NATIONAL FISH AND WILD LIFE FOUNDATION

MATILIJA DAM REMOVAL DEMONSTRATION

PROJECT 00-351

FINAL REPORT

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PREPARED BY

VENTURA COUNTY FLOOD CONTROL DISTRICT

MATILIJA DAM EVALUATION/DEMONSTRATION
FINAL PROJECT STUDY

TABLE OF CONTENTS

MATILIJA DAM EVALUATION/DEMONSTRATION PROJECT

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Sergio/matilija thank you
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A. Project Objective:

The Project explored various methodologies for removing the concrete dam structure as part of a larger phase program to decommission the Matilija Dam. The methods were assessed according to their impact on the environment and dam structure. As a result of these activities, the most appropriate methods could be selected for use in the future full decommissioning of Matilija Dam.

B. Narrative:

The proposed project target area comprised the upper 90 feet of the non-operational ogee spillway upper crest on the east side of the dam. The target dam section had no function in the dam, since the dam spillway had been notched previously to a level 40-feet below the design elevation of the dam crest (Figures 1 & 2).

C. Project Methodology:

The Matilija Dam Evaluation/Demonstration Project (Project) tested several methods for removal of the concrete dam. Approximately 90 linear feet of a non-operational portion of the concrete dam structure was targeted for the tests. Both cutting methods and material removal methods were evaluated.

Prior to the initiation of each method, scaffolding, which met all necessary requirements, was installed on both sides of the 90-foot section of the dam. The scaffolding was attached to the concrete dam, and required structural calculations for the scaffolding supports. It is anticipated that a debris & safety net of some kind will need to be installed along the project area and below the scaffolding on each side of the dam as a safety measure. All personnel entering the scaffolding were required to have user awareness training.

1. Concrete Cutting

The methods proposed for the tests included: diamond wire saw cutting, hydraulic splitting, drill blasting, expansive grouting, and pneumatic chipping. However, drill blasting was eliminated from the tests at the Contractor's request for replacement with expansive grouting alternative. A description of the methods used and their relative success are described below.

a. Diamond Wire Saw

This method proved to be a viable method for cutting the concrete dam. This method results in straight cut edges that provide better control of the size of the block. It also allowed only minimum disruption of the concrete structure. Holes (1.5-inch diameter) were drilled at the ends and underside of the block for initial saw access. The horizontal cut was made first, with shims inserted as the cut was made to prevent collapse. Then the vertical end cuts was made (Figure 3).

The saw was used to cut blocks approximately 5.6 feet high, 8 feet thick at the base, and 28 to 30 inches long. Eleven blocks were cut within the 30 foot work area. The activity required approximately 10 working days with a crew of 3 men operating the machinery. This included mobilization at the beginning and end of the project. Diamond Wire Saw belts were changed three times during the operation.

Environmental issues associated with the saw include noise, dust, and water. Noise generated by the saw reduced drastically with distance, so the neighbors of the project were not significantly affected. Dry vacuuming was used during the drilling of the holes in this portion of the Project (Figure 4). Water was used to spray the work area and saw blade during work to cool and lubricate blade action. This required a careful collection and recirculation mechanism for the water, which involved plastic collection sheets, a pump, a generator, and a large water container where the concrete cuttings could settle for later disposal. It was imperative to collect the water rather than discharge it to the soil or surface waters due to the extremely high pH of the concrete particles.

Overall, the diamond wire saw was very successful in cutting clean, manageable concrete blocks from the dam. More than one could be operated simultaneously safely to increase the work pace.

The overall cost of the diamond wire saw cutting operation during this Project was not clearly defined due to the various variations in cost distribution from the contractor's bids. The bid lump sum distribution was not representative of the cost of the work for this cutting process. The cost of the contract bid item was $122,000. The lump sum bid item incorporated the cost of removal which was about $30,000. Therefore, approximate real cost was $92,000 for $3,066 per linear feet. However, evaluating the manpower and equipment utilized to complete the work, a better representation of the cost could be achieved. The 30-foot section was cut in 15 working days with about 415 labor hours or 13.8 hours per linear foot of diamond wire saw cutting. The total labor hours included the mobilization, installation of lifting eyes, drilling and cutting. The work proceeded with two diamond wire machines running simultaneously. The approximate real cost based on this labor and material plus profit was approximately $67,000 or $2,233 per foot at an approximate rate of two linear feet per day. The process may be made more economical if additional machines were added to the cutting operation.

a. **Hydraulic Splitting**

The splitting method required the drilling of one- and one half-inch holes along the expected cut plane (approximately 12 inches apart, depending on the condition of the concrete). Usually splitters are inserted in pairs in adjacent holes, then activated to create pressure and break along the plane of least resistance. Three were used in adjacent holes in this trial, which would better the control of the cut (Figure 5). A 30-foot section of the dam was drilled in preparation for this method.

