	0	0	4	504	0	0	0	0	0	0	6	1847	139	44202		
1993	27	21012	16	10886	0	0	0	0	7	963	5	1039	4	785	0	0	0	0	0	0	0	0	0	0	0	59	34685	
1994	0	0	13	1645	7	932	0	0	6	927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	3504		
1995	3	1323	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1323	
1996	0	0	0	0	6	1291	0	0	4	371	0	0	0	0	0	0	0	0	0	0	2	354	9	3355	21	5371		
1997	18	7134	6	1843	4	917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2002	32	11896		
1998	5	1366	6	4972	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	6338		
AVG	8	2287	11	3485	11	3262	8	1369	5	569	4	238	2	177	0	27	1	53	0	32	2	458	5	1041	56	12996		
MAX	31	21012	28	15331	31	16623	30	10488	31	8909	30	1742	31	2710	5	504	11	620	4	821	14	11676	28	8782	200	50349		
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Rain is average water year rainfall for Casitas Dam, Casitas Recreation Area and Matilija Dam rain gages in inches a.f. : acre-feet



**ATTACHMENT D:**

**WATER SUPPLY SPREADSHEETS**



**Matilija Dam Removal Appraisal**  
**Sediment Removal Schedule as a Function of Slurry Line Capacity**

<b>Summary of Sediment and Slurry Characteristics:</b>	
Total Volume of Sediment in Reservoir:	6.0 M CY
Fraction of Fines (<1mm):	85 %
Total Volume of Fines in Reservoir:	5.1 M CY
Total Volume of Gravel & Sand (>1mm):	0.9 M CY
Bulk Dry Density of Fine Sediment:	94.0 pcf
Specific Gravity of Solids:	2.65
Unit Weight of Water:	62.4 pcf
Percent Solids in Fines:	57 %
Dry Weight of Fines:	6,471,900 tons
Actual Volume of Solids in Fines:	2.9 M CY
Slurry Sediment Concentration by Volume:	5.0 %
Slurry Sediment Concentration by Weight:	13.3 %
Slurry Sediment Concentration:	130,000 ppm
Minimum Bypass Flow in Matilija Creek:	20 cfs
Average Annual Total Sediment Inflow:	70 Acre-feet
Annual Solid Fine Sediment Inflow:	34 Acre-feet
Volume of Water Required to Remove Fines:	31,178 Acre-feet

**Matilija Dam Removal Appraisal**  
**Sediment Removal Schedule as a Function of Slurry Line Capacity**

**Time for Sediment Removal Using Available Runoff for Slurry**

Q water in Matilija Creek (cfs)	Exceedence Frequency (%)	Days per year exceeding Flow (days)	Incr. Days per yr exceeding (365 total) (days)	PIPE SIZE (Pipe Flow after Bypass) (cfs)	Sediment Flow in Pipe (cfs)	Daily Sediment Load for given Q (CY)	Annual Sediment Load for Exceedence (CY)	Annual Sediment Load for Increment (CY)	Cumulative Annual Sediment Load (incr.) (CY)	Annual Sediment Load in Pipe (CY)	Net Annual Sediment Removal after Inflow (CY)	Years to Remove Sediment in Reservoir (yrs)
0	100	365	128	0	0	0	0	0	0	0	-54,568	-
5	65	237	110	0	0	0	0	0	0	0	-54,568	-
10	35	128	37	0	0	0	0	0	0	0	-54,568	-
15	25	91	18	0	0	0	0	0	0	0	-54,568	-
20	20	73	11	0	0	0	0	0	0	0	-54,568	-
25	17	62	7	5	0.3	842	52253	0	0	52253	-2,315	-
30	15	55	7	10	0.5	1684	92211	6147	6147	98358	43,790	66
35	13	47	4	15	0.8	2526	119874	12295	18442	138316	83,748	35
40	12	44	4	20	1.1	3368	147537	9221	27663	175200	120,632	24
45	11	40	2	25	1.3	4211	169053	12295	39958	209011	154,442	19
50	10.5	38	2	30	1.6	5053	193642	7684	47642	241284	186,716	16
60	10.0	37	9	40	2.1	6737	245895	9221	56863	302758	248,190	12
80	7.5	27	4	60	3.2	10105	276632	61474	118337	394968	340,400	9
100	6.5	24	2	80	4.2	13474	319663	36884	155221	474884	420,316	7
120	6.0	22	2	100	5.3	16842	368842	24589	179811	548653	494,085	6
140	5.5	20	2	120	6.3	20211	405726	30737	210547	616274	561,706	5
160	5.0	18	2	140	7.4	23579	430316	36884	247432	677747	623,179	5
180	4.5	16	2	160	8.4	26947	442611	43032	290463	733074	678,506	4
200	4.0	15	2	180	9.5	30316	442611	49179	339642	782253	727,685	4
220	3.5	13	13	200	10.5	33684	430316	55326	394968	825284	770,716	4



**Matilija Dam Removal Appraisal**  
**Sediment Removal Schedule as a Function of Slurry Line Capacity**

<b>Time for Sediment Removal Using Constant Water Supply (supplemental groundwater pumping or other means)</b>												
Flow (Q)				Operating 12 months per year			Operating 9 months per year			Operating 6 months per year		
PIPE SIZE (Slurry Pipe Capacity)	Water Supply Rate	Sediment Flow in Pipe	Daily Sediment Load for given Q	Net Annual Sediment		Years to Remove Sediment	Net Annual Sediment		Years to Remove Sediment	Net Annual Sediment		Years to Remove Sediment
				Annual Sediment Load Removed	Removal after Inflow		Annual Sediment Load Removed	Removal after Inflow		Annual Sediment Load Removed	Removal after Inflow	
(cfs)	(cfs)	(cfs)	(CY)	(CY)	(CY)	(yrs)	(CY)	(CY)	(yrs)	(CY)	(CY)	(yrs)
0	0	0	0	0	-54,568	-	0	-54,568	-	0	-54,568	-
5	4.7	0.26	842	307,368	252,800	11.5	230526	175,958	16.5	153684	99,116	29.2
10	9.5	0.53	1684	614,737	560,169	5.2	461053	406,485	7.1	307368	252,800	11.5
15	14.2	0.79	2526	922,105	867,537	3.3	691579	637,011	4.6	461053	406,485	7.1
20	18.9	1.05	3368	1,229,474	1,174,906	2.5	922105	867,537	3.3	614737	560,169	5.2
25	23.7	1.32	4211	<b>1,536,842</b>	<b>1,482,274</b>	<b>2.0</b>	<b>1152632</b>	<b>1,098,064</b>	<b>2.6</b>	<b>768421</b>	<b>713,853</b>	<b>4.1</b>
30	28.4	1.58	5053	1,844,211	1,789,642	1.6	1383158	1,328,590	2.2	922105	867,537	3.3
40	37.9	2.11	6737	2,458,947	2,404,379	1.2	1844211	1,789,642	1.6	1229474	1,174,906	2.5
60	56.8	3.16	10105	3,688,421	3,633,853	0.8	2766316	2,711,748	1.1	1844211	1,789,642	1.6
80	75.8	4.21	13474	4,917,895	4,863,327	0.6	3688421	3,633,853	0.8	2458947	2,404,379	1.2
100	94.7	5.26	16842	6,147,368	6,092,800	0.5	4610526	4,555,958	0.6	3073684	3,019,116	1.0
120	113.7	6.32	20211	7,376,842	7,322,274	0.4	5532632	5,478,064	0.5	3688421	3,633,853	0.8
140	132.6	7.37	23579	8,606,316	8,551,748	0.3	6454737	6,400,169	0.5	4303158	4,248,590	0.7
160	151.6	8.42	26947	9,835,789	9,781,221	0.3	7376842	7,322,274	0.4	4917895	4,863,327	0.6
180	170.5	9.47	30316	11,065,263	11,010,695	0.3	8298947	8,244,379	0.4	5532632	5,478,064	0.5
200	189.5	10.53	33684	12,294,737	12,240,169	0.2	9221053	9,166,485	0.3	6147368	6,092,800	0.5
220	208.4	11.58	37053	13,524,211	13,469,642	0.2	10143158	10,088,590	0.3	6762105	6,707,537	0.4



**ATTACHMENT E:**

**COST ESTIMATES**



<b>FEATURE:</b>  <p style="text-align: center;"><b>MATILJA DAM REMOVAL ALTERNATIVE 1BB DAM REMOVAL (USBR 2000b)</b></p>	05-Apr-00	<b>PROJECT:</b>  <b>DIVISION:</b> <p style="text-align: center;">Civil Engineering</p> <b>UNIT:</b>
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PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization		1	L.S.	\$8,500,000	\$8,500,000
	2	Excavation of concrete dam	D-8130	48,000	cyds	\$30.00	\$1,440,000
	3	Excavation of concrete fish trap	D-8130	120	cyds	\$200.00	\$24,000
	4	Excavation of concrete control house	D-8130	70	cyds	\$250.00	\$17,500
	5	Drilling for Blasting for dam removal					
		Horizontal holes	D-8130	8,100	each	\$60.00	\$486,000
		Drilling horizontal holes		115,000	lin-ft	\$14.00	\$1,610,000
		Vertical holes		7,000	each	\$120.00	\$840,000
		Drilling horizontal holes		115,000	lin-ft	\$10.00	\$1,150,000
	6	Process concrete for hauling	D-8130	48,190	cyds	\$2.00	\$96,380
	7	Hauling removed concrete to recycling plant	D-8130	48,190	cyds	\$15.00	\$722,850
	8	Removal and disposal of miscellaneous metalwork	D-8130	40,700	lbs	\$2.00	\$81,400
	9	Diversion and care of stream	D-8130	5,280	lin-ft	\$200	\$1,056,000
	10	Dewatering	D-8130	1	L.S.	\$1,500,000	\$1,500,000
		Subtotal Sheet 1					\$17,524,130
		Unlisted items @ 10 percent					\$1,752,413
		Contract cost					\$19,276,543
		Contingencies @ 25 percent					\$4,819,136
		Field Cost for Dam Removal, Diversion, and Dewatering					\$24,095,679

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
Ernie Hall	J. Markley		
DATE PREPARED	APPROVED	DATE	PRICE LEVEL
03/08/00			

**ESTIMATE WORKSHEET**

SHEET 2 OF 4

<b>FEATURE:</b>  <p align="center"><b>MATILJA DAM REMOVAL ALTERNATIVE 1BB REMOVAL OF FINE SEDIMENT TO BEACH BY SLURRY PIPE</b></p>	'05-Apr-00	<b>PROJECT:</b> <p align="center"><b>APPRAISAL REPORT SUPPLEMENT</b></p> <hr/> <b>DIVISION:</b> <p align="center">Tt</p> <hr/> <b>UNIT:</b>
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PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Excavation of Reservoir Sediment (fines)		5,000,000	cyds	\$1	\$5,000,000
	2	Processing Plant / Sluicing Plant		1	L.S.	\$350,000	\$350,000
	3	Pipeline					
		Slurry Pipeline - 16.5 miles		87,120	L.S.	\$150	\$13,068,000
		Pipeline Corridor Clear and Preparation 20' x 87120		1,742,400	SF	\$1.00	\$1,742,400
		Pump Station - 1125 hp per Station		8.0	EA	\$1,500,000	\$12,000,000
		Operational Electricity Costs - 24 Month Continuous Flow		120,000,000	KW/hr	\$0.12	\$14,400,000
		Sediment Processing for Slurry Mix		5,000,000	cyds	\$1.00	\$5,000,000
		Sediment Dispersal at the Outlet of Pipeline		5,000,000	cyds	\$1.00	\$5,000,000
		Property Acquisition		1	L.S.	\$1,000,000	\$1,000,000
		Removal Costs Offset by Salvage Value					
	4	Water for Pipeline		31,000	ac-ft	\$500.00	\$15,500,000
	5	Water Conveyance Facilities					
		Pipeline - 18" HDPE		5,280	lin-ft	\$150.00	\$792,000
		Pump Stations		1	EA	\$1,500,000	\$1,500,000
		Operational Electricity Costs - 24 Month Continuous Flow		22,000,000	KW/hr	\$0.12	\$2,640,000
	6	Revegetation		70	acre	\$3,000.00	\$210,000
		Subtotal Sheet 2					\$78,202,400
		Unlisted items @ 10 percent					\$7,820,240
		Contract cost					\$86,022,640
		Contingencies @ 25 percent					\$21,505,660
		Field cost for Slurry Pipe only					\$107,528,300

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
KP	HG		
DATE PREPARED	APPROVED	DATE	PRICE LEVEL
04/05/00			

**ESTIMATE WORKSHEET**

<b>FEATURE:</b>  <p align="center"><b>MATILJA DAM REMOVAL ALTERNATIVE 1BB REMOVAL OF COARSE SEDIMENT TO ROBLES BY CONVEYOR</b></p>	05-Apr-00	<b>PROJECT:</b>  <p align="center"><b>APPRAISAL REPORT SUPPLEMENT</b></p>
		<b>DIVISION:</b> <p align="center">Tt</p>
		<b>UNIT:</b>

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	13,200 ft of 36-inch Belt Conveyor		1	L.S.	\$4,300,000	\$4,300,000
	2	Excavation Reservoir Sediment (coarse)		1,000,000	cyds	\$1	\$1,000,000
	3	Sediment Processing and Crushing		1,000,000	cyds	\$1	\$1,000,000
		Processing Plant - Cost Included In Pipeline Estimate					
	4	Conveyor Installation					
		Conveyor Corridor Clear and Preparation 10 x 13200		132,000	SF	\$1.00	\$132,000
		Easement Additional to Pipeline Easement					
		5-man Crew and Crane for 25 days		25	Day	\$1,500.00	\$37,500
		Removal Costs offset by salvage value					
	5	Dispersal of Material					
		Dispersal of Material at Temporary Site		1,000,000	cyds	\$1.00	\$1,000,000
		Final Disposal by Hauling ~30 mi.		1,000,000	cyds	\$10.00	\$10,000,000
		Place and Sort Material after Haul		1,000,000	cyds	\$1.00	\$1,000,000
		Repair Haul Roads		12	mi.	\$50,000	\$600,000
		Dust Abatement		1	L.S.	\$100,000	\$100,000
	6	Property Acquisition for Additional 10" Easement		1	L.S.	\$100,000	\$100,000
	7	Conveyor Operations (1000 tons/hour)					
		4-Man Crew - 2000 Hours of Operation		1,100	Day	\$850.00	\$935,000
		Monitoring System		1	L.S.	\$500,000	\$500,000
	8	Electricity Requirements					
		8 Drives @ 300 hp each; 2000 Hours of Operation		3,600,000	KW/hr	\$0.12	\$432,000
	9	Revegetation -Cost Accounted for in Pipeline Estimate					
		Subtotal Sheet 3					\$21,136,500
		Subtotal Sheets 1-3					\$116,863,030
		Unlisted items @ 10 percent					\$11,686,303
		Contract cost					\$128,549,333
		Contingencies @ 25 percent					\$32,137,333
		Field Cost for 16.5-mi. Slurry Pipe and 2.5-mi. Conveyor					<b>\$160,686,666</b>

