Attachment D

Field Investigation Report

Matilija Dam Ecosystem Restoration Feasibility Study

Final Geotechnical Field Investigations

Ventura County, California

July 2002

DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

United States
Department of the Interior
Bureau of Reclamation
Mid-Pacific Regional Office
Division of Design and Construction
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PART 1 - GENERAL INFORMATION

INTRODUCTION AND BACKGROUND

The U.S. Bureau of Reclamation began its involvement with the geotechnical aspects of the Matilija Dam Ecosystem Restoration Study in the Fall of 1999. A scope of work and cost estimate for feasibility-level geotechnical field investigations, materials testing and sediment toxicity analyses was developed by Reclamation in mid 2000. In the winter of 2000/2001, the U.S. Army Corps of Engineers (USACE) reviewed Reclamation's proposed scope of work as part of the development of their Project Management Plan (PMP). Following their review and after discussions with Reclamation personnel, the USACE took responsibility for materials testing and sediment toxicity analyses with Reclamation field personnel responsible for sampling according to protocols developed by the USACE. Funding for the feasibility geotechnical investigations was provided by the California Coastal Conservancy in mid 2001. All field work was completed between July 30 and September 15, 2001.

PURPOSE AND SCOPE

The geotechnical investigations described in this report were required to determine the distribution, character and toxicity of the large wedge of sediment that has accumulated upstream of Matilija Dam over a period of 55 years.

The data collected by the subject investigations is intended for use in the following three main areas:

- Sediment Transport (Hydrology and Hydraulic) Analyses
- Development and Evaluation of Dam and Sediment Removal Options
- Identification and Evaluation of Beneficial Sediment Uses

CHRONOLOGY

• Develop Scope of Work and Cost Estimate for Geotechnical Field Investigations	June 15, 2000
• Clear Footpath into Jobsite	February - April 2001
• Construct Access Road into Delta	July 30 - August 3, 2001
• Conduct Geotechnical Investigations (15 drill holes)	August 13 - September 15, 2001
• Complete materials and sediment toxicity testing	October 2001
• Prepare geotechnical Report	October 2001 - March 2002

GEOTECHNICAL INVESTIGATIONS

Previous Investigations

Appraisal investigations, conducted by Reclamation during the period October 1999 through February 2000, included:

1) Field reconnaissance of the reservoir area conducted on October 21, 1999

2) Sampling and Surveying of the reservoir area from December 13 through 17, 1999

3) A data search of the Ventura County Flood Control District (VCFCD) and Casitas Municipal Water District (CMWD) files where pertinent topographic, hydrologic and water chemistry data was obtained.

4) Calculation of the reservoir sediment volume by Reclamation's Mid Pacific Geographic Information Service (MPGIS).

5) Determination of materials properties (gradation, plasticity limits and moisture content) by Reclamation's Phoenix Area Office (PXAO) Materials Testing Lab.

6) Sediment toxicity analyses by a contract chemical testing laboratory under the oversight of Reclamation's Mid Pacific Region Environmental Monitoring Branch.

All appraisal data is included in *Appraisal Investigations Report for Matilija Dam Decommissioning, Ventura County, California, February, 2000.*

Current Investigations

Geotechnical investigations performed between July 30 and September 15, 2001, consisted of:

- 15 drill holes; 8 drilled from a barge in the Reservoir and 7 drilled with a truck-mounted drill rig in the Delta and Upstream Channel.
- 83 materials samples obtained for gradation, plasticity limits and moisture content determinations.
- 39 samples obtained for sediment toxicity analyses.

All geotechnical field work (drilling and sampling, logging and sample collection) was performed by Reclamation's Mid Pacific Geology Section and Pacific Northwest Region Drill Crew. Geologic plan maps and cross sections showing surface and subsurface geologic conditions and locations of explorations are included in the **Drawings** section of this report; geologic drill hole logs are included in the **Logs** section. Materials testing was performed by the USACE Los Angeles District Materials Lab with limited additional testing performed by Reclamation's Mid Pacific Region Construction Office Materials Lab. Materials data is included in the **Lab Data** section. A photographic summary of the entire field investigations program is included in the **Photographs** section. Sediment toxicity testing was performed by the Navy Regional

Environmental Laboratory (NREL) in San Diego, California under a USACE contract. Sediment toxicity data will be included in **Appendix A** when available.

Table 1 (following page 5) is a summary of drill hole data that includes for each drill hole: dates drilled, collar elevation, total depth, bottom of hole elevation, thickness of Reservoir Sediment (Qrs), elevation of top of Alluvium (Qal) and a brief classification and description of the Reservoir Sediment and Alluvium recovered during drilling. Table 1 also notes the depth and elevation that some drill holes encountered natural gas (pressurized methane gas), drill holes DH-03, -04, -06, and -07, and the depth of water and lake bottom elevation for those holes drilled from a barge in the reservoir, drill holes DH-01, 02, -03, -04, -05, -06, -07 and -15.

Sediment volume was calculated for the entire reservoir area (total volume) and for a series of 500-foot long increments extending from the dam to the upstream limit of the original reservoir. Sediment volume data is included in **Appendix B**. Correspondence generated by Reclamation's Mid Pacific Geology Section during the period June 15, 2000 through July 11, 2001 in regards to planning, cost estimate, scope of work, equipment access, trail clearing, description of drilling operations, status of geologic investigations, and occurrence of natural gas is included in **Appendix C**.