The hydraulic splitting was initialized on the horizontal plane to attempt to separate the 30-foot section. This method failed during initial attempt to cut the vertical plane, which would have resulted in removable concrete blocks.

The primary reason this method failed was due to the presence of steel bars (rebar) in the dam. The hairpin shape rebar found was smooth with thread at its end and was placed in semi-random locations. The rebar appeared to be used for the concrete forms during the construction of the dam. The As-built drawings did not show the rebar in this portion of the dam. Thus, when the concrete block had been cracked away from the base and sides with the splitter, the block could not be lifted until the rebar was cut with saw or torch. This method was discontinued after two days.

Environmental issues associated with the hydraulic splitters included noise, dust, and generation of small pieces of concrete. Noise generated by the splitters appeared to be within reasonable noise level standards. Some dust was generated, but not in the quantities generated by the diamond wire saw, so dry vacuuming was used and was successful. The method did generate small pieces of concrete debris, which were contained in the work area, collected and removed to avoid discharge to soil or water.

The overall cost of the hydraulic splitter based on the contract bid item was $60,000 or $2,000 per linear foot. The lump sum bid item incorporated the cost of concrete removal which was about $25,000. Therefore, approximate real cost was $35,000 or $1,166 per linear feet. The method failed prematurely due to the unexpected finding of steel rebar in the concrete making this method unsuitable. Unless the rebar can be located and cut prior to the removal of the concrete blocks, this method will remain unsuitable.

b. **Expansive Grouting**

The expansive grouting required the drilling of one- and one half-inch to two-inch holes every 28 inches horizontally through the dam face and approximately 12 inches apart vertically across the dam to provide cut planes. By design, the expansive grout, when inserted into the holes expands causing cracks along the drilled planes. The grout was mixed without special equipment, and was easy to insert, and cured in approximately 24 hours (Figure 6). Eyebolts were fixed to the block, which was expected to break away from the dam as a crane lifts the block.

A total of 15 linear feet of the dam was to be removed by this method (Sta 0 to 0+11 and 0+41 to 0+45). This method was implemented for four days with three crew-members. Less than 15 feet of the planned 30 feet were successfully removed.

Several problems with this method were encountered. First, the presence of rebar precluded a simple breaking and lifting of the block. The rebar had to be exposed by using the pneumatic hammer before cutting. Second, the condition of the dam concrete, which was riddled with small cracks due to the reactive aggregate, actually absorbed the energy of the expansive grout. This prevented the grout from causing direction breaks as planned. Thus, directional breaks were not achieved. Future methods involving expansive grout would require alternative placement and quantity, as well as a secondary method to cut the rebar.

Environmental issues associated with the expansive grout method are similar to the other methods, with noise, dust, and debris generated. Noise generated during this method occurred when drilling and cutting the rebar. Each of these activities generated minor noise. Dust and debris are generated during drilling, which required a vacuum collection and cleanup.

The overall cost of the expansive grouting based on the contract bid item was $78,000 or $2,600 per linear feet. The lump sum bid item incorporated the cost of removal which was about $25,000. Therefore, approximate real cost was $53,000 or $1,766 per linear foot. The method failed prematurely due to the unexpected finding of steel rebar in the concrete making this method unsuitable, unless the rebar can be located and cut prior to the removal of the concrete block being cut. Less than a 15-foot section was cut in 8 working days with approximately 250 working hours, or 16.6 hours per linear foot of expansive grouting. The total labor hours included the mobilization, installation of lifting eyes, drilling and applying the expansive grout.

c. **Pneumatic Chipping**

Pneumatic chipping originally was not considered a feasible method to use for the demonstration project, due to the larger dust particles produced with the operation. Containment of dust and debris was considered infeasible. However, this method proved to be very effective in removing the dam concrete (Figure 7). A 15-foot section of the dam was removed in 3 days or 5 feet/day using a hoe-ram. Water was used to contain the dust and debris chips, which was effectively contained by a plastic catchment system. The pieces of concrete were small and easy to place in a metal tray for removal via the crane to a temporary stockpile site. The rebar required cutting as the hoe-ram broke through the concrete, as with most of the other methods attempted during the project.