QUANTITIES		PRICES	
BY	CHECKED	BY	CHECKED
KP	HG		
DATE PREPARED	APPROVED	DATE	PRICE LEVEL
04/05/00			

**ESTIMATE WORKSHEET**

SHEET 4 OF 4

<b>FEATURE:</b>  <p align="center"><b>MATILJA DAM REMOVAL ALTERNATIVE 1BB REMOVAL OF ALL SEDIMENT TO ROBLES BY CONVEYOR</b></p>	05-Apr-00	<b>PROJECT:</b>  <p align="center"><b>APPRAISAL REPORT SUPPLEMENT</b></p>
		<b>DIVISION:</b> <p align="center">Tt</p>
		<b>UNIT:</b>

PLANT ACCT.	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Dam Removal (from Sheet 1 Subtotal)		1	L.S.	\$17,524.130	\$17,524.130
	2	13,200 ft of 36-inch Belt Conveyor		1	L.S.	\$4,300.000	\$4,300.000
	3	Excavation of Sediment at Dam		6,000.000	cyds	\$1	\$6,000.000
	4	Processing Plant		1	L.S.	\$350,000	\$350,000
		Processing and Crushing Sediment		6,000.000	cyds	\$1	\$6,000.000
	5	Conveyor Installation					
		Conveyor Corridor Clear and Preparation 20 x 13200		264.000	SF	\$1.00	\$264.000
		5-man Crew and Crane for 25 days		25	Day	\$1,500.00	\$37,500
		Removal Costs Offset by Salvage Value					
	6	Dispersal of Material					
		Dispersal of Material at Temporary Site		1,000.000	cyds	\$1.00	\$1,000.000
		Haul Sediment for Disposal ~30 mi.		6,000.000	cyds	\$10.00	\$60,000.000
		Place and Sort Sediment after Haul		1,000.000	cyds	\$1.00	\$1,000.000
		Dust Abatement		1	L.S.	\$540,000.00	\$540,000
		Repair Haul Roads		12	mi.	\$300,000.00	\$3,600.000
	7	Property Acquisition		1	L.S.	\$250,000	\$250,000
		not including Barton Brooks parcel					
	8	Conveyor Operations					
		4-Man Crew - 12,000 Hours of Operation		1,500	Day	\$850.00	\$1,275.000
		Monitoring System		1	L.S.	\$500.000	\$500.000
	9	Electricity Requirements					
		8 Drives @ 300 hp each: 12,000 Hours of Operation		47,300.000	KW/hr	\$0.12	\$5,676.000
	10	Revegetation		70	acre	\$3,000.00	\$210.000
		Subtotal					\$108,526.630
		Unlisted items @ 10 percent					\$10,852.663
		Contract cost					\$119,379.293
		Contingencies @ 25 percent					\$29,844.823
		Field cost for Conveyor Only					\$149,224.116

QUANTITIES		PRICES	
BY KP	CHECKED HG	BY	CHECKED
DATE PREPARED 04/05/00	APPROVED	DATE	PRICE LEVEL



**ATTACHMENT F:**

**SETTLING POND GUIDELINES**



**CONSTRUCTION SITE EROSION AND  
POLLUTION CONTROL**

**COURSE MANUAL**

By

Richard R. Horner

Sponsored by

University of Washington  
Center for Urban Water Resources Management  
and  
Professional Engineering Practice Liaison Program

Offered in Cooperation with

University of Washington  
Engineering Professional Programs  
Seattle, WA 98185

January 2000



## SETTLING PONDS

### GENERAL INFORMATION

Note: Settling pond is a general term for sediment basins, "sediment traps" (small sediment basins without a piped discharge), and permanent ponds used in temporary construction-phase sediment control.

#### Planning Guidelines

1. The low settling velocities of particles smaller than medium silts make it impossible to capture them with a pond of feasible size. While well designed and operated settling ponds can capture 80% of the total suspended solids, most finer particles will escape. Therefore, settling ponds generally should not be the primary technique and should be reserved in most cases as a secondary practice or backup to other practices. Preventive erosion control practices should be emphasized.
2. Ponds can function through all construction phases. Therefore, plan to build ponds at the outset of construction if at all possible.
3. Try to locate settling ponds to intercept runoff before and after the on-site drainage system is developed. Attempt to use ponds to avoid having to rely on inlet protection, which is usually problematic. It may be possible to divert water from the drainage system to a pond until the site is fully stable. Alternatively, a pond could be placed to receive drainage from the on-site system and supplement inlet protection at the system's inlets.
4. Plan settling pond locations so that they catch only construction site runoff, not clean water from off-site.

### SEDIMENT BASIN

#### Planning Guidelines

1. Generally use sediment basins for drainage areas of 3-10 acres where a stable outlet is critical.
2. Do not place a sediment basin where structural failure could cause a hazard or serious property damage.

1. Set settling depth ( $D_{set}$ ) to be at least 2 ft. A good selection is usually in the range 2-4 ft.
2. Calculate settling volume ( $V$ ,  $ft^3$ ):

$$V = (1.2 * D_{set} * Q_{10-y,24-h}) / v_{sed}$$

1.2 accounts for 3 horizontal:1 vertical side slopes.

$Q_{10-y,24-h}$  = Peak flow rate from 10-year, 24-hour rain (cfs); refer to Section 1.1).

$v_{sed}$  = Settling velocity of design soil particle. Use 0.00096 ft/s for  $v_{sed}$ . This is the settling velocity for medium silt. Approximately 80% of the particles in sandy loams are larger. Therefore, the design efficiency in a sandy loam soil would be 80% with ideal settling, but somewhat less in practice.

3. Set sediment storage depth ( $D_{sed}$ ). It should be a minimum of 1 ft, but a greater depth allows more time for sediment accumulation. A maximum of 3 ft will avoid anaerobic conditions in the deepest water should the pond be full in the summer.  $D_{sed} = 3$  ft is generally recommended.

4. Calculate the surface area at the top of the settling zone ( $A_{sur}$ ,  $ft^2$ ):

$$A_{sur} = V / D_{set}$$

5. Select length ( $L$ , ft) and width ( $W$ , ft) to provide the needed surface area, with the L:W ratio ( $R$ ) preferably being at least 5:1, if space is available, and 3:1 minimum.  $A_{sur} = L * W = (R * W) * W = RW^2$ . Therefore:

$$W = (A_{sur}/R)^{0.5}$$

$$L = R * W$$

6. Provide 0.3 m 1 ft of freeboard (distance from the top of the settling zone to the base of the emergency spillway).
7. Provide 1 ft of spillway depth.
8. Extend side slopes no steeper than 3 horizontal:1 vertical.
9. If space permits, divide the pond into two separate cells, preferably with the flow forced to pass from one to another through a restriction (e. g., a pipe).

10. Design the spillway width (in ft) to be 2-3 times the number of acres contributing drainage to the pond.

11. Install baffling if necessary to prevent short circuiting (see diagram for typical situations). Baffling should be placed to make the  $(L_1 + L_2)/W_e$  ratio at least 5:1, preferably, and 3:1 minimum.

12. Design a perforated riser discharge pipe. Perforations should be arranged along the vertical length of the riser from near the top to the bottom of the settling zone. The discharge flow rate ( $Q_d$ ) through the perforations is:

$$Q_d = V/T$$

T = Emptying time; the best settling will be obtained with extended storage, optimally 48-72 hours. Select a time in hours and convert to seconds by multiplying by 3600.  $Q_d$  will then be in cfs.

The necessary total perforation opening area ( $A$ ,  $\text{ft}^2$ ), from the standard orifice equation, is:

$$A = Q_d / (5 * h^{0.5})$$

$h$  = Average depth of perforations below water surface (ft); approximate  $h$  as half of  $D_{\text{set}}$ .

Select a diameter ( $d$ , inches) for the perforations. To avoid clogging risk it is best to have several perforations each of which is no smaller than 0.5 inch.

Calculate the number of perforations ( $N$ ) needed:

$$N = 183 * A/d^2$$

The constant 183 takes into account  $\pi$  (3.14) and the unit conversions necessary with  $A$  in  $\text{ft}^2$  and  $d$  in inch.

Arrange the perforations in rows with 2-4 perforations per row.





**Appendix H - Project Plan for Future Work by United States  
Geological Survey**



## Appendix H

# PROPOSED WORKPLAN FOR U. S. GEOLOGICAL SURVEY STUDIES RELATED TO THE MATILJA DAM DECOMMISSIONING PROJECT

## CONTENTS

### Introduction

### Workplan Components

- I. Changes in Channel Morphology Resulting from Historical Floods  
Principal investigator: Charles Kaehler, Water Resources Division
- II. Relative Importance of Flow-Regulated and Bed-Sediment-Regulated Transport  
Principal investigator: David Rubin, Geologic Division, Coastal and Marine Geology
- III. Evolution of Channel Sediment Grain-Size Distribution  
Principal investigator: David Topping, Water Resources Division, National Research Program
- IV. Modeling Sediment Transport and Geomorphic Response  
Principal investigators: J.M. Nelson and P.J. Kinzel, Water Resources Division, National Research Program
- V. Biological Studies to Facilitate Ecosystem Restoration and Evaluation After Removal of Matilija Dam  
Principal investigator: Reg Reisenbichler, Biological Resources Division, Western Fisheries Research Center
- VI. Hydrologic Processes Affecting the Extent of Salmonid Habitat in Matilija Creek  
Principal investigators: E.D. Andrews and John Buffington, Water Resources Division, National Research Program
- VII. Littoral Transport of Sand Originating from Matilija Reservoir and the Ventura River  
Principal investigator: John Dingler, Geologic Division, Coastal and Marine Geology
- VIII. Surface-Water Discharge, Quality, and Suspended-Sediment Load in the Ventura River and Matilija Creek  
Principal investigators: Charles Kaehler and E.D. Andrews, Water Resources Division

### References Cited



## **PROPOSED WORKPLAN FOR U. S. GEOLOGICAL SURVEY STUDIES RELATED TO THE MATILIJA DAM DECOMMISSIONING PROJECT**

### **INTRODUCTION**

In recent years, widespread interest has developed in removal of obsolete or unsafe dams and in restoration of habitat in streams and rivers. In mid-1999, the several agencies of the Department of the Interior, including the U.S. Bureau of Reclamation (USBR), the U.S. Geological Survey (USGS), and the U.S. Fish and Wildlife Service (USFWS), began to assist the County of Ventura, California, and other Federal, State, and local agencies and groups, in initiation of the planning process for decommissioning and removal of Matilija Dam. In this workplan, three divisions of the USGS--Water Resources Division (WRD), Biological Resources Division (BRD), and Geologic Division (GD)--have contributed to proposals for integrated studies that strive to not only provide scientific information and research useful in the appraisal, feasibility, and design phases of the planning process for removal of Matilija Dam, but also to add knowledge that may be useful for its transfer value to other locations where dam removal, sediment transport, coastal processes, or fish-habitat restoration are important issues. The finalized scope of USGS work undertaken during the Matilija project will depend on the obtaining of adequate study funds for the coming years (beyond the funds from within the USGS that have been provided for Appraisal-Level efforts in the current Federal fiscal year [FY2000]). In addition, the completion of the full scope of each of the workplan components, individually, also is dependent upon obtaining adequate overall funding from one or more sources such as local and State governments, nonprofit organizations and foundations, other Federal agencies, and (or) specific Congressional appropriations.

Until the late 1940's, the Ventura River supported substantial runs of spawning steelhead. Steelhead runs to the Ventura River, however, declined greatly during the decade following a number of changes to the watershed. A 190-foot-high concrete-arch dam was constructed on Matilija Creek, a major tributary, in 1948. Flow diversions caused by this and other later projects, substantially reduced, and at times, eliminated surface flow in the lower 14 miles of the Ventura River. In addition, water quality was impaired by wastewater discharged into the river. Similar developments affected most other coastal rivers throughout southern California and steelhead runs also declined regionally. In 1997, southern steelhead were listed as an endangered species.

Matilija Dam no longer achieves its original flood-control and water-storage objectives. The Matilija Creek watershed is highly erodable, and average sediment yields are typically a few thousand tons per square mile annually (Scott and Williams, 1978). Over a 22-year period from 1948 to 1970, approximately 3.4 million tons of sediment were deposited behind Matilija Dam (Taylor, 1981). The storage capacity of the reservoir has been greatly reduced--owing to the combined effect of notching of the dam and deposition of a total of approximately 6 million cubic yards of sediment--from an original 7,000 acre-feet (acre-ft) to an estimated 500 to 700 acre-ft in 1999. The impoundment of sediment in Matilija Reservoir may contribute to beach erosion, or a decrease in beach-sand replenishment, at City of Ventura beaches.

Recently, concerns for the structural integrity of Matilija Dam owing to an ongoing alkali-aggregate reaction have prompted an evaluation of possible remedies, including the decommissioning and removal of Matilija Dam. Matilija Dam is one of the largest to be considered for removal, and the volume of sediment in the reservoir is amongst the largest to be dealt with, to date. Several alternatives exist for removing and (or) stabilizing the large volume of sediment stored behind the dam. The cost of these alternatives varies greatly. Similarly, the manner and extent to which the dam is removed and the river channel is restored will provide widely different benefits to the steelhead recovery effort. In addition, decisions regarding the removal, disposal, or subsequent placement of the trapped sediment, especially the sand fraction, could affect beach erosion or replenishment. The sediment-removal scenarios that the USBR and the U.S. Army Corps of Engineers (USACE) are concentrating on in the Appraisal-Level Study are (a) mechanical removal, and upstream storage; (b) mechanical removal, and transport downstream by truck; (c) mechanical removal and transport downstream by slurry pipeline or conveyor belt; and (d) phased lowering of the dam, allowing time between phases for erosion and transport of sediment downstream through streamflow. A combination of methods ultimately may be selected for removal of the dam and sediment because of the multiple constraints on the project. Owing to concerns of the possible effects of a large increase in sediment load in the Ventura River, option (d) is not likely to be selected as the sole method of sediment removal unless the dam is to be lowered in very small vertical increments over a period of many years (3 to 4 decades).

The objectives of the overall Matilija Dam Removal project are to (1) improve aquatic and terrestrial habitat along Matilija Creek and the Ventura River to benefit fish and wildlife species; (2) restore the hydrologic and sediment-transport regime to support downstream coastal beach sand replenishment to pre-dam conditions; and (3) enhance recreational opportunities along Matilija Creek and the downstream Ventura River system. The sequential phases for the project (and the estimated time spans) are: the planning phase, consisting of appraisal study (lasting 0.5 to 1 year), and feasibility study and NEPA compliance (2 to 4 years); the design phase, consisting of design-data collection and engineering design (1.5 to 2 years); and, the "construction" phase (dam and sediment removal) (1 to 30 years). A number of options regarding methods and degree of dam removal, methods and degree of sediment removal, methods of sediment transport and disposition, and actions assisting restoration of a viable population of steelhead will be considered during the planning and design phases of the project, as outlined in the USBR Dam Removal Appraisal Report. Throughout the planning, design, and construction phases of the dam-decommissioning project, hydrologic, geologic, and biologic expertise will be needed to facilitate decision-making and to monitor effects.