ENVIRONMENTAL CONSIDERATIONS AND PERMITS

All drilling operations were conducted on Matilija Reservoir or within the Matilija Creek floodplain. Given the environmental nature of the project, the sensitive character of the local riparian habit and the presence of the threatened red-legged frog, a high degree of care for the environment was maintained by all onsite personnel during their conduct of the varied field activities: clearing, road building, site access, refueling, drilling and sampling.

The following permits were obtained prior to performing the geotechnical field investigations:

- Department of the Army Nationwide Permit (404 Permit) – USACE
- USFWS Biological Opinion (1-8-01-F-26)
- Request to Deviate from Measure 6 of Programmatic Biological Opinion -- USFWS (allowed for an approved method of onsite refueling within a riparian area)
- Programmatic Formal Endangered Species Act Consultation – USFWS (red-legged frog)
- California Regional Water Quality Control Board Conditional Certification, Los Angeles Region

A Spill Prevention Control and Countermeasure Plan and Refueling Procedure for the required drilling operations were also prepared by Reclamation as part of the investigations. These are included in **Appendix D**.

TABLE 1. SUMMARY OF DRILL HOLE DATA – MATILIJA DAM

RESERVOIR AREA										
DRILL HOLE	COLLAR EL (1) TOTAL DEPTH	WATER	LAKE BOTTOM	RESERVOIR SEDIMENT (2) (Qrs)		ALLUVIUM (Qal)		NATURAL GAS	
	BOTTOM EL	DEPTH	ELEVATION	THICK	CLASSIFICATION AND DESCRIPTION	ELEV	CLASSIFICATION AND DESCRIPTION	DEPTH	ELEV
DH-01-01 (8/15-17)	1086.9 83.8 1003.1	13.3	1073.6	67.8	Silt with Sand 7 matls / 2 toxicity (3)	1005.8	Hard, calcareous sandstone. Bedrock ridge. 2.7 ft core run.	Not Encountered	
DH-15-01 (8/25,27)	1087.2 91.0 996.2	12.8	1074.4	72.2	Silt with Sand, Clay & 1-2 ft Silty Sand lenses 8 matls / 8 toxicity	1002.2	Gravel and cobbles.	Not Encountered	
DH-02-01 (8/18-20)	1087.4 81.0 1006.0	11.5	1075.5	64.0	Silt, Sandy Silt, Clay & 1-3 ft Silty Sand lenses 6 matls / 3 toxicity	1011.5	1, 5.5 ft boulder.	Not Encountered	
DH-03-01 (8/21-22)	1086.9 68.3 1018.6	9.6	1077.3	>58.7 (4)	Sandy Silt, Silt, Clay & 1-4 ft Silty Sand lenses 4 matls / 3 toxicity	[1017.6] (5)	Not Encountered	68.3	1018.6
DH-04-01 (8/23)	1087.0 33.0 1051.4	11.1	1075.9	>21.9 (4)	Sandy Silt, Silt w/ Sand & Clay 2 matls / 1 toxicity	[1017.6]	Not Encountered	33.0	1054.0

RESERVOIR AREA (CONT.)

DRILL HOLE	COLLAR EL / TOTAL DEPTH / BOTTOM EL	WATER	LAKE BOTTOM	RESERVOIR SEDIMENT (Qrs)		ALLUVIUM (Qal)		NATURAL GAS	
		DEPTH	ELEVATION	THICK	CLASSIFICATION AND DESCRIPTION	ELEV	CLASSIFICATION AND DESCRIPTION	DEPTH	ELEV
DH-05-01 (8/29)	1087.4 74.8 1012.6	9.4	1078.0	60.0	Sandy Silt, Silt w/ Sand , Clay & 1- 4 ft Silty Sand lenses 5 matls / 2 toxicity	1018.0	1, 2 ft boulder	Not Encountered	
DH-06-01 (8/28)	1087.4 38.0 1049.4	9.4	1078.0	>28.6 (4)	Sandy Silt, Silt, Silt w/ Sand, Clay & a 2.5 Silty Sand lens 1 matls / 1 toxicity	[1025.6]	Not Encountered	31.5 33.0	1055.9 1054.4
DH-07-01 (9/5,6)	1087.8 38.0 1049.8	8.3	1079.5	>29.7 (4)	Sandy Silt, Silt, Silt w/ Sand, Peat & Silty Sand 4 matls / 1 toxicity	[1022.6]	Not Encountered	33.0 38.0	1054.8 1049.8

DELTA AREA

DRILL HOLE	COLLAR EL / TOTAL DEPTH / BOTTOM EL	RESERVOIR SEDIMENT (Qrs)		ALLUVIUM (Qal)	
		THICKNESS	CLASSIFICATION AND DESCRIPTION	ELEVATION	CLASSIFICATION AND DESCRIPTION
DH-08-01 (8/21,22)	1100.8 64.8 1036.0	59.7	0.0 to 34.0: SP-SM w/ Gravel 34.0 to 59.2: SM & thin CL/ML lenses 7 matls / 3 toxicity	1041.8	59.7 to 64.8: Cobbles and Boulders
DH-09-01 (8/25-27)	1100.6 68.8 1031.8]	64.5	0.0 to 34.0: SP-SM w/ Gravel 34.0 to 64.5: SM, SP-SM, PT, CL/ML 9 matls / 3 toxicity	1036.1	64.5 to 68.8: Gravel, Cobbles and Boulders
DH-10-01 (8/28)	1101.4 58.1 1043.3	54.3	0.0 to 54.3: SM, SP, ML w/ Gravel 8 matls / 3 toxicity	1047.1	54.3 to 58.1: Gravel, Cobbles and Boulders
DH-11-01 (9/8)	1104.1 50.5 1053.6	45.5	0.0 to 45.5: SM, (GP-GM)s, (ML)s 8 matls / 3 toxicity	1058.6	45.5 to 50.5: Gravel, Cobbles and Boulders