Environmental issues associated with the pneumatic chipping method include noise, dust and debris. This was the noisiest method of dam removal due to the hammer and motors used. Dust and debris control problems and mitigation were implemented similar to the other concrete removal methods.

The total cost of this method was a direct cost of $16,000 or $1,066 per linear foot. It must be noted that this method was used on areas where the expansive grout had been attempted to be used and failed. The concrete state was fractured before this method began. It could be assumed that this rate may be possible in a larger production.

Summary

Of the concrete cutting methods tested during the project, the diamond wire saw was most effective and resulted in few negative impacts (Table 1). Second, the pneumatic chipping combined with the cutting of rebar proved to be another feasible method, although it was noisy and created concrete debris. Hydraulic splitting and expansive grout were not as effective.

Some of these methods may need further studying to obtain a better grasp of alternatives for the dam structure commission. For instance, the combination of diamond wire saw cutting with hydraulic splitters may provide an alternative method at a lower cost than the diamond wire alone. We must also use caution in applying the result of this study to portions of the dam structure below the current water and sediment levels. Pressure and saturation for much of the dam structure may affect the outcome of future concrete removal activities.

Table 1
Summary of Concrete Cutting Methods

CUTTING METHOD	ADVANTAGES	DISADVANTAGES	SUCCESS
Diamond Wire Saw	Can cut straight line edges; Concrete remains intact; Minimal dust produced; Low environmental impact	Requires water for temp. control; Water residue requires separation, treatment and offsite disposal	Yes
Expansive Grout	Low environmental impact; Simple to use; Cost-effective	Not effective due to rebar and condition of concrete, Dust generation from drilling to insert grout	No
Hydraulic Splitting	Low environmental impact; Simple to use; Cost-effective	Not effective due to rebar and condition of concrete Less accurate cut lines; Dust generation from drilling	No
Pneumatic Chipping	Small size pieces makes for easier removal; Effective offsite transport.	Small particles produced require containment method; additional permit requirements for particle abatement. Noisy	Yes

2. Concrete Removal

Due to the limited accessibility to the site, very few options are available for removal of the concrete sectioned blocks. Possible alternatives include the use of a long span crane, a helicopter crane, or a contained belt conveyor (only if Pneumatic Chipping cutting method is used). If the dewatering of the dam is allowed, construction planks may be utilized for access to back of dam for crane and hauling equipment.

a. Long Span Crane

A long Span Crane was considered a viable option for lifting concrete blocks due to the high weight capacity and long reach, and the possible staging from the existing crane pad on the downstream side of the dam. A 300-ton to 500-ton crane was needed in order to remove sufficient size blocks from the far end of the project area. The 200-foot long boom facilitated access and removal of the pre-cut concrete blocks to a temporary stockpile location behind the dam. A 140-ton crane with a 120-foot boom stationed on the upstream side of the dam, adjacent to existing service road, was used by the Contractor. A staging pad was built just off the service road, and away from the lake. Estimated loads varied from 10 to 15 tons for this type of crane.

b. The **Helicopter Crane** option was considered but has a weight limitation. The limited load capacity of approximately 20,000 pounds for the largest and high cost (approximately six times the cost of the Long Span Crane) of the helicopter crane made it unfeasible. The smaller and more affordable air crane, with a limited load capacity of 3,000 to 4,000 pounds, required the reduction of concrete block size, and increases the number of concrete blocks from approximately 18 to 130. As a result it would have required an additional cutting at approximately five times the cost. Overall, the helicopter cranes are a less desirable method of concrete removal.

c. The **Contained Belt Mechanism** could be used only if the Pneumatic Chipping method is used. It would have required the installation of a temporary truss structure within the dam, which would have made it unlikely for the evaluation/demonstration project due to an increase in permit requirements.

D. The Demonstration Project Evaluation

The Matilija Dam Removal Demonstration Project was a success. Four methods of concrete removal were tested resulting in important information applicable to the future full decommissioning of the dam.