Preliminary appraisal of the Ventura River system and of the goals of the dam-removal project has allowed assessment and conceptualization of key hydrologic, geologic, and biologic processes, and has resulted in formulation of eight USGS workplan components. A primary hypothesis resulting from our appraisal is the importance and controlling influence of flood events and large flows. The prevailing erosion rate is quite large--approximately 3,000 (tons/mi<sup>2</sup>)/yr. In a regional study of hillslope processes, Scott and Williams (1978) concluded that a substantial part, perhaps a most, of the sediment supplied to the channel entered during "dry" periods when streamflow was insufficient to transport even relatively fine sand and coarse silt. Consequently, the contributed sediment accumulates in parts of the channel, filling pools and infiltrating gravel bars. Flood discharges sufficient to scour pools and entrain gravel particles do not occur every year in the Ventura River basin. Hill and McConaughy (1988) found that 96 percent of all sediment transported through a section of the lower Ventura River during a 12-year period occurred in just 3 of the years by relatively large floods. Conversely, in between these relatively rare floods, the channel morphology (form) and bed characteristics adjust to conditions of decreased flow and decreased suspended-sediment loads. Qualitative preliminary assessment indicates that many reaches of the main stem of the Ventura River, especially downstream from the confluence of San Antonio Creek, currently are either close to being graded--the variables of slope, velocity, depth, width, roughness, pattern, and channel morphology are in approximate mutual adjustment, resulting in minimal net accumulation or erosion of sediment--or are sediment limited--the power available to transport the sediment load is greater than the power needed. Some reaches, such as near, and upstream from, the Robles Diversion, appear to be flow limited--the stream power available to transport the sediment load is less than the power needed--and are characterized by braided channels and aggradation (net deposition of sediment). An increase in sediment load, such as would result from the stream-transport sediment-removal option for Matilija Dam, may cause some sediment-limited reaches to become flow-limited, resulting in deposition of sediment.

Floods and large flow events also may play an important role in both fish migration and beach-sand replenishment. Neither fish migration nor beach-sand replenishment can take place effectively without occurrence of floods of sufficient size to break through the beach barrier at the mouth of the Ventura River, allowing entry of fish from the ocean and allowing transport of sand from the river to the littoral (beach or intertidal) zone.

Owing to the relation between floods, channel morphology, and sediment transport, these three factors are of key importance with regard to the environmental and economic issues related to removal of Matilija Dam. Major issues, concerns, and questions include:

- How much sediment is transported in the fluvial (river or stream) system, currently and historically? How much sediment is the fluvial system capable of transporting (and what is the amount of sediment that can be transported for a given flow or hydrograph without rapid aggradation in some reaches)? Is sediment transport regulated mainly by flow or mainly by grain size?
- How has channel morphology changed as a result of past floods? Which reaches are more likely to experience deposition (or scouring), or, for a particular reach, what is the likely sequence and timing of scour and deposition? As a result of floods, are changes in channel width dominant over changes in gradient? At which locations is channel aggradation likely, and will the aggradation result in increased potential for flooding?
- What is the spatial and temporal distribution of gravel bars and pools suitable for steelhead habitat in Matilija Creek upstream from Matilija Dam and Reservoir, and what is the relation between bar- and pool-distribution and flood magnitude and duration?
- What is the potential for modification or destruction of important riverine habitats, particularly pool and riffle complexes, as a result of increased sediment load downstream from Matilija Dam? What will be the effects of different flow and sediment-supply conditions (dependent on different dam- and sediment-removal scenarios) on the morphology of the channel?
- What is the interannual variability in rainbow trout and steelhead both upstream and downstream from Matilija Dam, and what are the habitat requirements of southern steelhead? What are the ancestry and population structure of resident rainbow trout upstream from Matilija Dam? What are the interrelations between resident rainbow trout and steelhead?
- What will be the effects of different flow and sediment-supply conditions (dependent on different dam- and sediment-removal scenarios) on the size, depth, and bottom characteristics of the Ventura River Estuary?
- What are the production dynamics and habitat utilization for tidewater goby in the estuary?
- What will be the effects of different flow and sediment-supply conditions (dependent on different dam- and sediment-removal scenarios) on the delivery of sediment to the nearshore region?
- How will river-mouth and downdrift beaches respond to sediment delivery resulting from various scenarios of removal, transportation, and coastal deposition of the sand from behind the dam?



## **WORKPLAN COMPONENTS**

The components of the USGS Workplan are:

- ◆ I. Changes in Channel Morphology Resulting from Historical Floods
- ◆ II. Relative Importance of Flow-Regulated and Bed-Sediment-Regulated Transport
- ◆ III. Evolution of Channel Sediment Grain-Size Distribution
- ◆ IV. Modeling Sediment Transport and Geomorphic Response
- ◆ V. Biological Studies to Facilitate Ecosystem Restoration and Evaluation After Removal of Matilija Dam
- ◆ VI. Hydrologic Processes Affecting the Extent of Salmonid Habitat in Matilija Creek
- ◆ VII. Littoral Transport of Sand Originating from Matilija Reservoir and the Ventura River
- ◆ VIII. Surface-Water Discharge, Quality, and Suspended-Sediment Load in the Ventura River and Matilija Creek

A summary of each of the USGS workplan components is given below. The individual components are subject to re-evaluation and revision as the feasibility and design phases progress, as choices are narrowed regarding dam- and sediment-removal methods, as additional preliminary data are collected and analyzed, and (or) as sources and amounts of funding (Federal, State, and local) are defined or modified. The components are not presented in any particular order with regard to priority, importance, or proposed start date. Many of the components are linked to each other by use of information generated by one or more of the other components (fig. 1). For most of the components, existing-data compilation and evaluation, site evaluation, and preliminary baseline-data collection will take place in Federal fiscal year (FY) 2000, as existing funding allows. Estimated timelines for the workplan components are shown in figure 2. The timelines assume a start of removal of Matilija Dam and reservoir sediment at the end of 2005. The timelines are subject to revision depending on study funding, dam-removal planning decisions, and actual progress of the dam-removal project.

In addition to the components described in this proposed workplan, potential exists for participation by another research organization in an additional, related, component. This collaborative participation currently is being explored.

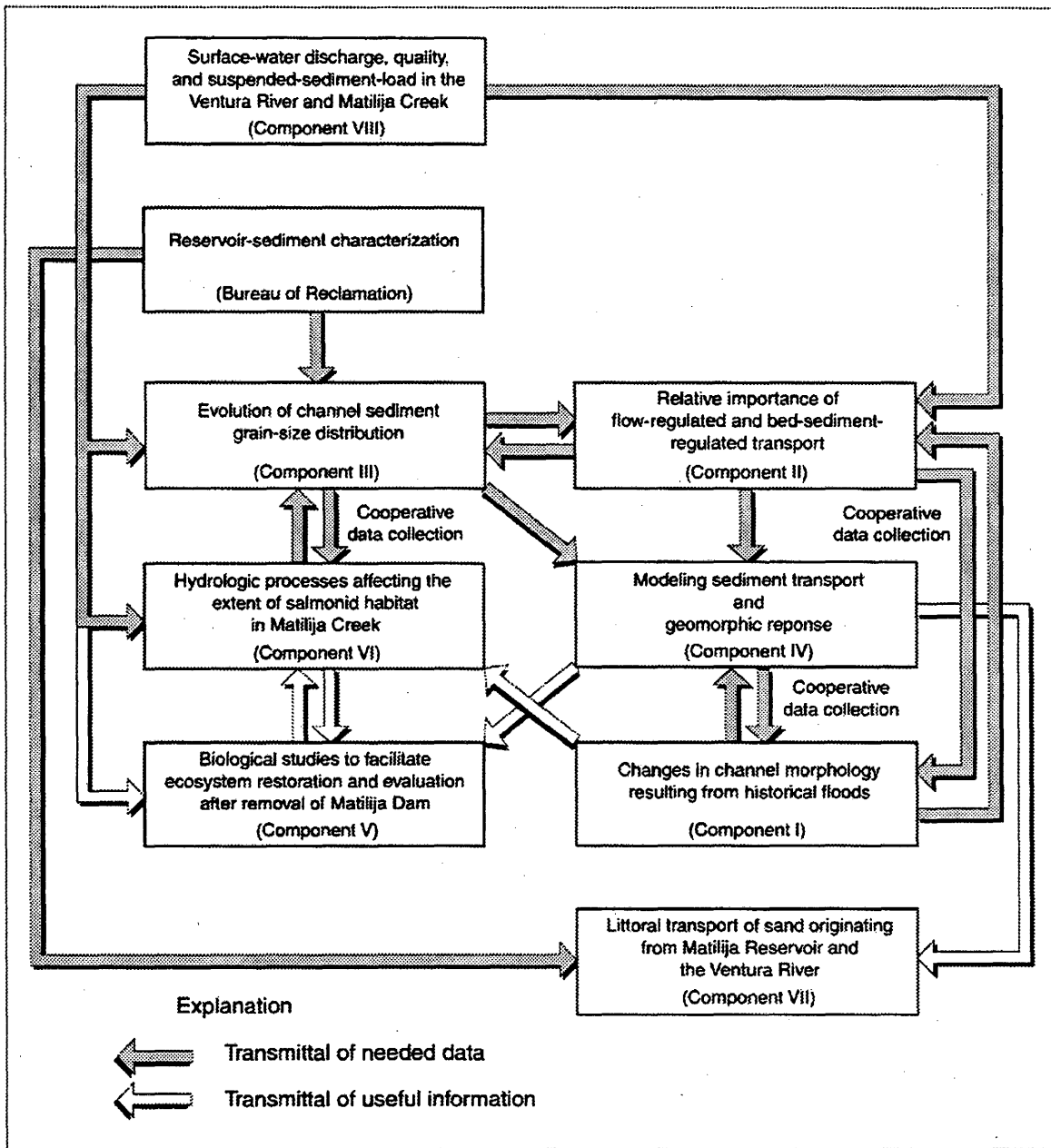
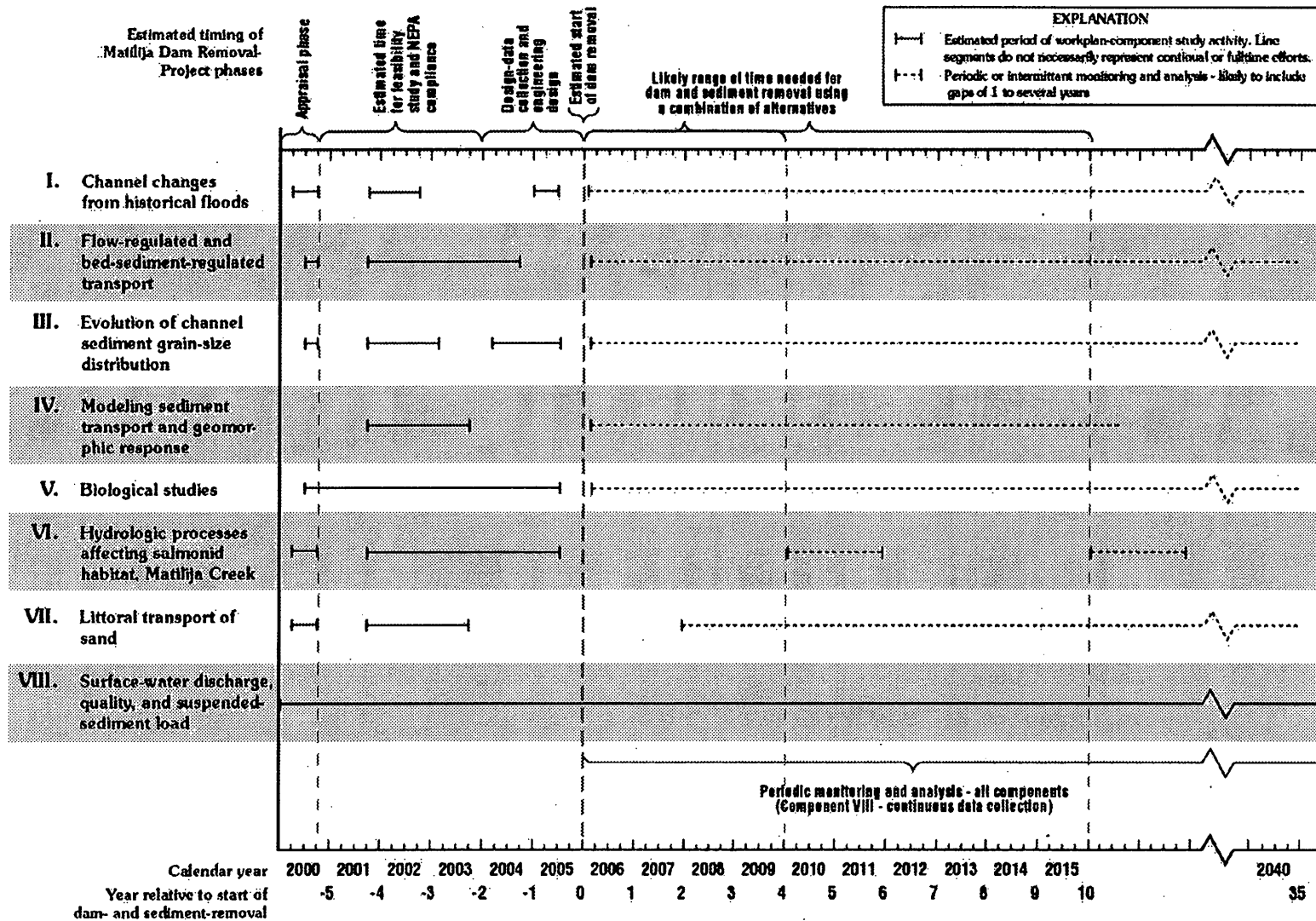


Figure 1. Information linkage for workplan components.



**FIGURE 2.** Estimated timelines for USGS proposed workplan components. Assumes start of removal of Matilija Dam and reservoir sediment at end of 2005. Timing and duration of during- and post-removal monitoring depends on timing and duration of the removal method actually used (estimated removal duration of 2 to 25 years; more likely 4 to 10 years for a combination of methods). Timelines are subject to revision depending on funding, dam-removal planning decisions, and actual progress of the dam-removal project.



## I. Changes in Channel Morphology Resulting from Historical Floods

Principal Investigator: Charles Kaehler

**Background:** Construction of Matilija Dam in 1948, Casitas Dam in 1958, and Robles Diversion Dam in 1959 resulted in a reduction in the sediment load transported by the Ventura River. The dam removal and sediment-removal scenarios under consideration in connection with the Matilija Dam Removal project would increase the sediment load in the Ventura River to varying degrees: at the upper end of the range, phased lowering of the dam, allowing time between phases for erosion and transport of sediment downstream through streamflow would result in the transport of a total of more than 6 million yd<sup>3</sup> of reservoir sediment in addition to the existing sediment load; at the lower end of the range, the Matilija Creek drainage basin produces an estimated 89,000 yd<sup>3</sup>/yr of sediment, which will be contributed to the Ventura River after removal of the dam and restoration of the channel regardless of the method used to deal with the reservoir sediment (currently, part of the sediment load is carried past the dam as suspended sediment). Most sediment transport and major channel changes take place during flood events--Hill and McConaughy (1988) found that 96 percent of all sediment transported through a section of the lower Ventura River during a 12-year period (1969-81) occurred in just 3 of the years by relatively large floods.

In the last 65 years, high-flow years have included 1938, '43, '52, '69, '78, '80, '83, '92, '95, and '98. A variety of channel changes have occurred as a result of past floods. Knowledge of the effects of past floods would help in gaining a better understanding of sediment transport and channel morphology in the Ventura River and Matilija Creek, and in providing baseline data useful as input in other studies--many of which are oriented toward prediction of future sediment transport and channel changes--associated with planning for the removal of Matilija Dam.