UPSTREAM CHANNEL					
DRILL HOLE	COLLAR EL / TOTAL DEPTH / BOTTOM EL	RESERVOIR SEDIMENT (Qrs)		ALLUVIUM (Qal)	
		THICKNESS	CLASSIFICATION AND DESCRIPTION	ELEVATION	CLASSIFICATION AND DESCRIPTION
DH-12-01 (9/10)	1104.3 41.2 1063.1	38.0	0.0 to 38.0: (GP/GW)sc, SM, s(ML) 5 matls / 1 toxicity	1066.3	38.0 to 41.2: Gravel, Cobbles and Boulders
DH-13-01 (9/13)	1104.5 32.5 1072.0	29.0	0.0 to 29.0: (SM)g, (GP-GM)s, (SM)g 5 matls / 1 toxicity	1075.5	29.0 to 32.5: Gravel, Cobbles and Boulders
DH-14-01 (9/14)	1106.6 25.0 1081.6	21.5	0.0 to 21.5: (GW)s, SM 4 matls / 2 toxicity	1085.1	21.5 to 25.0: Gravel, Cobbles and Boulders

NOTES

1) Datum = 83/88
2) Only the most common soil types are listed. See geologic logs for complete soils descriptions.
3) Only materials samples obtained during drilling operations are indicated. A few additional samples were obtained and after the field work had been completed. See geologic logs and materials testing summary sheets for all materials testing data.
4) Hole terminated within reservoir sediments upon encountering methane gas.
5) Elevations shown in [brackets] are estimates from the proposed drilling and sampling program (memo dated June, 15, 2000 in Appendix C).

PART 2 - SITE CHARACTERIZATION

The Matilija study site was divided into three major areas: 1) Reservoir; 2) Delta; and 3) Upstream Channel (see Drawings, Figure 1A,). The primary basis for demarcation of these three areas is gradation of the contained sediment package (as determined by drilling).

Boundary lines separating the three areas were determined by examining the gradation of sediment within drill holes, and the lines were designated based on major changes in volumes of sediment gradation. The boundary lines separating the three areas are approximate because sediment in the Delta is interbedded with coarser grained sediments upstream and finer grained sediments downstream. However, on a large scale the project area does not need to be subdivided into more than three categories of sediment size gradation to address the primary question of sediment removal for various uses, including 1) Beach Restoration; 2) Agricultural Applications; and 3) Concrete Aggregate / Road Base.

- **Reservoir** - The Reservoir area starts at Matilija Dam and continues upstream for about 1,400 feet along section A-A' (see Drawings Figure 2). The Reservoir area hosts approximately 2.12 million cubic yards of sediment, about 36% of the total sediment package behind the dam. Sediment in this area is characterized by thick layers of silt with minor amounts of silty sand and gravel.

- **Delta** - The Delta area extends from about 1,400- to 2,900-feet upstream of the dam along section A-A' (Figure 2). This area hosts approximately 2.47 million cubic yards of sediment, about 42% of the total sediment behind the dam. Sediment in this area is characterized by complexly interfingered beds of sand, silty sand, silt, and gravel with or without cobbles.

- **Upstream Channel** - The Upstream Channel extends from about 2,900 feet upstream from the dam along section A-A' to about 5,400 feet upstream (Appendix B). The Upstream Channel hosts approximately 1.30 million cubic yards of sediment, about 22% of the total volume of sediment behind the dam. A large volume of gravel and cobbles with minor boulders, sand and silt dominates the sediment in this area.

RESERVOIR

GENERAL DESCRIPTION

The Reservoir area starts at Matilija Dam and continues upstream for about 1,400 feet along section A-A' (Figure 2). This area contains approximately 36% (2.12 million cubic yards) of the total sediment package behind the dam. Even though the boundary between the Reservoir and Delta areas is based on a major change in sediment gradation, the present-day pond elevation also roughly marks the boundary between the two areas.

The Reservoir area is about 1,100 feet wide on its upstream side and narrows down to a point just upstream of the dam where it is only about 350 feet wide (Figure 1A). The thickness of reservoir sediment varies from about 60 feet on the upstream end (MDH-05-01) to about 72 feet thick (MDH-15-01) near the dam.

Topography on both sides of the Reservoir is very steep, and pre-dam topography shows steep canyon walls to continue below the Reservoir sediment package (Figure 1). Cross sections B-B' and C-C' (Figures 5 & 6) show the pre-dam canyon topography and the present-day sediment wedge.