Both the diamond wire saw and the pneumatic hammer were most effective of the methods tested. The saw effectively cuts clean blocks of concrete that can be lifted, transported, and perhaps reused in block form. Dust control via water capture and recirculation was easy and effective. The pneumatic hammer is also effective, despite the noise and concrete rubble produced. Neither the hydraulic splitter nor the expansive grout appears to be an effective means of concrete removal due to the presence of rebar in the dam.

Of equal importance to the methods of removal tested, the demonstration project resulted in the characterization of the dam structure. The discovery of rebar in the concrete was significant in that it affects all aspects of dam decommissioning, from the costs and types of removal methods to the disposal of the material. Further, the extent of fracturing due to the reactive aggregate was evaluated.

The demonstration project also tested the feasibility of dust and debris containment. With all tests conducted, methods to reduce airborne concrete and capture small concrete debris with water or vacuums proved practical and effective. Therefore, the environmental damage potentially caused by air and water borne concrete residues can effectively be minimized.

Noise did not appear to be a significant issue with adjacent neighbors. However, equipment may require shielding with noise barriers for future dam work.

The removal of concrete material was a critical aspect of the dam removal during the Project. Removal was accomplished primarily by stationing a crane on the upstream side of the dam. The crane lifted concrete blocks from the dam crest and placed them near the crane pad for future disposal. Future concrete removal and disposal methods will vary based on equipment access, material storage site options, and many other factors.

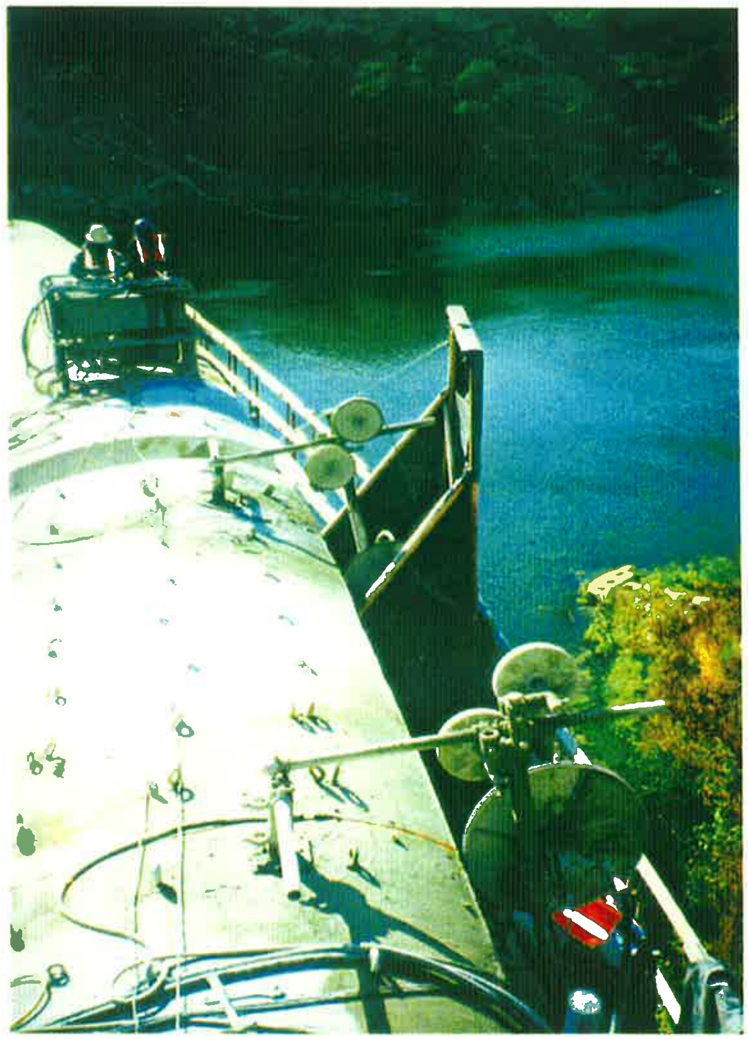
Figure 1

Front View of East Side of Matilija Dam

Figure 2

Back View of East Side of Matilija Dam

Figure 3



Diamond Wire Saw Cutting operation in progress.

Figure 4

Dry vacuuming was used while drilling the holes.

Figure 5

Hydraulic Splitting method being used to attempt a horizontal concrete cut.

Figure 6

Expansive grout being inserted into horizontal holes
for horizontal concrete separation.

Figure 7

Pneumatic chipping operation being used to break concrete.