**Purpose and Scope:** The purpose of this study component is to document and interpret changes in channel morphology resulting from floods in the Ventura River (and estuary) and in Matilija Creek. The changes will be examined through comparison of aerial photographs that bracket the dates of floods during the past 65 years, and through comparison of cross sections and other topographic information. The study will provide baseline data for other studies, and will help to identify reaches that are likely to experience the most change in future flood events and in response to future sediment-transport scenarios associated with removal of Matilija Dam. The baseline data are linked to, or will be used by workplan components II (Relative importance of flow-regulated and bed-sediment-regulated transport), IV (Modeling sediment transport and geomorphic response), and VI (Hydrologic processes affecting the extent of salmonid habitat in Matilija Creek).

**Methods:** Aerial photographs of the Ventura River and Matilija Creek will be compiled. Sets of photographs for selected dates that bracket the dates of floods will be scanned and imported into a geographic information system (GIS) for processing. The processing will allow registration of the photos to landmarks, which will allow comparison of features such as channel width, channel form, sinuosity, and area of inundation. Information compiled from the aerial photographs also will be transferred to workplan component II (flow regulated and bed-sediment-regulated transport) for use in calculating paleoflood discharges. Cross sections and channel topography will be measured at selected sites using global positioning system (GPS) surveying instruments for comparison with surveys made as part of past flood studies. Measurement of cross sections and topography will be done in cooperation with workplan components IV (Modeling of sediment transport) and VI (Hydrologic processes, Matilija Creek). The temporal comparison will provide information on locations and amounts of net aggradation or scour. Where possible, the data will be interpreted with regard to records of surface-water discharge, suspended-sediment load, and the dates of dam construction, manmade changes affecting the channel, and fires in the watershed. Periodic monitoring of channel morphology will occur, through measurement of cross sections, during and after removal of the dam. Of interest, in addition to downstream changes in channel morphology, will be changes upstream from the Matilija Reservoir as the channel adjusts to the lowered base level and steepened gradient resulting from lowering and (or) removal of the Matilija Dam.

**Study Duration and Timing:** Elements of this workplan component will assist in the initial phases and planning of other components through the identification of optimum reaches of the Ventura River and Matilija Creek for monitoring deposition or erosion, and for monitoring changes in bed-sediment grain size. Compilation and processing of existing photographs, maps, and cross sections will be done in FY2000. Measurement of cross sections and channel topography will begin in FY2000 and will continue periodically after high-flow winters prior to start of dam removal (coordinated with workplan components IV and VI). In addition, monitoring of reaches that are important with regard to deposition or erosion will take place during and after removal of the dam.

**Products:** A pre-dam-removal report will contain descriptions and interpretations of changes in channel morphology resulting from historical floods. A second report will describe channel changes that resulted from floods and high flows during and after removal of the dam.

### III. Evolution of Channel Sediment Grain-Size Distribution

Principal Investigator: David Topping

**Background:** Following removal of a dam, the sand and silt that is supplied to the downstream reaches from the reservoir delta will travel downstream--primarily as a result of high flows and floods--as an elongating sediment wave, with the finest sizes (because of their lower settling velocities) traveling the fastest. Because the grain size of the sand from the reservoir fill is much finer than that on the bed of the river downstream from the dam, substantial changes in the grain size of the bed occur as a sediment wave migrates downstream.

The downstream motion of sediment waves (composed of sand, silt, and clay) over substrates of gravel and bedrock has been documented by Topping and others (2000b). As the fine-grained front of a sediment wave reaches a given location and the upstream supply of sediment becomes enhanced, the concentration of the finer grain sizes in suspension will be higher than that which can be supported by the grain-size distribution of the bed downstream. This produces a mass transfer of the finest sizes from the suspended sediment to the bed, resulting in fining of the bed. As the front of a sediment wave passes a given location and the upstream supply of sediment becomes depleted, the concentration of the finer grain sizes in suspension will decrease to be lower than that which can be supported by the now finer grain-size distribution of the bed. This produces a mass transfer of the finest sizes from the bed back to the suspended sediment (that is, the fines will be winnowed from the bed), resulting in coarsening of the bed.

Knowledge of how the sediment waves originating at the Matilija Reservoir move down the Ventura River is crucial to the investigations of transport modeling and channel-topographic change (workplan component IV: Modeling of sediment transport and geomorphic response), beach evolution (workplan component VII: Littoral transport of sand), and steelhead habitat (workplan component V: Biological studies--steelhead and tidewater goby).

**Purpose and Scope:** The purpose of the channel-sediment evolution component is to (a) determine the degrees to which sediment transport in the Ventura River system is controlled by the flow or by changes in the upstream supply of sediment (in conjunction with workplan component II: Relative importance of flow-regulated and bed-sediment-regulated transport); (b) determine the grain-size distribution of the streambed over both time and space; and (c) document the motion of waves of sediment released from the Matilija Reservoir during and after removal of the dam. If it is determined as part of goal (a) that a dominant or substantial historical control of fine-sediment (that is, sand and finer material) transport in the Ventura River is the upstream supply of fine sediment, then the downstream release of sediment from the Matilija Reservoir will not necessarily result in substantial aggradation (and associated increased flood hazards or negative effects on steelhead habitat) in the Ventura River. However, if it is determined that the only dominant historical control of fine-sediment transport in the Ventura River is the flow (this would probably be the case in only an equilibrium alluvial channel), then the downstream release of sediment from the Matilija Reservoir may result in substantial aggradation.

Prior to removal of the dam, determination of streambed grain-size distribution over both time and space will provide some of the input data needed in determining the relative importance of flow-regulated and bed-sediment-regulated transport (workplan component II), and in modeling of sediment transport (workplan component IV). During and after removal, monitoring of evolution of channel-grain-size distribution will provide information useful in the verification process of modeling and in documenting travel of sediment waves.



**Methods:** As a first step in determining the effect of the sediment released from the Matilija Reservoir on the Ventura River, all historical sediment-transport data from the Ventura River and its tributaries will be compiled and analyzed. In addition, prior to removal of the dam, baseline grain-size distributions of bed- and suspended-sediment data will be measured. A portion of the analysis will be achieved in conjunction with workplan component II using the alpha-beta methods developed by Topping and others (2000a) and Rubin and Topping (in press). In addition, to compare the downstream changes in bed grain size with those that seasonally occur in the river under natural conditions, bed-sediment and suspended-sediment samples also will be collected upstream from the reservoir. At each of the sampling sites, cross sections will also be surveyed to record baseline data and the topographic changes associated with the passage of the sediment wave.

Accurate physically based modeling of the downstream migration of such a sediment wave (workplan component IV: Modeling sediment transport and geomorphic response) requires detailed measurements of the grain-size distribution of the bed over both time and space. To document the motion of the sediment waves released from the reservoir, bed samples will be collected during and after removal of the dam at multiple locations every 2 months in the reach downstream from the dam.

**Study Duration and Timing:** The proposed work, subsequent to initial compilation and collection of some of the baseline data (FY2000), is planned for 2 periods of 1.5 years, beginning about 4 years to 1.5 years prior to the beginning of removal of the dam. In addition, periodic monitoring and analysis will take place after removal of the dam.

**Products:** One pre-removal and one post-removal report or journal article.



#### IV. Modeling Sediment Transport and Geomorphic Response

Principal Investigators: J.M. Nelson and P.J. Kinzel

**Background:** A central goal of the full appraisal and monitoring project for the Matilija Dam Removal Project is to predict the geomorphic effects of the release of reservoir sediments on the river channel and nearshore regions. To reach this overall goal, there are several critical steps, including: (1) accurate determinations of the sediment sizes and volumes currently stored in the reservoir (to be done by the USBR); (2) surveys of existing channel and nearshore topography and grain sizes; and (3) construction of conceptual models and development and calibration of predictive-flow and sediment-transport modeling tools for the evaluation of geomorphic change. These tools should predict channel adjustment as a function of existing conditions, the method and quantity of supply of reservoir sediment to the channel, and the flow hydrographs in the basin before, during, and following removal of the dam.

**Purpose and Scope:** In component IV of the USGS study, the concentration will be on obtaining input data and applying predictive-flow and sediment-transport models to evaluate the effects of different flow and sediment-supply scenarios on the morphology of the channel and the delivery of sediment to the nearshore region. The components of a model to route reservoir sediment through the channel are (1) a 1-dimensional flow model for routing flows through the channel from the dam to the beach and computing local, averaged values of boundary shear stress; (2) a detailed 3-dimensional model for flow to be applied at two or three relatively short (5 to 10 channel widths) sites to evaluate the effects of lateral flow structure and secondary flows; (3) a sediment-transport algorithm for computing both bedload and suspended-sediment load for multiple grain sizes using inputs from either of the above models along with the grain-size information to be obtained from work done under workplan components III (Evolution of channel sediment grain-size distribution) and II (Relative importance of flow-regulated and bed-sediment-regulated transport), plus reservoir-sediment characteristics investigated by the USBR; and (4) a time-stepping algorithm to evaluate erosion and deposition in the channel given hypothetical hydrographs and sediment supplies from the reservoir. By combining these elements, a method for evaluating the effects of a variety of potential sediment-release methodologies can be linked to the associated effects on the channel. Importantly, on the basis of current (rough) estimates of the volumes and sizes of material in the reservoir, it appears that the finer sizes may easily pass through the system without significant erosion or deposition, because they are currently supply limited (that is, the amount transported is set by the upstream supply, rather than by the channel hydraulics). However, there is still a significant fraction of sediment (estimated to be 30 to 40 percent by Brauner and others, 1999) in the reservoir that is medium sand or coarser. Using a combination of the modeling results and the methods described by Rubin and Topping (in press), it will be possible to identify the fractions that are not supply limited. These coarser sizes are critical for assessment of the amount of sediment that can be supplied to the channel for a given flow or hydrograph without rapid aggradation in some reaches.

**Methods:**

- (1) Collection of long-reach topographic data: We envision the need for a minimum of 80 cross sections between the dam and the beach (approximately 16 miles). About half of those should be located to coincide with the existing FEMA cross-sections to enable comparison with earlier observations. The other 40 will be strategically located to provide the best resolution possible for the 1-dimensional modeling effort for routing flow and sediment. At least some subset of these cross sections will be monitored during and after the dam removal and sediment release, assuming that some significant portion of the sediment stored in the reservoir will be evacuated by river flows.
- (2) Collection of short-reach topographic data: At 2 to 3 sites, detailed topographic surveys of the channel will be carried out in order to resolve local storage of sediment associated with lateral variability in the flow patterns and secondary flows (including flow separation). In addition, dispersion coefficients for the 1-dimensional modeling will be set using the results of the 3-dimensional models applied at these short reaches. Each site will consist of 10 to 20 cross-sections in 5 to 10 channel widths, plus longitudinal surveying of banks, islands, and thalwegs.
- (3) 1-dimensional modeling: An unsteady 1-dimensional model for flow and sediment transport will be applied and calibrated for local roughness using the survey data along with gaged hydrographs and measured grain sizes. Using the existing gage information, the model predictions for timing, duration, and inundation will be tested for accuracy. This should provide some assessment of model accuracy and potential errors in applications for hypothetical hydrographs. For a variety of sediment inputs and hydrographs, gross patterns and rates of erosion and deposition through the reach will be developed. The goal of this work will be to provide estimates of channel response for various sediment-release scenarios from the reservoir. The model will also predict the delivery rate (and size composition) of sediment arriving at the river mouth as a function of sediment release and hydrograph.
- (4) 3-dimensional modeling: A steady 3-dimensional model for flow and sediment transport will be applied at the short-reach study sites in order to provide dispersion coefficients for the 1-dimensional model and estimates of local erosion and deposition patterns for various input sediment loads. Model results will be obtained for several discharges and sediment inputs. These results should help in making more accurate estimates of in-channel storage of sediment, and will also provide a corroboration or invalidation of the 1-dimensional results. For one of the detailed sites, velocity patterns will be measured at relatively low flows for comparison with the model results.

All surveying will be carried out using standard surveying techniques. The equipment used will consist of Trimble 4700 and 4800 (two-rover) GPS surveying instruments. Generally, this configuration will enable location of as many as 2,000 points/day with accuracy of 1 to 2 cm.

Existing flow and sediment-transport models will be employed on existing Sun workstations and 500+ MHz PC workstations. No additional equipment will be required to carry out the proposed work.

**Study Duration and Timing:** Topographic surveying, preparation of water-surface profiles, and collection of velocity data should be done in the period between approximately 4 and 2 years prior to initiation of dam removal. Computational work, model calibration and testing, and model application runs should be completed in the second year before removal. Depending on the time scale of dam removal and channel response, minimal additional monitoring and data collection should be carried out following the start of removal in order to assess the accuracy of predictions.

**Products:** One open file report containing topographic data finished 1 year after commencement of funding. One peer-reviewed article covering model testing and application two years after commencement of funding. One peer-reviewed article on comparison between model predictions and actual channel response (only if reservoir sediment is routed through the river, or principally so).



V. **Biological Studies to Facilitate Ecosystem Restoration and Evaluation after Removal of Matilija Dam, Ventura River, California**

**Principal Investigator:** Reg Reisenbichler

**Background:** The Department of the Interior will play a prominent role in studies of, and in the planning process for, removal of Matilija Dam in the Ventura River system, California, and wishes to use this project as a case study to develop valuable information and conceptual frameworks for planning the removal of other dams and predicting the physical and biological consequences. The primary biological goal for removal of Matilija Dam is to allow steelhead access to approximately 19 miles of nearly pristine habitat above the dam, (presumably) while causing no irreparable harm to native biological communities downstream in the river system.

Restoration of a viable steelhead (*Oncorhynchus mykiss*) population above Matilija Dam is an implicit goal for dam removal because habitat without the target organism(s) is unlikely to motivate the political support necessary to fund removal of Matilija Dam, and lack of a substantial number of steelhead after millions of dollars are spent to remove the dam will dampen public support for removing other dams, and perhaps for other conservation efforts, throughout the country. The reopening of habitat above Matilija Dam is expected to result in production of about 1,000-2,000 adult steelhead per year.

**Purpose and Scope:** The study proposed herein addresses five issues that are important to the evaluation or success of dam removal: (1) interannual variability in production of resident rainbow trout or steelhead both above and below Matilija Dam, and habitat requirements of southern steelhead; (2) ancestry and population structure of resident rainbow trout above Matilija Dam; (3) interrelations between resident rainbow trout and steelhead; (4) structure and function of riparian habitat downstream from Matilija Dam; and (5) production dynamics and habitat utilization for tidewater goby. The first and last issues are important for evaluation; the last three are important for success. The first issue and an additional issue mentioned below (parental origin of *Oncorhynchus mykiss* in the mainstem Ventura River) are particularly appropriate for U.S. Fish and Wildlife Service (USFWS)-USGS cooperation.