Both sides of the reservoir pond are covered in thick vegetation, composed of reeds, brush, arundo, and small trees. Travel through this thick vegetation is difficult, and is often limited to existing trails. The steep canyon walls along both sides of the pond host a moderately dense to dense growth of trees and brush (Photos 18 & 24). The upstream transition area between the reservoir pond and land hosts a lush growth of water plants and reeds.

Vehicular access to the Reservoir area is limited to one road coming in along the northeastern side of the reservoir pond. This road was used during the present investigation to transport the barge segments, drill rig, cranes, and a variety of support vehicles to staging areas adjacent to the reservoir pond (Figure 1). A temporary drilling access road constructed across the Delta area ends about 550 feet upstream of the reservoir pond.

The Reservoir area was investigated using a drill rig on top of a barge (Photos 18 &20). The upstream boundary of barge-drilling investigations was primarily limited by dense waterweed in the shallow parts of the pond between water and land.

INVESTIGATIONS

Eight holes (MDH-01-01 thru MDH-07-01, & MHD-15-01) were drilled in the reservoir to characterize sediment gradation, the homogeneous / heterogeneous distribution of sediments, and sediment toxicity (Figure 1). Drill holes range in depth from 33.0 ft. to 91.0 ft. and generally took 1- to 2-days to complete (Table 1). Four of eight holes encountered pressurized methane gas and were terminated for safety reasons before attaining their target depths.

Drilling and Sampling Operations

The barge, drill rig, and drilling equipment were mobilized from Reclamation's Pacific Northwest Region via trucks (Photo 13). The drilling barge has a maximum load capacity of approximately 14,000 pounds and is comprised of three separate segments each having its own floatation cells and weighing between 4200 and 5200 pounds. Two of the three segments are connected via beams and decking, and the third segment is attached to the first two by bolts. The fully assembled barge is self-propelled and is moved into position by a 35 hp outboard motor (Photo 17). The barge is secured at drilling sites by a four-point mooring system incorporating deck winches, cables and Danforth anchors (soft bottom anchors) each weighing approximately 30 pounds (Photo 19). A small aluminum boat with outboard motor was used to ferry personnel, supplies, and small equipment to and from the barge (Photo 17) The boat was also used to set and retrieve anchors for the barge.

The barge, drill rig, and equipment was lifted with a crane from the upstream dam access road, over inaccessible terrain and placed onto the reservoir pond (Photos 14 & 15). The crane used was a GROVE 120 ton crane with a 130-foot boom, having a lifting capacity of about 6,500 pounds at a radius of 120 ft. The maximum load lifted during the project was the 7,600-pound drill rig which was lifted at a picking radius of less than 105 feet. The company supplying the crane is OST Trucks and Cranes from Ventura, CA, (800) 400-4852).

Upon completion of drilling in the reservoir, the drilling barge and drill rig were recovered with a 70-ton hydraulic crane owned and operated by OST Trucks and Cranes. The crane was positioned at an abandoned landing located about 500 feet upstream of the dam that had been cleared of vegetation prior to the start of drilling operations (Photos 34 & 35). This location, which had been used as a landing for the small work boat throughout the reservoir drilling operation, allowed the crane to be positioned close to the water, shortening the picking radius and allowing the use of a 70-ton crane as opposed to the 120-ton crane that was used to launch the barge and drill rig adjacent to the dam.

Drilling was carried out with an Ingersoll-Rand, Model A200 drill. Drilling depth was measured from the water surface of the reservoir pond. The pond depth varied from 8.3 ft. (hole MDH-07-01) to a maximum depth 13.3 ft. (hole MDH-01-01).

A 7 ¼-inch o.d. by 3 ¾-inch i.d. Hollow Stem **F**light **A**uger Continuous **D**ry **C**ore (FADC) system with a 5-ft. long 3 ½-inch o.d. by 3-inch i.d. split tube sample collection barrel was used to collect continuous 3-inch diameter core samples of the reservoir sediment (Photos 21 & 23). The augers used a bullet bit for cutting. When the augers reached pre-dam alluvium below the reservoir sediment, sample collection was changed over to a rotary diamond coring system.

Diamond core drilling of the pre-dam alluvium was accomplished using NWD-4 rods and a face discharge 2.060 i.d. and 2.980 o.d. diamond bit, which collected a 2-inch diameter core of the alluvium.

<u>Sampling Procedures</u>
Samples were collected for determination of their size gradation, plasticity limits (Atterberg Limits), and moisture content with a limited number of samples collected for toxicity analyses.

Sediment was retrieved from the 3-inch i.d. by 5-ft. long split tube core sampler recovered from the 3 ¾-inch i.d. by 7 ¼-inch o.d. hollow stem flight augers. Samples were collected directly from the core barrel before the core was transferred to core boxes. The split tube sample barrel was cleaned with reservoir water before going back into the augers. A special cleaning and handling protocol developed by the USACE (described below) was required for samples collected for toxicity analyses.

Samples for Materials Testing

A total of 37 samples were collected for materials testing. All samples were analyzed for gradation and Atterberg Limits (where applicable). A total of thirteen of these samples were measured for moisture content. All samples collected for Toxicity Analysis had duplicate samples submitted for materials testing.

Nearly all samples collected for materials testing were done so over the entire length of core present in individual runs of the core barrel. Only rarely were samples collected for a specific size fraction, over part of the sample. Most samples were collected over 5-foot intervals, skipping every other 5-foot sample run. Two holes, MDH-07-01 and MDH-15-01 are the main exceptions. In hole MDH-07-01 samples were collected of every run (generally 5 foot intervals) from the top of the sediment column to the end of the hole. In hole MDH-15-01, after the first 5-foot run, samples were collected as 10-foot composites combining sediment from two five-foot runs into each sample for materials testing.

Of the 37 samples collected for materials testing all but 2 samples contained greater than 85% fines, and most samples contained fines in the mid-to-high 90% range. It was recognized early on that sediment in the reservoir is composed primarily of fines (most of which is non-plastic) and that there was little need to attempt discrete sampling of specific size fractions. Visual logging picked up a few discrete sand and gravel lenses within the silt.

Samples for Toxicity Testing

A total of 21 samples of reservoir sediment were collected for toxicity testing. The results of this testing are in Appendix A. Most samples were collected over the full 5-foot interval of the core barrel regardless of sediment gradation, except for drill hole MDH-15-01. In hole MDH-15-01, following the initial 5-foot sample, toxicity samples were collected over 10-foot intervals as a composite of two 5-foot core runs. In most holes only 1- to 3 toxicity samples were collected. In MDH-15-01 the entire hole was continuously sampled for toxicity (a total of 8 samples). This hole also contained the thickest reservoir sediment package drilled (72.2 feet).

The sample protocol included the following:

- The sampler wore new, disposable, rubber gloves for collection of each sample.
- The sample was collected with a stainless steel spoon.
- The sample was placed in a clean jar (supplied by the lab) with Teflon lid.
- The jar lid was sealed with duct tape, and then the jar was labeled and placed on ice, in an ice chest (Photos 49, 50, & 51).
- A duplicate sample was collected for materials testing (samples were double bagged).
- All equipment coming into contact with samples was cleaned with a solution of Alquinox and deionized water, including: the sample spoon; the core barrel; and the top collar and shoe for the core barrel (Photos 46, 47, & 48).
- Vegetable oil was used as needed to lubricate drilling equipment, such as the threads of drill rods.
- At the end of the day, samples were wrapped in bubble-wrap, kept on ice, and every one to

two days shipped overnight to the laboratory for analysis. A copy of the chain of custody was placed with the samples, in the ice chest, prior to shipping.

GEOLOGY

In the Reservoir area, pre-dam alluvium is composed primarily of coarse grained gravel, cobbles, and boulders, similar to the alluvium shown in Photos 52 and 53. Reservoir sediment overlying this alluvium is predominantly fine grained, non-plastic sediment deposited in the slack water environment behind the dam and for about 1,400- to 1,800-feet upstream.

Silt control lines (included in Reclamation's February 2000 report) indicate that the majority of sediment behind the dam was transported during large flood events and was probably deposited very rapidly.

Subsurface Conditions

Continuous sediment samples recovered from eight drill holes show subsurface geologic conditions to be comprised of thick layers of non-plastic fines and clay punctuated by thin, discontinuous beds of silt-with-sand or sandy-silt, and very thin beds of silty-sand, Section A-A', B-B', and C-C' (Figures 2, 5, and 6).

Based on drill holes MDA-01, -15, -02, -03, and -05 (Figures 1, 1A, 2, 3, 4, 5 and 6) the following generalizations can be made about the reservoir sediments.

- Each drill hole intercepted 11 to 15 individual beds of sediment.
- Silt (ML) and Lean Clay (CL) beds are more frequent and thickest near the dam (up to 23 feet thick) and become fewer and thinner (up to 9.5 feet thick) upstream.
- Drill holes closest to the dam contain 72- to 78-% fines with 1- to 15-% Silty Sand (SM).
- Drill holes near the upstream end of the Reservoir area contain 67- to 69-% fines with 11- to 14-% Silty Sand (SM).
- Even though the sand content of the reservoir sediment increases upstream, drilling only intercepted one bed of clean sand (SP) (95% sand), and that bed was very thin (0.7 ft.).
- Beds of Silty Sand (SM) generally contain 30- to 40-% silt and, throughout the Reservoir area, are only 1 to 3 feet thick.
- No significantly thick beds of clean sand were encountered during drilling, and the beds of Silty Sand (SM) that are present are too thin to be separated out by normal excavation methods.

When drilling encountered pre-dam alluvium, the contact was abrupt and easy to determine. Core of the pre-dam alluvium frequently recovered cobble to boulder size sediment with some gravel (Core Photograph MDH-05-01; 49.0 to 78.8 feet).

Surface Conditions

At the time of the geotechnical investigations, the reservoir ranged in depth from about 2 to 18 feet, with an average depth of about 10 feet. The interface between the reservoir pond and the reservoir sediments is one of thick water-weed growth. The upper few feet of reservoir sediment is composed of unconsolidated silt and silty sand and is difficult to sample, even with sand-fingers in the sample core barrel.

PRESSURIZED METHANE GAS

Pockets of pressurized methane gas were encountered in four of eight holes drilled in the Reservoir area (drill holes MDH-03, -04, -06 and -07) and traces of methane gas were detected in MDH-15. Pressurized methane gas was encountered over an area covering about 500 feet by 1,000 feet of the upstream half of the Reservoir area (Figure 1A).