The stream system above Matilija Dam is nearly pristine; however, like all southern California streams, only parts of it are suitable for steelhead throughout the year. In addition, the watershed is subject to catastrophic floods, fire, landslides, and drought, and data are lacking regarding the effects of these conditions on the sustainability of a steelhead population in this limited area (approximately 19 miles of stream). Periodic flood events and high sediment loads are historical characteristics of the Ventura River system, both prior to and after construction of Matilija and Casitas Dams. The degree to which steelhead are adapted to, or are able to survive these conditions, as well as those of low flows and droughts, is not well known. High flows, for example, may destroy gravel bars, needed for spawning, by scouring or by burial with fine-grained sediment, or may repair gravel bars by deposition of coarse sediment and removal of fine-grained sediment. (In addition, high flows generally are needed to breach the sand barrier at the mouth of the river to allow upstream migration of returning fish.) Characterization of the habitat requirements of southern steelhead, and the interannual variability in reproductive success and in production of resident trout above and below the dam site will provide a valuable basis for population viability analyses for steelhead, and will dovetail with the characterization of interannual variation in stream habitat to be done as part of workplan component VI (Hydrologic processes affecting the extent of salmonid habitat in Matilija Creek). Monitoring of population levels before and after dam removal is essential to evaluating the effects of dam removal; however, primary responsibility for monitoring may reside with the USFWS and (or) the USBR, and the USGS role may be one of secondary support.

The incidence and population dynamics of (endangered) steelhead in the mainstem Ventura River (which is downstream from Matilija Dam) also is an important unknown for evaluating pre-removal conditions. Baseline monitoring of the *O. mykiss* population below Matilija Dam may be conducted by one of the resource management agencies (for example, USFWS or California Department of Fish and Game [CDFG]). If so, WFRC will cooperate with those agencies by analyzing the otolith (ear stone) microchemistry for each sacrificed juvenile *O. mykiss* to determine whether the female parent was a steelhead or a resident rainbow trout.

Habitat surveys and the presence of a substantial rainbow trout population above Matilija Dam leave little doubt that the area above the dam site can produce steelhead if the fish have access to the area; however, genetic analysis of approximately 50 of these resident trout has suggested that most are not native but are descendants of hatchery rainbow trout from outside the southern steelhead Environmental Study Unit (ESU). Conservation concerns or restrictions from the Endangered Species Act (ESA) may require that excessive numbers of nonnative trout above the dam site be eliminated before the dam is removed. Consequently, the ancestry and population structure of the resident trout is a critical uncertainty.



The interrelation between resident trout and steelhead is another critical unknown --that is, are (native) resident trout more likely to promote or to inhibit steelhead restoration? If (native) resident trout produce smolts and if production of smolts is a genetically determined trait, these smolts may be the preferred founders for a steelhead population. Alternatively, it is possible that competition between resident trout (presumably well adapted to the local environmental conditions) and juvenile steelhead may hinder or preclude restoration of steelhead.

Riparian habitats are important for steelhead, other fishes, amphibians, and many terrestrial animal species by providing food and cover, and through effects on stream-channel morphology and water quality. These habitats should respond to changes in the hydraulic and sediment regimes that follow dam removal, and understanding these changes is an important aspect of evaluating the effects of dam removal.

The Ventura River estuary is small, structurally simple, and therefore vulnerable to catastrophe. Species that require estuary habitat have no refuge areas within the Ventura River system if catastrophic or long-term changes in their habitat result from removal of Matilija Dam. In particular, the tidewater goby, an obligate brackish-water species currently listed under ESA, is vulnerable. Altered-sediment delivery regimes caused by dam removal may substantially alter estuary morphology, with corresponding effects on tidewater goby. For example, substantial deposition (filling) in the estuary might eliminate most of the Ventura Estuary habitat for rearing or reproduction of gobies. Other changes in morphology might favor competitor or predator species, with substantial effects on the viability of the goby population. Tidewater goby live approximately 1 year and reproduce multiple times during the year. Understanding the production dynamics (factors affecting reproductive success within and between years) and habitat utilization for tidewater goby is important for predicting the effects of dam removal alternatives whereby natural flows are used to transport sediments now stored behind Matilija Dam, and for evaluating the effects of dam removal ("before and after" comparisons). This work will dovetail with possible work by the USGS or others to predict the morphological effects on the estuary from the various dam-removal alternatives.

The actual scope of work performed will depend on the level of funding. Only a modest effort on a subset of the goals identified below will be possible without supplemental funding.

**STUDY PLAN:**

**Goal 1:** Characterize the interannual variability in reproductive success of resident rainbow trout in Matilija Creek and the Ventura River system below the dam; collaborate with USFWS or CDFG to determine the proportion of *O. mykiss* in the Ventura River from an anadromous (that is, a steelhead) mother; and, characterize the habitat requirements of southern steelhead.

**Methods:** Populations will be censused annually and reproductive success measured, primarily by electrofishing and age composition analyses from scales. Differences in reproductive success between years and reaches will be evaluated in relation to flow, temperature, substrate composition, and channel morphology data to be collected and interpreted in workplan component VI (Hydrologic processes affecting the extent of salmonid habitat in Matilija Creek). Work toward this goal will involve collaboration with WRD and USFWS or CDFG. WFRC also will assay Sr/Ca at the primordia of otoliths (ear stones) from any juvenile *O. mykiss* sacrificed during sampling by USFWS, CDFG, or others to determine whether the female parent was anadromous (part of its life cycle spent in fresh water; part in salt water). In addition, we will synthesize existing data and conduct field and laboratory studies to describe the temperature, water quality, and physical habitat requirements of southern steelhead.

**Goal 2:** Characterize the population structure (hatchery versus native ancestry) of resident rainbow trout upstream from Matilija Dam.

**Methods:** This work will be done in collaboration with the Alaska Science Center (Jennifer Nielsen), and will employ existing, non-lethal, molecular genetics techniques (mtDNA and micro-satellites). Samples of 50 fish are to be assayed from each of eight potential subpopulations, and compared with baseline data from southern steelhead and from hatchery populations of rainbow trout. We will test the hypothesis that distance upstream from road access and presence of high-gradient reaches downstream (that is, increased "remoteness" or isolation from stocking locations) are negatively related to genetic contribution from hatchery trout.

**Goal 3:** Characterize the genetic and behavioral relations between steelhead and resident rainbow trout, and the life history of southern steelhead.

**Methods:** Interrelations between steelhead and resident rainbow trout will be evaluated in laboratory and field studies of (a) mate and spawning site selection (to determine the likelihood of interbreeding), (b) outbreeding depression (to evaluate the consequences of interbreeding), (c) the ability of resident fish to produce anadromous progeny and the heritability of anadromy (to estimate the likelihood that resident trout could be the progenitors of a restored steelhead population), and (d) competitive interactions between resident trout and (juvenile) steelhead (to estimate the risk that resident fish might hinder or preclude steelhead restoration). The (apparent) production of smolts by resident rainbow trout will be evaluated by trapping downstream migrants during spring as allowed by availability of personnel and traps. We anticipate almost continuous trapping with a 5-foot-diameter screw trap during the spring of each year. Studies of the heritability of anadromy will be initiated or proposed for longer duration funding, depending on feasibility and required duration of study.

Existing data and sample steelhead populations will be synthesized to describe the variability in age and size at entrance to sea; age, size, and fecundity of mature fish; incidence of repeat spawning; extent and importance of instream migrations (that is, limited evidence suggests that seasonal use of intermittent stream reaches is important for resident rainbow trout in Matilija Creek and other parts of the Ventura River system); and importance of estuaries for juvenile southern steelhead.

**Goal 4:** Characterize the spatial structure and species composition of the riparian plant community downstream from Matilija Dam.

**Methods:** Riparian communities will be characterized using aerial photography supplemented by detailed surveys by foot over a 3-year period prior to dam removal. Age and size composition of dominant species, and successional stage of the community will be evaluated. In addition, post-dam-removal monitoring of riparian communities may occur if funding is available.

**Goal 5:** Characterize the reproductive success and habitat utilization of tidewater goby in Ventura River estuary within and between years and relate to environmental factors such as estuary depth, salinity, and temperature; river flow; and seasonal occurrence of other species.

**Methods:** Populations will be censused seasonally, by habitat type, and environmental data will be collected continually for the 3 years of the study. Age composition (period of hatching or recruitment) will be determined from length-frequency distributions or scale analysis. Laboratory studies will be used where appropriate to elucidate habitat requirements. Such studies might include characterization of temperature or salinity tolerances or “scopes for activity,” or might include tests for competitive exclusion through interspecific interactions with other native or nonnative fishes, or might include predator-avoidance tests.

**Study Duration and Timing:** Goals 1, 2, and 5 require at least 5 years of data collection to adequately describe the interannual variation, and should be initiated immediately because of the possibility that dam removal will begin in 5 years or less. Goal 3 should require only 1 year, but should be initiated early to ensure that the data are available for managers well ahead of dam removal. Goal 4 requires three years, and can be initiated 3-5 years before dam removal. Work during the first year will include completion of a detailed study plan (objectives, hypotheses, sampling plan, and proposed statistical analyses) that reflects the logistical and informational limitations and level of collaboration from USFWS and other entities.

**Products:** A final report will describe the results of the study and the implications of the results for removal of Matilija and other (for example, Malibu Creek, Calif.; Elwha River, Wash.) dams along the West Coast. At least five publications in peer-reviewed journals are expected: one from each of goals 1, 2, 4, and 5, and two or more from goal 3.

## VI. Hydrologic Processes Affecting the Extent of Salmonid Habitat in Matilija Creek

Principal Investigators: E.D. Andrews and John Buffington

**Background:** Until the late 1940's, the Ventura River supported substantial runs of spawning steelhead. Steelhead runs to the Ventura River, however, declined greatly during the decade following a number of changes to the watershed. A dam was constructed on Matilija Creek, a major tributary. Flow diversions substantially reduced, and at times, eliminated surface flow in the lower 14 miles of the Ventura River. In addition, water quality was impaired by wastewater discharged into the river. Similar developments affected most other coastal rivers throughout southern California and steelhead runs also declined regionally. In 1997, steelhead was listed as an endangered species.

Matilija Dam no longer achieves its original objectives. The Matilija Creek watershed is highly erodable, and average sediment yields are typically a few thousand tons per square mile annually (Scott and Williams, 1978). Over a 22-year period from 1948 to 1970, approximately 3.4 million tons of sediment were deposited behind Matilija Dam (Taylor, 1981). The storage capacity of the reservoir was greatly reduced. Today, the active storage is estimated to be about 500 to 700 acre-ft. Recently, concerns for the structural integrity of Matilija Dam have prompted an evaluation of the possible remedies, including the decommissioning and removal of Matilija Dam. Several alternatives exist for removing and (or) stabilizing the large volume of sediment stored behind the dam. The cost of these alternatives varies greatly. Similarly, the manner and extent to which the dam is removed and the river channel is restored through the accumulated sediment will provide widely different benefits to the steelhead recovery effort. Approximately 20 miles of stream channel suitable for steelhead spawning lie upstream from Matilija Dam. This reach represents about half of the steelhead habitat that once existed in the Ventura River basin, and it remains today in much better condition than the channel of the Ventura River below the dam. Removal of Matilija Dam and the accumulated sediment could provide substantial benefits to balance the costs of specific alternatives, depending on the quality and extent of habitat for steelhead spawning and rearing that exists upstream from Matilija Dam.

The purpose of this study is to examine and quantify the hydrologic and geomorphic processes that create and maintain the channel features, principally deep pools and gravel bars, that are essential steelhead habitat. The dry, hot summers typical of southern California create stressful and frequently lethal conditions for salmonids. Streamflows in Matilija Creek immediately above the reservoir are commonly less than 1 ft<sup>3</sup>/sec (gaging station 11114500, 1948–69) during August and September when daily mean air temperatures frequently exceed 80°F. Studies of similar streams in California have found that deep, thermally stratified pools provide the necessary refugia during periods of high temperature and low flow. Ground-water inflow to such pools is common, and may become an essential attribute for fish survival in relatively shallow pools (Nielsen and others, 1994; Keller and others, 1995).

The second essential type of habitat is gravel bars composed of relatively clean, medium-sized gravel. Studies of steelhead spawning have found that gravel bars with a median particle size of 10 to 40 mm (Kondolf and Wolman, 1993), and less than 10 percent fine sediment (Bjorn and Reiser, 1991), provide the most favorable conditions for spawning success. Development of buried steelhead embryos requires sufficient flow through the gravel bar to supply oxygen and remove waste products. Intergranular flow is impeded by the accumulation of fine sediments. Where the proportion of fine sediment exceeds 20 percent, spawning success is greatly diminished (Chapman, 1988; Bjorn and Reiser, 1991).

Both the gravel-bar spawning habitat and the deep-pool rearing habitat are relatively dynamic channel features that are degraded by the accumulation of fine sediment. As noted above, the prevailing erosion rate is quite high, approximately 3,000 (tons/mi<sup>2</sup>)/yr. In a regional study of hillslope processes, Scott and Williams (1978) concluded that a substantial part, perhaps more than half, of the sediment supplied to the channel entered during "dry" periods when streamflow was insufficient to transport even relatively fine sand and coarse silt. Consequently, the contributed sediment accumulates in the channel, filling pools and infiltrating gravel bars. Flood discharges sufficient to scour pools and entrain gravel particles do not occur every year in the Ventura River basin. Hill and McConaughy (1988) found that 96 percent of all sediment transported through a section of the lower Ventura River during a 12-year period occurred in just 3 of the years by relatively large floods. The extent of spawning-gravel bars and rearing pools varies depending on the magnitude and time since the most recent large flood and (along the channel) depending on the gradient, channel morphology, and size of bed material. Given the large volume of sediment contributed to the channel during periods of low streamflow and the infrequency of floods sufficient to scour and remove the accumulated sediment, it is hypothesized that the extent of suitable gravel bars for spawning and deep pools for rearing will vary significantly from year-to-year and longitudinally along Matilija Creek.

**Purpose and Scope:** The working hypothesis developed above suggests that gravel bars suitable for spawning steelhead and relatively deep pools that become refugia for juvenile fish during period of very low flow are reconstructed by relatively large floods, and then are gradually degraded over time as fine sediment accumulates in the channel. The flood magnitude and duration required to reconstruct gravel bars and pools, most likely varies significantly along the channel depending on gradient, channel morphology, and bed-material size. Similarly, the rate at which fine sediment accumulates in the channel during periods of sustained low flow depends on the supply of fine sediment and on channel characteristics. This study will seek to describe and quantify the spatial and temporal distribution of gravel bars and pools suitable for steelhead habitat in Matilija Creek, upstream from the Matilija Dam site.

**Methods:** The first phase of fieldwork will involve an initial reconnaissance of channel types, associated geomorphic processes, and potential use by salmonids for spawning, rearing, and refuge (from both floods and droughts). Differences in channel type will be related to local geology (rock type, tectonic setting, and characteristic geomorphic processes), position within the watershed (valley slope, confinement, and connectivity to hillslope processes), riparian influences (bank strength owing to vegetation, in-channel wood debris, and so forth), and anthropogenic activity (Montgomery and Buffington, 1997, 1998).

The second phase of fieldwork will be a more detailed study of geomorphic processes within selected study reaches that are characteristic of the observed channel types. In particular, we are interested in identifying and quantifying the processes that create usable salmonid habitat and examining their spatial and temporal variability.

To obtain a representative sample of channel morphology and processes, each reach will be approximately 10 channel widths long. Detailed maps of channel topography and bed-surface grain size will be constructed and used as templates for monitoring long-term changes in channel morphology and availability of aquatic habitat (Buffington and Montgomery, 1999). Surface and subsurface sediment samples will be obtained, stratified by mapped textural facies, and will provide information on the quality and quantity of spawning sites in each channel reach. In particular, we will examine the availability of preferred spawning gravels (Kondolf and Wolman, 1993), and the percentage of fine grain sizes and consequences for survival of salmonid embryos (Bjornn and Reiser, 1991). Spatial and temporal variations in grain size will be evaluated in terms of both geomorphic processes and anthropogenic activity.