Following is a brief description of the character of methane occurrence in each hole:

- Hole MDH-03 - This was the first hole to encounter methane gas which was tapped at a depth of 68.3 feet, about 8 feet above the expected contact with pre-dam alluvium. The pressure of the gas expelled water and drill cuttings up through the augers and 2- to 3-feet into the air. Augers were pulled from the hole and reservoir sediments sloughed in, sealing the gas off almost immediately.
- Hole MDH-04 - Pressurized methane gas was encountered at 33 feet in this hole. The pressure of the gas was such that it expelled all of the water and drill cuttings from the inside of the augers and continued to escape with a loud hissing. After about 20 hours of venting to the surface, escaping methane gas was hissing just as loud as the previous day. Augers were pulled from the hole and reservoir sediments sloughed in, sealing the gas off within a few hours.
- Hole MDH-06 - Pressurized methane gas was encountered in this hole at a depth of about 33 feet Gas in this hole was under high pressure, blowing water, drill cuttings, and coarse gravel (reservoir sediment, max. size 30 mm) up to 15 feet into the air (Photo 25). An attempt was made to drill through the methane gas pocket, but at a depth of 38 feet, gas had eroded a pathway between the outside of the augers and the reservoir sediment. At this point, gas was boiling up along the outside of the augers and creating a sizeable plume of turbid water (Photo 26). Augers were pulled, but a bubble stream of methane gas continued for a few days before reservoir sediment sloughed in to seal the hole (Photos 30 and 31).
- Hole MDH-07 - Methane gas was initially encountered at about 33 feet, but escaping gas stopped within a few minutes. Drilling continued until a large volume of pressurized methane was encountered at about 38 feet. Here methane gas expelled water and drill cuttings up through the inside of the augers and 1 to 2 feet into the air. Gas then started eroding a channel between the outside of the augers and the reservoir sediment and the hole was ended. Barite mud was put down the hole to seal off the gas as the augers were pulled out.

Two samples of methane gas were collected in SUMMA canisters from drill hole MDH-07 (Photo 33). Both gas samples were analyzed by Zymax Envirotechnology of San Luis Obispo, CA. Preliminary test results showed a high number of Carbon 14 hits, indicating a relatively young biogenic source.

The presence of methane gas in reservoir sediment is now interpreted as being due to rotting vegetation. Methane gas appears to have migrated over time into the sandy layers of the reservoir sediment, and locally built up considerable pressure. The presence of thick beds of silt and clay overlying sandy beds acts to cap the methane. Drill core often hosts casts of gas bubbles in fine grained sediment directly above pockets of pressurized methane gas (Photo 27).

It is further interpreted that the lack of a capping layer of fines in the Delta area may have allowed any methane gas generated to migrate to the surface and dissipate.

The exact horizontal and vertical limits of methane gas in the Reservoir area are unknown, as is the total quantity of methane. An estimate of the major area of methane accumulation is shown on Figure 1A, but other areas of the reservoir are also likely to host some methane, i.e. MDH-15 and Photo 32.

GEOTECHNICAL CONSIDERATIONS

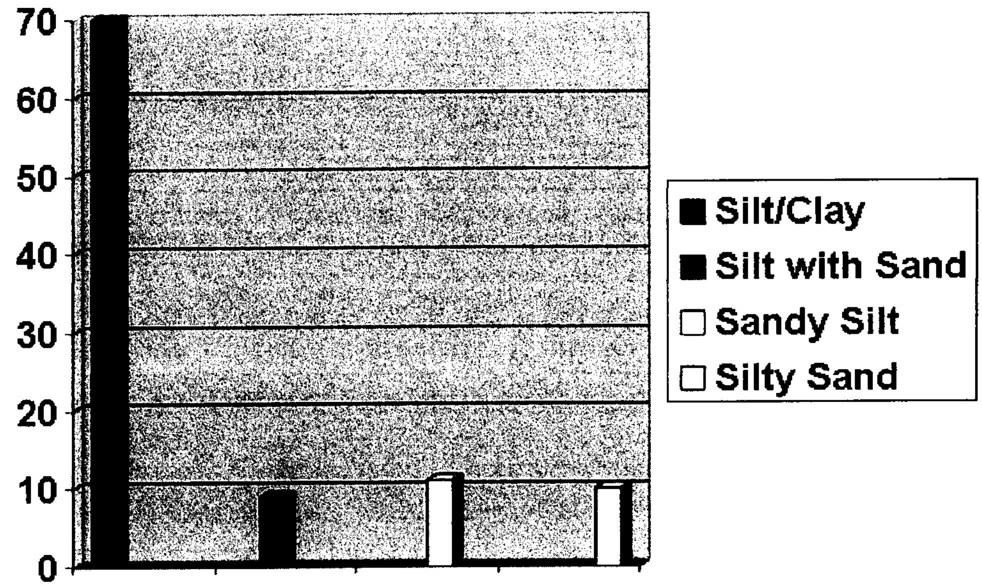
The volume of Silt/Clay (ML & CL) and Silty Sand (SM) throughout the Reservoir area changes from the area near the dam, where about 72- to 79-% Silt/Clay and 1- to 15-% Silty Sand is present, to the upstream end of the reservoir where about 67- to 69-% Silt/Clay and 11- to 14-% Silty Sand is present.

Approximate percentages of the various size fractions of reservoir sediment are:

Silt/Clay (ML & CL)	70%)		
Silt with Sand (ML)s	9%	> 90%	1.90 million cubic yards
Sandy Silt s(ML)	11%)		
Silty Sand (SM)	10%		210,000 cubic yards

Most of the silty sand encountered contained 20 to 40% silt. To date the only potential use identified for sediment from the Reservoir area is for agricultural purposes. The suitability of reservoir sediment for this use is presently being studied, and is beyond the scope of the present report.

There are no sand beds within the Reservoir area that were clean enough or thick enough to be considered for alternate uses, i.e. beach replenishment.



Percentage of Sediment Types within the Reservoir

Chart 1. Percentages of various sediment types averaged from drill holes MDH-01, -02, -03, -05, and -15 in the Reservoir area.

DELTA

GENERAL DESCRIPTION

The Delta area extends from about 1,400 to 2,900 feet upstream of Matilija Dam along section A-A' (Figure 2). The Delta encompasses an area about 1,500 feet in length and is situated between the Reservoir area and the Upstream Channel area (Figure 1A). The boundaries between these areas are based on sediment gradation, which was determined by drilling and laboratory analyses.

The Delta area is about 1100 feet wide (ranges from approximately 950 to 1200 feet) and 1500 feet long. Sediment deposited since construction of the dam in 1947 ranges in thickness from 50.5 feet (MDH-11-01) to 68.8 feet (MDH-09-01). Post-dam sedimentation is roughly wedged-shaped and volume decreases upstream. Approximately 42% (2.47 million cubic yards) of the total volume of sediment impounded behind the dam is contained in this area.

Steep canyon walls define the limits of the river channel and the entire study area. Pre-dam topography shown in section D-D' (Figure 7) illustrates the narrow and steep nature of the sediment-choked Matilija Creek Canyon.

Nearly 90% of the Delta area is covered by dense vegetation composed primarily of arundo (Photo 1). Arundo is a non-native plant which was introduced into this area and flourishes in the project area. Proliferation of the arundo has hindered the growth of other reeds, small trees (willows), and brush native to the canyon.

Prior to drilling operations the only access into the Delta area was by a footpath that was cleared using hand tools. Thick vegetation prevented vehicular access. A Hydroaxe and Caterpillar D8 Bulldozer and Caterpillar 980B Front End Loader were employed to clear and build a road suitable for drill rig and vehicular access (Photos 4, 6, and 7). A single road about 15 feet wide was constructed along the alinement of the footpath, and avoided most of the larger trees and natural drainages (Photo 11). The road terminates approximately 500 feet upstream of the reservoir pond. Biological oversight of the clearing and road building operation was provided by the U.S. Fish and Wildlife Service and Padre Associates, Inc. (Photos 2 and 9).

INVESTIGATIONS

Four drill holes (MDH-08-01 thru MDH-11-01) were drilled in the Delta area for the purpose of characterizing sediment gradation, toxicity, and distribution (Figure 1). The four drill holes range in depth from 50.5 to 68.8 feet and were terminated in pre-dam Quaternary alluvium sediments (Table 1). Drilling operations in the Delta area began on 8/21/01 and ended on 9/9/01.

The geologic log and sample data from drill hole MDH-11-01 is a composite of two drill holes, MDH-11-01 and MDH-11B-01. The initial hole (MDH-11-01) was completed to a depth of 35.7 feet and terminated in a cobble lens that was incorrectly identified as Quaternary alluvium. Pre-dam topography predicted depth to Quaternary alluvium to be much deeper and investigations completed further upstream suggested the cobbles encountered in MDH-11-01 were not

Quaternary alluvium. A second drill hole, MDH-11B-01 was completed ten feet downstream of MDH-11-01 to a depth 50.5 feet to determine the depth to Quaternary alluvium. MDH-11B-01 penetrated the same cobble zone in the first hole, and sampled Quaternary alluvium sediments from 45.5 to 50.5 feet. This hole was completed from 9/14/01 to 9/15/01.

Drilling and Sampling Operations
The Delta area drill holes were drilled with a Central Mining Equipment 750 (CME 750) drill rig (Photo 38). The CME 750 is a truck mounted rig weighing approximately 35,000 pounds. It was mobilized from the U.S. Bureau of Reclamation's Pacific Northwest Region (Boise, Idaho) along with utility trucks, a rig tender, and other drilling equipment. Access to the drill sites for the CME 750 and equipment was via the road described earlier in this report.

Two sizes of hollow stem flight auger systems were used while drilling in the Delta area. Drill holes MDH-08-01 and MDH-11-01 used the 10-1/2 inch o.d. by 6-5/8 inch i.d. augers with a five foot long 5-3/4 inch i.d. split tube inner barrel for sample collection (Photos 40 and 41).

The second hollow stem flight auger system used was an 8-1/2 inch o.d. by 4-1/4 inch i.d. augers with a five foot long 3-1/2 inch i.d. split tube inner barrel for sample collection. This system was used on drill holes MDH-09-01 and MDH-10-01. Both hollow stem auger systems employed a spade and bullet auger bit for cutting.

If the auger systems refused, either in coarse material or when pre-dam Quaternary alluvium was encountered then drilling and sample collection proceeded using a rotary diamond coring system. Diamond core drilling employed an HWD-4 core barrel and a face discharge diamond bit with a 3.9 inch o.d. and 3.0 inch i.d.