Repeat topographic surveys will provide information on both sediment storage and magnitudes of bed-material scour. Combined with data on egg pocket depths, the latter can be used to examine the potential for fluvial excavation of buried salmonid embryos (Montgomery and others, 1996).

Pool frequency, size and cause of formation will be determined from field surveys and constructed topographic maps. Selected pools will be monitored for water temperature, dissolved oxygen, and ground-water input, providing information on the quality of refugia during summer low flow and droughts. Flood-flow refugia will be quantified in terms of the size and frequency of in-channel obstructions (for example, boulders and wood debris) and off-channel habitat (abandoned and (or) side channels).

**Study Duration and Timing:** Restoring steelhead access to potential spawning habitat in the headwaters of Matilija Creek is a primary objective for the removal of Matilija Dam. Providing this access, however, does significantly constrain the choice of alternatives to stabilize the dam and probably adds substantially to the cost. A thorough understanding of the temporal and spatial extent of steelhead habitat in the upper reaches of Matilija Creek will benefit the analysis of dam-removal options, as well as the long-term management of the southern steelhead population. This study is planned to coincide with other studies and investigations concerning the feasibility of removing Matilija Dam, and to continue for 3 to 5 years.

**Products:** One to two journal articles will be written summarizing the results of the study.



VII. **Littoral Transport of Sand Originating from Matilija Reservoir and the Ventura River**

Principal Investigator: John Dingler

**Background:** At present, the beach from the mouth of the Ventura River southeast to Ventura Harbor is narrow, and beach erosion threatens coastal structures in the area. Before construction of Matilija Dam, the beach was accreting because the combination of littoral sand from the west and sand from the river was greater than the transport capacity of incoming waves. Reduction of the amount of sand supplied by the river resulted in a deficiency of littoral sand with respect to the longshore transport potential, and was a major contributor to the ensuing coastal erosion. This, and other factors, led to the construction of groins between the Ventura Pier and Harbor to protect coastal structures and provide for an adequate recreational beach. However, the beach is still narrow and ongoing beach erosion at the river mouth has damaged a bike path and parking area adjacent to the fairgrounds. In addition, in some areas beach erosion has left behind gravel and cobbles in place of an all-sand beach.

**Purpose and Scope:** The objective of this component of the USGS research endeavor is to address the question of what will happen in the littoral zone when reservoir sand is placed on, or near, the beach. This will be done by using a mathematical model to determine how the river-mouth and downdrift beaches might respond to sediment delivery for various scenarios of removal, transportation, and coastal placement of the sand from behind the dam. Research will include (1) determining pre-dam conditions along the coast, (2) modeling littoral drift and shoreline-change rates for various wave and sediment-supply conditions, and (3) calibrating and verifying the model results.

**Methods:****(1) Determine pre-dam conditions:**

Shoreline orientation and beach width can radically change with anthropogenic intervention in the coastal zone. In the Ventura area, intervention includes construction of a major highway on the coastal terrace, protection of that highway with a seawall, placement of dams on tributaries of the Ventura River, and building of groins to control beach width. To determine the state of the coast prior to those activities, I will study existing aerial photos; existing summary reports; and available data sets, such as the approximately 15 years of beach profiles measured at the Ventura Pier. Much of the anthropogenic activity took place in the past 50 years, and, consequently there are aerial photos from before and after significant anthropogenic activity.

**(2) Model littoral transport:**

I will use the NEMOS model, developed by the U. S. Army Corps of Engineers, to estimate littoral transport. The model requires historical wave data, nearshore bathymetry, shoreline orientation, grain size of the beach sand, and sediment delivery details. With that information, the model predicts a longshore transport rate and changes in beach width. The input parameters are available from various sources. Wave data are collected at offshore buoys and refracted into shore. Hindcast wave data also are available. Bathymetry will be determined from navigation charts. Shoreline orientation will be derived from aerial photos. Grain size is available from previous beach studies and from planned Bureau of Reclamation sampling and analyses of the reservoir material. Delivery details will be based on the various dam- and sediment-removal scenarios.

**(3) Calibrate and verify model:**

Known dredging volumes at the Ventura Harbor mouth and historical beach profiles from the Ventura pier will be used to calibrate the model. When the model output correlates reasonably well with those volumes, the program will be used to estimate shoreline configurations for the different dam-removal and sediment-delivery scenarios and for post-dam-removal conditions. After dam removal commences, shoreline shape calculated from the NEMOS model will be compared with the actual shoreline.

**Study Duration and Timing:**

- (1) Gathering and synthesizing the historical information will be completed during FY2000.
- (2) Operation of the NEMOS model will commence in FY2000 and resume in FY2002 (unless funding is available in FY2001). By the end of FY2000, the program will be running and a simple model produced to see if the approach is reasonable. If the program is appropriate for the parameters of the study, a detailed model will be developed in FY2002 using sediment-characterization data from the USBR.
- (3) Model calibration will take place in FY2002 and FY2003. Comparison with actual littoral transport and shoreline shape will take place during and after dam removal.

**Products:** The historical analysis will be available for the first-year report. A final pre-removal report will describe the results of the model in terms of predicting littoral transport and shoreline change. Another report, after dam removal, will compare theoretical and actual coastal changes. That report should be useful in evaluating the feasibility of placing reservoir sand in the littoral zone during removal of other dams.



**Surface-Water Discharge, Water Quality, and Suspended-Sediment Load  
in the Ventura River and Matilija Creek**

Principal Investigators: Charles Kaehler and E.D. Andrews

**Background:** Streamflow, suspended-sediment, and water-quality data for the Ventura River and Matilija Creek form a fundamental group of critical data needed for many of the workplan components, as well as for elements of the feasibility, design, and construction phases of the Matilija Dam Removal project. Historical and baseline streamflow and sediment-load data, especially for high flows and floods, are needed in studies of various aspects of sediment transport (and therefore in Matilija planning, design, and construction activities), and in biological studies. In addition, water-quality data are needed for planning and design activities and in biological habitat and survivability studies.

A study of sediment loads in the Ventura River Basin by Hill and McConaughy (1988) used data collected during 1969-81 to develop relations between bedload and coarse-suspended-sediment loads and streamflow. During this 12-year period, 96 percent of both total load (98 percent of which is suspended) and coarse-sediment annual load was transported during 3 high-flow years. Hydrologic data currently are collected and compiled for station 11118500 (Ventura River near Ventura, CA [Foster Park]) by the USGS in cooperation with the Ventura County Public Works Agency (VCPWA) and the Casitas Municipal Water District (CMWD). Owing to data needs of the Matilija Dam Removal studies, the USGS has stepped up suspended-sediment data collection this year at station 11118500, and is in the process of installing a real-time data-collection platform for discharge data (data will be available online). A USGS stream gage (11114500) on Matilija Creek upstream from Matilija Reservoir was operated from 1948 until it was destroyed in the floods of 1969; the lack of this station has led to a serious gap in collection of data that are needed for the Matilija Dam Removal project.

**Purpose and Scope:** The purpose of this component of work is to collect and analyze hydrologic data for Matilija Creek and the Ventura River. In the Ventura River system, flood events, and variation in timing and magnitudes of flows, are important factors in sediment transport, channel morphology, riverine and estuarine habitats, fish migration and reproduction, and beach-sand replenishment. These hydrologic data (including water quality) are needed for many of the workplan components (fig. 1), as well as for elements of the feasibility, design, and construction phases of the Matilija Dam Removal project. Baseline data are needed during planning and design phases prior to the start of removal of the dam, and monitoring data are needed during and after removal.

In addition to ongoing data collection at surface-water station 11118500 (Ventura River Near Ventura, CA), a surface-water station will be reconstructed at or near the former site of station 11114500 (Matilija Creek Above Matilija Reservoir) if sufficient funding is obtained. Owing to its location upstream from the reservoir, flow, sediment, and water-quality data from this site will be needed in the feasibility, design, and construction phases of the project, as well as for many of the workplan components. Downstream, at station 11118500, data collection is being expanded as part of this work component to include more frequent suspended-sediment sampling and the addition of online real-time discharge data availability.

**Methods:** In addition to ongoing continuous flow measurements made at station 11118500 (Ventura River near Ventura, CA), the station will be converted to provide the discharge data on line in real time. The ongoing suspended-sediment sampling will be expanded to include sampling twice per month during November-April, plus additional sampling during stormflow events, if needed. Determination of the sand-silt break will be added to all suspended-sediment analyses. Analyses of periodically collected water-quality samples will include major anions and cations, nitrogen and free ammonia, boron, metals, temperature, alkalinity, pH, and dissolved oxygen.

If (depending on funding) a surface-water station is reconstructed on Matilija Creek upstream from the reservoir, continuous flow measurements will be made. The gage will be capable of measuring all magnitudes of flow, including the high flows and very low flows that are important data in studies of fish habitat and reproduction. Suspended-sediment and water-quality sampling will be similar to the sampling proposed for station 11118500.

**Study Duration and Timing:** Flow and suspended-sediment measurements have been made at station 11118500 (Ventura River Near Ventura, CA) for more than 70 years by the California District of the USGS, in cooperation with local agencies. Continued and expanded collection of baseline data is needed for any future studies of the Ventura River system, including studies regarding Matilija Dam removal. The expanded data collection will begin in FY2000 and should continue past completion of removal of Matilija Dam. A similar need exists for baseline and monitoring data for Matilija Creek upstream from the reservoir. If funds are available, the station will be constructed, and data collection will begin, in FY2001.

**Products:** Real-time discharge data for station 11118500 will be available on-line on the USGS WRD web site. Summaries of discharge, suspended sediment, and water quality will be published for both stations in the annual USGS California Water-Data Report.





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**Appendix I - Planning Aid Memorandum by the Fish and Wildlife  
Service**





# United States Department of the Interior

## FISH AND WILDLIFE SERVICE

Ventura Fish and Wildlife Office  
2493 Portola Road, Suite B  
Ventura, California 93003

April 6, 2000

### Memorandum

To: Regional Planning Officer, U.S. Bureau of Reclamation, Division of Planning, Mid-Pacific Region, Sacramento, California (Attention: Federico Barajas)

From: *Diane K. Nade*  
Field Supervisor, Ventura Fish and Wildlife Office, U.S. Fish and Wildlife Service, Ventura, California

Subject: Revised Planning Aid Memorandum for the Proposed Matilija Dam Removal Project Appraisal Study, Ventura County, California

This Planning Aid Memorandum (PAM) transmits the U.S. Fish and Wildlife Service's (Service) revised comments to the U.S. Bureau of Reclamation (Reclamation) to assist with the preparation of an Appraisal Study for a proposed project to remove Matilija Dam, Ventura County, California, and to restore habitat in the vicinity of this dam. These comments have been prepared under the authority, and in accordance with the provisions of Section 2(b) of the Fish and Wildlife Coordination Act [(FWCA) 48 stat. 401, as amended: 16 U.S.C. 661 et seq.]. The purpose of the FWCA is to provide for equal consideration of fish and wildlife conservation with other project features of federally funded or permitted water resource development projects. Pursuant to the FWCA, the Service has coordinated with the National Marine Fisheries Service (NMFS) and the California Department of Fish and Game (CDFG) before providing these comments. We have also consulted with the U.S. Forest Service (USFS).

Reclamation is in the process of conducting an Appraisal Study for a proposed project which involves the removal of Matilija Dam, located 16 miles upstream from the Pacific Ocean, on Matilija Creek, a major tributary of the Ventura River. Matilija Dam was originally built in 1947 as a 192 feet high, 620 feet wide, concrete arch structure to provide domestic water storage and flood control. The creation of Matilija Dam caused the formation of Matilija Reservoir upstream of the dam. Since being created, structural problems have required the height of Matilija Dam to be lowered to a present height of 140 feet by a technique known as notching. Combined effects of notching and sedimentation have reduced the water storage capacity of Matilija Reservoir from an original 7,000 acre-feet (AF) to a present 500 AF. With the loss of approximately 93% of the

original storage capacity, Matilija Dam no longer performs it's intended purpose of domestic water storage and flood control.

There are three main Project objectives: 1) to improve aquatic and terrestrial habitat, to benefit fish and wildlife species (including endangered steelhead), along Matilija Creek and the Ventura River; 2) restoration of hydrologic and sediment transport regime in support of downstream coastal beach sand replenishment to pre-dam conditions; and 3) enhancement of recreational opportunities along Matilija Creek (including U.S. Forest Service land) and the downstream Ventura River system.

Since the project is in the early stages of development, all alternatives and potential impacts have not been determined. Impacts to fish and wildlife resources will be assessed when specific project designs are developed. For the purposes of this PAM, the study area will be defined to include the following areas: Matilija Creek Delta located upstream of Matilija Reservoir, Matilija Reservoir, Matilija Creek below Matilija Dam, and Ventura River from the confluence of Matilija Creek to the Pacific Ocean.

To facilitate the planning process for this project, this PAM will focus upon the following topics: 1) Existing fish and wildlife resources data for the study area from technical reports, published papers, memorandums, letters, and unpublished data; 2) Ventura River watershed wildlife, vegetation, and habitats in the study area; 3) Special status species in the study area; and 4) Comments from NMFS, USFS, CDFG, and the Service regarding agency concerns about potential dam removal impacts upon fish and wildlife resources.

### **Existing Fish and Wildlife Resources Data**

A variety of studies and reports of fish and wildlife resources have been conducted in the Ventura River watershed which may provide useful information on fish and wildlife resources in the project area. Some of the more informative sources of fish and wildlife resource data would include the following:

- Bennet (1993) is a memorandum regarding field observations conducted on January 4, 1993 of steelhead/rainbow trout in the Ventura River, near the Shell Road bridge.
- Capelli (1973a) provides a brief description of the Ventura River watershed physical environment, history of dams and water diversions, and water pollution sources. The main focus of this report was on the history of rainbow trout/steelhead fishing in the Ventura River watershed, plus the description of a habitat restoration proposal to restore the watershed and trout fishery.
- Capelli (1973b) provides a review from literature and personal communications of flora, fauna, and habitats present in the City of San Buenaventura. Sections of this report contain information on the biotic communities of the Ventura River, Ventura River Estuary, and adjacent ecosystems.

- Capelli (1995) consists of a letter regarding field observations conducted on August 14, 1994 of steelhead/rainbow trout in upper San Antonio Creek.
- Capelli (1997) conducted a presence/absence survey for steelhead/rainbow trout in the Ventura River mainstem. Trout were sampled using artificial flies and barbless hooks along approximately 5.75 miles of the 16 mile-long Ventura River during April and May 1995. Scale samples were collected and analyzed to determine if anadromous rainbow trout were present. Fin tissue was collected and analyzed to determine molecular genotypes.
- Carpanzano (1996) provides an account of original fisheries survey field work performed during June and July 1993 on several Santa Barbara County and Ventura County streams, including the Ventura River and Matilija Creek. On Matilija Creek, 13 habitat units from three reaches totaling 6,680 meters in length were surveyed. On the Ventura River, three habitat units from one 1,646 meter-long reach were surveyed. This study focused on studies on steelhead related to mitochondrial genotypes, physical habitat descriptions, and habitat parameters affecting distribution.
- Chubb (1997) compiled an analysis of the Ventura River watershed on Los Padres National Forest lands using USFS field data and a review of literature. The focus of this report was on potential for steelhead restoration, and included such topics as historical presence of fish species, current presence of fish species, other aquatic species, and steelhead habitat quality.
- Clanton and Jarvis (1946) consists of a memorandum of biological field observations conducted in the Matilija Creek area during 1946. Topics include the proposed building of Matilija Dam, water diversions, steelhead spawning locations, trout stocking, and recreational fishing.
- Entrix, Inc. and Woodward-Clyde Consultants (1997) provides a comprehensive technical report containing previous natural resource studies and historic environmental accounts of the Ventura River watershed relevant to a proposed steelhead restoration and recovery plan. Chapters in this report included hydrology, steelhead trout biology, trout habitat conditions, other sensitive aquatic and riparian vertebrate species, operation of sand maintenance activities along the river, other activities along the river, potential mitigation measures for ongoing maintenance activities, potential conservation actions, and recommended actions.
- Ferren *et al.* (1990) provides a description of the physical environment, land use history, botanical resources, regulatory authorities and policies, management opportunities, potential interpretive themes, and natural resource management recommendations for the Ventura River Estuary and adjacent Emma Wood State Beach. This report utilized historic data, plus the data gathered from numerous field surveys conducted between April 1987 and October 1989.

- Henke (1998) provides a compilation of life-long observations and personal commentary about the social and natural history of the Ventura River watershed with frequent references to steelhead/rainbow trout.
- Holmgren (1999) provides field notes taken during a field survey for birds on and adjacent to Matilija Reservoir on November 26, 1999. Brief descriptions of vegetation types are also provided.
- Hunt (1991a) is an environmental report which contains information recorded during biological field surveys performed between October 1990 and March 1991 along a 1.6-mile section of the lower Ventura River, with the downstream end of the study area located about a half-mile from the river mouth. This study evaluates vertebrate fauna, compares wildlife activity and habitat use, and predicts future impacts resulting from an ongoing gravel and sand mining operation.
- Hunt (1991b) wrote a memorandum regarding field observations on August 5, 1991 of steelhead/rainbow trout in the Ventura River, about 1.5 miles north of the Main Street Bridge.
- Hunt (1991c) designed a habitat restoration plan for the project site studied in Hunt (1991a) along the lower Ventura River. This document utilizes previous studies to describe habitats, plants, and animal species. Details for habitat restoration, including revegetation, maintenance, and monitoring are also described.
- Hunt (1994) conducted a biological assessment for a five-mile long recreational trail along the Ventura River, extending from Main Street to Foster Park. Using literature from previous studies of riverine and upland vegetation and wildlife habitats along the lower and middle portion of the Ventura River, this assessment discusses such topics as wildlife habitats, plant communities, and sensitive species.
- Hunt (1996) provides a report of the first-year of implementation and planting efforts of a habitat restoration project. The project site was located on a 1.6-mile long lease site in the lower Ventura River flood plain, with the downstream end of the study area located about one half-mile from the river mouth. Topics of this report included existing vegetation, site preparation, weed control, soils, seed mixes and nursery-grown stock, analysis of edaphic conditions of naturally-occurring tree and shrub species, and survivorship. This document contains information which may prove to be relevant for potential habitat restoration efforts in Matilija Reservoir.
- Hunt and Lehman (1992) provides a portrayal of habitat use and present management recommendations for fishes, amphibians, reptiles, birds, and mammals in the Ventura River Estuary and adjacent Emma Wood State Beach. This report utilizes historic data, plus the data gathered from original field surveys conducted between June 1991 and July 1992. A chapter on special status species is also provided.



- Leidy (1991) wrote a memorandum regarding field observations on May 5, 1991 of steelhead/rainbow trout in the upper Ventura River Estuary.
- Mertes *et al.* (1995) provides data for wetlands located in the Ventura River watershed, primarily based upon original field work from more than 100 sampling stations surveyed from April 1993 to July 1994. Many of these sampling stations were located along the Ventura River Matilija Creek, and tributaries of Matilija Creek. Field data obtained from April 1987 to October 1989 (Ferren *et al.* 1990) was used to evaluate the estuary area of the Ventura River. Fine resolution aerial photography was used to analyze the wetlands of a few areas where access was denied on private property. Wetland topics of this report include classification, geomorphic data, assessment of functions and values, and description of types and distribution.
- Moore (1980a) provides a compilation of field data sheets and field notes collected during summer 1979 field surveys of streams in the Ojai Ranger District of the Los Padres National Forest. Data is included for streams located within several watersheds, including the Ventura River watershed. Within the Ventura River watershed, the following streams were surveyed: Murrieta Creek, Matilija Creek, Upper North Fork Matilija Creek, North Fork Matilija Creek, Coyote Creek, and Gridley Creek. For these surveyed streams, data is provided for such topics as physical habitat, and incidental observations of invertebrates, fishes, amphibians, reptiles, and birds.
- Moore (1980b) conducted a study to evaluate conditions affecting survival of steelhead/rainbow trout in portions of the Ventura River during three consecutive summer-fall base flow periods during June - October of 1976, 1977, and 1978. The study area was a portion of the Ventura River near the community of Casitas Springs, below the confluence with San Antonio Creek. Topics related to environmental concerns include surface flow, habitat characteristics, water quality, and waste discharges. Topics related to steelhead/rainbow trout include population size, growth rates, bioassay data, predation sources, and survival rates.
- Tippets (1979) collected steelhead/rainbow trout in the middle Ventura River and upper Ventura River above the Robles Diversion during February 1977. Otoliths from collected specimens were extracted, prepared, and analyzed. Statistical results from the otolith analyses indicate that wild steelhead were successfully spawning in the Ventura River.
- Wetlands Research Associates *et al.* (1992) conducted a study of the natural resources of the Ventura River Estuary using a combination of field work, surveys of museum and literature records, and personal communications with local scientists. Topics covered include historical changes, vegetation, wildlife, water quality, and hydrology. Biological field surveys were conducted between June 1991 and July 1992.
- Wetlands Research Associates *et al.* (1994) provide a plan based upon their 1992 report to enhance and manage the Ventura River Estuary area and adjacent habitats. Included in this

plan are criteria and strategies for restoration, monitoring, and management of various wetland, riparian, dune, and other habitats.

In addition to the above materials, USFS and CDFG data sheets were examined by Service biologists for 25 stream surveys in creeks above and below Matilija Dam, including Matilija Creek (1949, 1975, 1993, 1996, and 1999), Old Man Creek (1996), Murietta Creek (1979, 1993, 1996), Upper North Fork of Matilija Creek (1979, 1993, and 1996), North Fork Matilija Creek (1996, 1998, 1999), and the Ventura River (1993). Parameters for these surveys varied, but often included data on stream flow, physical habitat, vegetation cover, invertebrates, fishes, and terrestrial fauna. Electrofishing and snorkel survey protocol were included in several of these surveys. Files containing these data sheets were obtained from Maeton Freel, Ecosystems Staff Officer, Los Padres National Forest, Goleta, California. The reviewed data sets represent only a portion of the USFS and CDFG stream survey field data available for streams of the Ventura river watershed.

Review of the above materials indicates that fish and wildlife resource studies have been conducted on many portions of the Ventura River watershed. However, a paucity of materials related to fish and wildlife resource studies of the Matilija Reservoir area was noted. Except for incidental observations conducted during stream surveys, data on invertebrates appeared to be scarce throughout the watershed.

### Ventura River Watershed Wildlife, Vegetation, and Habitats

#### **Matilija Reservoir Area**

A preliminary field inspection was conducted by Service biologists during November 1999 in the Matilija Reservoir area. The slopes surrounding Matilija Reservoir were vegetated by a mixed chaparral plant community, dominated by such plants as laurel sumac (*Malosma laurina*), purple sage (*Salvia leucophylla*), ceanothus (*Ceanothus sp.*), California sagebrush (*Artemisia californica*), buckwheat (*Eriogonum sp.*), deerweed (*Lotus scoparius*), and yucca (*Yucca whipplei*). As reported by Wehtje (2000) common wildlife in this upland chaparral area would include mule deer (*Odocoileus hemionus*), black bear (*Ursinus americanus*), mountain lion (*Felis concolor*), bobcat (*Felis rufus*), coyote (*Canis latrans*), California ground squirrel (*Spermophilus beechyi*), dusky-footed woodrat (*Neotoma fuscipes*), California quail (*Callipepla californica*), California towhee (*Pipilo crissalis*), wrentit (*Chamaea fasciata*), bushtit (*Psaltriparus minimus*), phainopepla (*Phainopepla nitens*), San Diego gopher snake (*Pituophis melanoleucus annectens*), California king snake (*Lampropeltis getulus californiae*), southern Pacific rattlesnake (*Crotalus viridis helleri*), red coachwhip (*Masticophis flagellum piceus*), Great Basin fence lizard (*Sceloporus undulatus biseriatus*), and side-blotched lizard (*Uta stansburiana*).

Wetland habitats are present around the perimeter of Matilija Reservoir, particularly at the upstream end where extensive riparian habitats are also present. During the Service site visit conducted during November 1999, these wetland and riparian habitats were dominated by arundo (*Arundo donax*), willow (*Salix spp.*), bulrush (*Scirpus sp.*), cattail (*Typha sp.*), watercress (*Rorippa sp.*), and various grasses. In the Matilija Creek flood plain upstream of the reservoir, vast stands of arundo, often greater than 15' tall, were the dominant vegetative feature. Common

wildlife species in these wetland and riparian areas would include raccoon (*Procyon lotor*), American coot (*Fulica americana*), ring-necked duck (*Aythya collaris*), green-winged teal (*Anas crecca*), gadwall (*Anas strepera*), ruddy duck (*Oxyjura jamaicensis*), mallard (*Anas platyrhynchos*), yellow-rumped warbler (*Dendroica coronata*), common yellowthroat (*Geothlypis trichas*), Pacific tree frog (*Hyla regilla*), California tree frog (*Hyla cadaverina*), bullfrog (*Rana catesbiana*), and western toad (*Bufo boreas*) [Wehtje 2000, Service unpublished field observations].

Holmgren (1999) conducted an ornithological survey of Matilija Reservoir and the surrounding wetland, riparian, and chaparral habitats on November 26, 1999. A total of 45 bird species was detected during this survey, and none of these were a special status species. The most common species were American coot, ring-necked duck, green-winged teal, gadwall, ruddy duck, mallard, western meadowlark (*Sturnella neglecta*), yellow-rumped warbler, and lesser goldfinch (*Carduelis psaltria*).

Cardenas (2000) has observed rainbow trout and smallmouth bass (*Micropterus dolomieu*) in Matilija Reservoir, and suspects that arroyo chub (*Gila orcutti*) are likely present.

### Ventura River

The Ventura River wetlands and riparian habitats are dominated by such species as sedge (*Cyperus* spp.), watercress, water primrose (*Ludwigia uruguayensis*), wild celery (*Apium graveolens*), cattail, arundo, white alder (*Alnus rhombifolia*), arroyo willow (*Salix lasiolepis*), red willow (*Salix laevigata*), mulefat (*Baccharis salicifolia*), black cottonwood (*Populus balsamifera trichocarpa*), California bay (*Umbellularia californica*), mugwort (*Artemisia douglasiana*), cocklebur (*Xanthium strumarium*), saltbush (*Atriplex* sp.), sycamore (*Platanus racemosa*), coast live oak (*Quercus agrifolia*), laurel sumac, poison oak (*Toxicodendron diversilobum*), California blackberry (*Rubus ursinus*), wild rose (*Rosa* sp.), Spanish broom (*Spartium laevigata*), wild fennel (*Foeniculum vulgare*), and various grasses [Moore 1980b, Hunt 1994, Mertes *et al.* 1995].

Habitats in and near the Ventura River area sustain some of the highest diversity of vertebrate species in southern California. Nearly 300 vertebrate species are known from the lower reaches of the Ventura River alone (Hunt 1994). Wildlife species from the Ventura River mainstem and adjacent wetland and riparian habitats include coyote, striped skunk (*Mephitis mephitis*), California mule deer, black bear, mountain lion, Virginia opossum (*Didelphis virginianus*), raccoon, California ground squirrel, house finch (*Carpodacus mexicanus*), Brewer's blackbird (*Euphagus cyanocephalus*), common yellowthroat, brown-headed cowbird (*Molthrus ater*), yellow-rumped warbler, bushtit, southwestern pond turtle (*Clemmys marmorata pallida*), southern alligator lizard (*Elgaria multicarinatus webbi*), bullfrog, Pacific treefrog, steelhead/rainbow trout, arroyo chub, Pacific lamprey (*Lampetra tridentata*), partially armored three-spine stickleback (*Gasterosteus aculeatus microcephalus*), common carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), and mosquitofish (*Gambusia affinis*) (Hunt 1994, Chubb 1997, Cardenas 2000, Wehtje 2000).

### **Ventura River Estuary**

Narrow-leaf cattail (*Typha domingensis*), California bulrush (*Scirpus californica*), alkali bulrush (*Scirpus maritimus*), several willow species, alkali heath (*Frankenia salina*), jaumea (*Jaumea carnosa*), pickleweed (*Salicornia virginica*), coastal saltgrass (*Distichlis spicata*), duckweed (*Lemna cirrhosa*), ditchgrass (*Ruppia cirrhosa*), duckweed fern (*Azolla filiculoides*), and enteromorpha (*Enteromorpha intestinalis*) are among the dominant plant species found in the wetland and riparian plant communities of the Ventura River Estuary [Ferren *et al.* 1990, Mertes *et al.* 1995].

Hunt and Lehman (1992) indicated that nearly 275 vertebrate species inhabit the Ventura River Estuary and vicinity. Birds were the most diverse group, while amphibians and reptiles were the least diverse groups. Common species included western harvest mouse (*Reithrodontomys megalotis*), California mouse (*Peromyscus californicus*), dusky-footed wood rat, big brown bat (*Eptesicus fuscus*), Yuma myotis (*Myotis yumanensis*), brush rabbit (*Sylvilagus bachmani*), California ground squirrel, coyote, opossum, mallard, American coot, killdeer (*Charadrius vociferus*), willet (*Catoptrophorus semipalmatus*), western gull (*Larus occidentalis*), elegant tern (*Sterna elegans*), cliff swallow (*Hirundo pyrronota*), southwestern pond turtle, Great Basin fence lizard, bullfrog, Pacific treefrog, common carp, tidewater goby, topsmelt (*Atherinops affinis*), arroyo chub, and partially armored three-spine stickleback.

### **Special Status Species in the Study Area**

At least 26 special status species are known from the aquatic, riparian, and wetland habitats from the study area, and include 13 listed species (endangered, threatened, or fully protected) and 13 California species of special concern.

### **Listed Species**

The 13 listed species known from the study area include 9 endangered species, 2 threatened species, and 2 fully protected species, as follows:

- Southern steelhead (*Oncorhynchus mykiss*), federally endangered; known to occur throughout the Ventura River watershed below Matilija Dam and Casitas Dam (Hunt and Lehman 1992).
- Tidewater goby (*Eucyclogobius newberryi*), federally endangered; known from the Ventura River mouth to about 2.0 miles upstream (Hunt and Lehman 1992).
- Least Bell's vireo (*Vireo bellii pusillus*), federally endangered and state endangered; known from riparian habitats of the lower Ventura River from the river mouth to about two miles upstream; breeding pairs known from this area (Hunt and Lehman 1992, Hunt 1994); suspected to use the Matilija Creek drainage as a migration corridor (Freel 2000).

- Southwestern willow flycatcher (*Empidonax traillii extimus*), federally endangered, state endangered; suspected to use the Matilija Creek drainage as a migration corridor (Freel 2000).
- Brown pelican (*Pelecanus occidentalis californicus*), federally endangered, state endangered; known from observations of roosting and feeding activities from the Ventura River estuary and adjacent beach and near shore marine areas (Hunt and Lehman 1992).
- California least tern (*Sterna antillarum browni*), federally endangered, state endangered; known from numerous sightings in the Ventura River Estuary area; no nesting activities have been observed, but feeding activities have been observed (Hunt and Lehman 1992).
- Peregrine falcon (*Falco peregrinus*), state endangered; known from a few sightings in the Ventura River Estuary area (Hunt and Lehman 1992).
- Belding's savannah sparrow (*Passerculus sandwichensis beldingi*), state endangered; known from coastal salt marsh areas of the Ventura River Estuary (Hunt and Lehman 1992).
- Ringtail (*Bassariscus astutus*); state fully protected; known from riparian areas near Matilija Reservoir and Ventura River mainstem (Hunt 1994, Wehtje 2000).
- Black-shouldered kite (*Elanus caeruleus*), state fully protected; known from the Ventura River Estuary area, particularly in adjacent uplands (Hunt and Lehman 1992).
- Western snowy plover (*Charadrius alexandrinus nivosus*), federally threatened (nesting); known from beach and dune habitats of Ventura River mouth and adjacent areas; foraging activity, but no nesting activity has been observed (Hunt and Lehman 1992).
- California red-legged frog (*Rana aurora draytonii*), federally threatened; reported in the Matilija Creek area (Freel 2000, Sweet 2000).
- California condor (*Gymnogyps californianus*), federally and state endangered species; historic habitat in the Matilija Creek drainage, last reported soaring and roosting in the Matilija Valley in 1998 (Austin 2000); although not an aquatic, riparian, or wetland species, the California condor is mentioned here because of its wide-ranging travel habits, inquisitive nature, and recent episodes of contact with humans.

Additionally, suitable habitat for the state endangered yellow-billed cuckoo (*Coccyzus americanus*) exists along the Ventura River near the confluence with San Antonio Creek (Wehtje 2000). This species is known from the adjacent Santa Clara River (Wehtje 2000), but has not been reported in any of the references cited in this PAM.

**California Species of Special Concern**

The following 13 species are known to occur in the Matilija Reservoir area, tributaries upstream of Matilija Dam, or downstream of Matilija Dam, and are considered to be species of special concern by CDFG:

- Arroyo chub (*Gila orcutti*); known to be widespread in distribution in most of the Ventura River watershed (Hunt and Lehman 1992).
- Southwestern pond turtle (*Clemmys marmorata pallida*); known to be widespread in distribution in the Ventura River, including the estuary, Matilija Creek, Matilija Reservoir, Lake Casitas, and San Antonio Creek (USFS unpublished data, Hunt and Lehman 1992, Entrix and Woodward-Clyde Consultants 1997).
- Silvery legless lizard (*Anniella pulchra pulchra*); known from coastal dunes near the mouth of the Ventura River (Hunt and Lehman 1992).
- Two-striped garter snake (*Thamnophis hammondi*); known from the Ventura River mainstem in the Casitas Springs area, and from 1.5 miles upstream of the mouth (Hunt and Lehman 1992).
- Tricolored blackbird (*Agelaius tricolor*), when in nesting colonies are considered a state species of special concern; known in riparian habitats from 1 mile upstream from Highway 101 (Natural Diversity Data Base 1999).
- White-faced ibis (*Plegadis chihi*); known from one sighting in 1989 on the beach adjacent to the eastern portion of the Ventura River mouth (Hunt and Lehman 1992).
- Osprey (*Pandion haliaetus*); known from several sightings of individuals feeding in the lower Ventura River, from the estuary to about 0.5 miles upstream (Hunt and Lehman 1992).
- Black swift (*Cypseloides niger*); known from one sighting at the Ventura River mouth in 1981 (Hunt and Lehman 1992).
- Cooper's hawk (*Accipiter cooperi*); known from sightings between Main Street Bridge and Foster Park (Hunt 1991, 1994).
- Yellow warbler (*Dendroica petechia brewsteri*); known from riparian woodland in the Ventura River Estuary area (Hunt and Lehman 1992).
- Blue grosbeak (*Guiraca caerulea*); known from unspecified areas of the Ventura River watershed (Mertes *et al.* 1995), expected in the Ventura River mainstem as a common spring and fall migrant, and as an uncommon breeder (Holmgren 2000).

- Yellow-breasted chat (*Icteria virens*); known from willow forest in the Ventura River Estuary area (Hunt and Lehman 1992).
- Pallid bat (*Antrozous pallidus*); known to roost under the Main Street Bridge over the lower Ventura River (Hunt and Lehman 1992).

Suitable habitat for the western spadefoot toad (*Scaphiopus hammondi*), a state species of special concern, occurs along the Ventura River in the Oak View area (Wehtje 2000), but this species has not been reported in any of the references cited in this PAM.

When considering all of the special status species in the study area, the Service has the most concerns for the potential impacts to California red-legged frog, tidewater goby, and southern steelhead.

Our concerns for the California red-legged frog are based upon reports of their presence in the vicinity of Matilija Reservoir. If California red-legged frogs are actually present in this area, they would be subjected to construction activities from the dam removal, plus the loss and modification of wetland and riparian habitats upon which they depend for survival.

Our concerns for the tidewater goby are based upon the potential for downstream impacts from sediment transport from Matilija Reservoir into the Ventura River Estuary. This sedimentation may cause changes to water quality, substrate characteristics, and estuary depths which may adversely impact the tidewater goby.

Our concerns for the southern steelhead are based upon the high potential for downstream impacts from sediment transport from Matilija Reservoir. This sedimentation may seriously impact steelhead migration and cause the loss of steelhead spawning and rearing habitat. We would like to emphasize that we defer to NMFS on steelhead issues, and encourage Reclamation to continue to coordinate with them on future steelhead issues.

### **Agency Comments**

On January 6, 2000, a meeting was held at the Service's Ventura Fish and Wildlife Office to discuss agency concerns for the proposed project. Participating in this meeting were biologists from the USFS (Maeton Freel), CDFG (Morgan Wehtje and Mauricio Cardenas), NMFS (Korie Johnson), and the Service (Greg Sanders and Glenn Greenwald). Topics of this group discussion focused on potential impacts to fish and wildlife resources. All agencies were in strong support of the proposed project, and in general, shared common perceptions about the impacts and benefits to fish and wildlife resources associated with the removal of Matilija Dam.

### **Data Gaps**

During this meeting several areas of biological data needed to evaluate impacts of the Matilija Dam removal project to fish and wildlife resources were determined to be scarce or absent. These

areas of greatest need were determined to include the following:

- An assessment of the value of this proposed restoration effort to the recovery of the steelhead run in the Ventura River watershed.
- Obtaining photos of the Matilija Reservoir area prior to construction of Matilija Dam to assist with restoration efforts at Matilija Reservoir if the dam was to be removed.
- Fauna surveys in the Matilija Dam and Matilija Reservoir area, particularly for amphibians, reptiles, and birds.
- Data regarding California red-legged frog presence in the study area and vicinity. A need exists to determine if this species is present in the study area.
- Data on the age class structure of steelhead/rainbow trout found in the Ventura River mainstem.

#### **Agency Concerns**

At the interagency meeting, the most serious concerns and impacts associated with the removal of Matilija Dam were determined to be the following:

- The greatest concern from impacts of this project is sediment transport. Removal of Matilija Dam will require a means to properly dispose, stabilize, and/or transport an estimated 7.5 million cubic yards of sediment which has been retained in Matilija Reservoir (Sturm 2000). Concern was expressed for the potential for sediment to modify or destroy important aquatic habitats, particularly pool and riffle complexes, both upstream and downstream of the Robles Diversion, located about 2 miles downstream of Matilija Dam. Special consideration should be given to protect the operation of the Robles Diversion fish ladder, which is now being designed, from being smothered by sediment. Special concerns were expressed for the potential impacts to steelhead migration and to the loss of steelhead spawning and rearing habitat from sedimentation. Questions were raised concerning the potential of the sediment load to reduce the Ventura River Estuary in size, depth, and tidal prism volume. The potential impacts to fish and wildlife resources from sedimentation were suspected to be the greatest from the finer-sized clay and silt particles. The type of impacts resulting from sediments were expected to largely depend upon the timing, volume, and methods employed to address the sediment issue.
- Loss of deepwater aquatic habitat and wetland habitat will occur in and around Matilija Reservoir. The areal extent of these habitats and the amount of direct and indirect losses of these habitat types should be quantified. Habitats, plants, and animals in the reservoir area should be studied so that needs for restoration or salvage can be evaluated



- Since the removal of Matilija Dam will eliminate the back up of Matilija Creek waters, and ground water levels in this area will likely drop, loss of wetland and riparian habitat will likely occur upstream of Matilija Reservoir. The areal extent of these habitats and the amount of direct and indirect losses of these habitat types should also be quantified. The habitats, plants, and animals in this upstream area should be studied so that needs for restoration or salvage can be evaluated
- Potential biological impacts to the Ventura River Estuary are a major concern, particularly to marine fishes which rely upon estuaries during part of their life cycle. A need to address concerns for potential values of the Ventura River Estuary as Essential Fish Habitat (EFH) exists under the Magnuson-Stevens Fishery Management and Conservation Act, as amended.
- If beach replenishment is conducted with sediments from Matilija Reservoir, impacts to California grunion (*Leuresthes tenuis*) would need to be addressed.
- Besides southern steelhead, many other listed species inhabit the study area and downstream habitats. Consideration must be given to protect these species and their habitats from harm from construction and sediment impacts.
- In addition to the protection of listed species, a need exists to protect and perhaps salvage species of special concern which would likely be impacted by a dam removal project, such as the southwestern pond turtle, two-striped garter snake, and arroyo chub.
- Consideration should be given to avoid impacts to nesting birds during the prime breeding period for neo-tropical migratory birds in southern California, approximately April 15 to September 1.
- The spread of arundo from the Matilija Reservoir area to areas downstream should be addressed. Removal of these invasive species should be conducted prior to removal of the dam.
- Concern exists that Ventura County Flood Control or other agencies may decide to implement replacement flood control measures once the dam is removed.
- Consideration should be given now, rather than later, to change CDFG fishing regulations to protect steelhead once the dam is removed. Consideration should also be given by NMFS to expand the Southern California Evolutionary Significant Unit (ESU) for southern steelhead above Matilija Dam. Since the creation of Matilija reservoir, fishing has not been legal in Matilija Reservoir, and, therefore, removal of the dam will not impact fishing activities in this area. However, if the ESU is expanded by NMFS to include steelhead above Matilija Dam, a loss of fishing activities will likely occur in several popular trout creeks above Matilija Reservoir.

- Plans should be created to deal with non-native amphibians and fishes in Matilija Reservoir. Since many of these non-native amphibian and fish species out compete and/or prey upon native species, they would need to be removed from the area. Destroying the invasive non-native amphibian and fish species should be considered. However, many of the non-native fishes are considered game species, and may be desirable in other ecosystems.
- Since hunting activities are minimal in the Matilija Reservoir area, impacts to hunting activities would not be significant.

### Summary

For the purposes of this review, the study area was defined as Matilija Reservoir, Ventura River, and Ventura River Estuary. A total of 26 fish and wildlife resource materials was reviewed for the study area. However, only one study on the Matilija Reservoir area was found.

High numbers of plant and animal species are present in the diverse habitats of the study area. Nearly 300 vertebrate species are known from the lower reaches of the Ventura River, and nearly 275 vertebrate species are known from the Ventura River Estuary. A variety of wetlands and riparian habitats are found in the study area.

At least 26 special status species are known from the aquatic, riparian, and wetland habitats from the project area. Included are 13 listed species (endangered, threatened, or fully protected) and 13 species of special concern.

The Service's greatest concerns for potential project impacts to special status species are for the federally endangered southern steelhead, federally threatened California red-legged frog, and the federally endangered tidewater goby.

Data gaps were found for assessing the value of the proposed project to the recovery of the steelhead run in the Ventura River watershed. Information is needed on the age class structure of steelhead/rainbow trout in the Ventura River mainstem. Data is especially needed to determine if the California red-legged frog is present in the study area.

The areal extent of deepwater aquatic, wetland, and riparian habitats in and near Matilija Reservoir should be quantified. Habitats, plants, and animals in the reservoir area should be studied so that needs for restoration or salvage can be evaluated. Data on the amphibians, reptiles, and birds of the Matilija Reservoir area are particularly scarce.

The greatest concern from impacts of this project is sediment transport. Concern was expressed for the potential for sediment to modify or destroy important aquatic habitats, particularly pool and riffle complexes, both upstream and downstream of the Robles Diversion. Special concerns were expressed for the potential impacts to steelhead migration and to the loss of steelhead spawning and rearing habitat from sedimentation. Besides southern steelhead, many other listed species inhabit the study area. Consideration must also be given to protect these species and their

habitats against harm from sediment impacts. A fish ladder is under design for passage of fish over the Robles Diversion. Consideration should be given to protect this fish ladder from being smothered by sediments. Questions were raised concerning the potential of the sediment load to reduce the size and depth of the Ventura River Estuary. Potential biological impacts to the Ventura River Estuary from these sediments are a major concern, particularly to marine fishes which rely upon estuaries during part of their life cycle. A need to address concerns for potential values of the Ventura River Estuary as Essential Fish Habitat (EFH) exists under the Magnuson-Stevens Fishery Management and Conservation Act, as amended.

The spread of arundo from the Matilija Reservoir area to areas downstream should be addressed. Removal of this invasive species should be conducted prior to removal of the dam.

Consideration should be given now, rather than later, to change CDFG fishing regulations to protect steelhead once the dam is removed. Consideration should also be given by NMFS to expand the Southern California Evolutionary Significant Unit (ESU) for southern steelhead above Matilija Dam. Since fishing has not been legal in Matilija Reservoir, removal of the dam should not impact fishing activities in the reservoir. However, if the ESU is expanded by NMFS to include steelhead above Matilija Dam, a loss of fishing activities will likely occur in several popular trout creeks above Matilija Reservoir.

Plans should be created to deal with non-native amphibians and fishes in Matilija Reservoir. Since many of these non-native amphibian and fish species compete with and/or prey upon native species, they may need to be removed from the area. However, many of the non-native fishes are considered game species by CDFG, and may be desirable in other ecosystems. Salvage and transport of these game species to desirable areas should be considered.

The Service recommends that biological field surveys of the Matilija Reservoir be initiated as soon as possible. We further suggest that directed searches for the California red-legged frog, least Bell's vireo, and southwestern willow flycatcher are included in these surveys. Delineation of wetlands and riparian habitats in the Matilija Reservoir area should also be initiated.

The Service appreciates the opportunity to comment on your Appraisal Study, and we look forward to providing you with further assistance. If you have further questions, please contact Glenn Greenwald of my staff at (805) 644-1766.



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