Sampling Procedures
Samples were collected for the purpose of characterizing particle size gradation, distribution and sediment toxicity of the material impounded upstream of the dam. Different sampling procedures were set for materials data sampling (gradation/distribution) and sediment toxicity, and will be discussed below. In both procedures the samples were collected directly from the split tube inner barrel as soon as possible after recovery, and before being transferred to the core boxes.

Materials Sampling
A total of thirty-two samples for material testing were collected from drill holes completed in the Delta area. Seven samples were collected from MDH-08-01, nine from MDH-09-01, eight from MDH-10-01, and eight from MDH-11-01. Delta area material samples were analyzed for gradation and Atterberg limits by the USACE laboratory. Samples were preserved and shipped in half gallon-sized ziplock bags with an extra ziplock bag to maintain moisture (Photo 44). Samples were kept in heavy canvas bags and stored in a shed at the Ventura County highway maintenance yard. Samples were delivered to the laboratory by USACE personnel.

Materials samples were collected during drilling operations at least every ten feet or where a change in conditions occurred. Materials samples were also collected whenever a sediment toxicity sample was obtained. Because of the variable nature of the sediments in the Delta area, composite samples were taken over the length of the recovered material (typically five feet), except where a major change of material took place and the sediment could be segregated into individual samples.

In most cases, the sediments were deposited as thin layers of alternating materials which could not be divided into discrete sample intervals during drilling. This composite sampling resulted in a "hybrid" soil classification. For example, a core may have thin alternating lenses of silt and sand which, in a composite sample, might result in a laboratory classification of Silty Sand or a Sandy Silt. Much later, after drilling operations were complete, some discrete sample intervals were selected from the same intervals where core was previously sampled and tested compositely. These discrete samples were sent to Reclamation's soil laboratory in Willows, California to verify if a hybrid soil classification was the result of a composite sample. Data from the Willows laboratory showed a different soil classification and provided evidence that composite sampling can yield a "hybrid" soil classification.

Sediment Toxicity Sampling

Fourteen sediment toxicity samples were collected from drill holes in the Delta area. Three samples were collected from MDH-08-01, four from MDH-09-01, four from MDH-10-01, and three from MDH-11-01. Results from the toxicity analysis will be used to evaluate various removal options and end-use of the impounded sediments.

Protocol for toxicity sampling was established by the U.S. Army Corps of Engineers, Los Angeles District. Prior to collection of sediment toxicity samples the split tube inner barrel (sampler) and sampling tools were decontaminated with *Alquinox* and double-rinsed with de-ionized water. The *Alquinox* solution was sprayed into the sample barrel and thoroughly scrubbed using a brush and then was rinsed off with de-ionized water (Photos 46 through 48). The purpose for this was to minimize any cross-contamination between samples.

Samples were collected directly from the decontaminated core barrel using a stainless steel spoon and scooped into a stainless steel bowl where the sample was mixed. The sample was then scooped with the stainless steel spoon into a new, clean, glass container which was provided by the USACE. The glass containers were filled entirely with the sediment toxicity sample to minimize empty space. The containers were labeled with the drill hole number, depth interval, date, time, preservative (ice), project, and collector's name (Photo 49). Disposable latex gloves were worn at all times during sample collection.

The labeled sample was then sealed with duct tape around the lid to prevent loosening and packaged in bubble wrap for protection during shipment (Photo 50). Samples were placed in a cooler and surrounded by ice. Samples were maintained in ice until ready for shipment, which was usually every other day, with the exception of weekends when FedEx does not deliver (Photo 51).

Samples were shipped in a secured ice chest to the Navy Regional Environmental Laboratory (NREL) in San Diego, California. A chain of custody form was filled out with each shipment and included information on number of samples, drill hole, depth interval, date, tests to be performed (full versus partial) and collector's name, address, and phone number. Furthermore, a phone call was made to NREL personnel each time a shipment was sent to verbally request the tests to be performed.

The NREL was requested to perform either a full suite of test or a partial suite of tests on each toxicity sample sent. A partial suite included analysis for the physical/convention tests (pH, percent solids, percent volatiles, total sulfides, oil and grease) and the metals suite. A full suite of tests included the same analyses as the partial suite but also included pesticide tests. Of the fourteen toxicity samples collected in the Delta area, twelve received the partial suite of tests and two received a full suite of tests.

The majority of the toxicity samples taken were collected from sandy or silty sand zones. This was done because the sand fraction of the sediment is being considered for beach replenishment in Ventura County.

The NREL has issued results of the toxicity data to the USACE, Los Angeles District. As of the date of this report Reclamation has not received any results from the toxicity analysis.

GEOLOGY

Sediments deposited by floods and meandering river channels are characteristic of this area and deltaic environments in general. The area is characterized by migrating channel deposits and prograding delta morphology.

Subsurface Conditions

Continuous soil samples recovered from four drill holes (MDH-08-01 thru MDH-11-01) show subsurface geologic conditions in the Delta area to be heterogeneous, variable, and layered; characteristics common to deltaic deposition (Figures 2 through 4 and 7 through 9). Core recovered from these holes showed very thick zones of Silty Sand (SM) up to 23 feet thick, with intervals of Silt (ML), Sandy Silt (s(ML)), and Silt with Sand ((ML)s) that range in thickness from about 0.1 to 5.0 feet.

Gravel lenses were also encountered in these holes and range in thickness from approximately 1 to 8 feet thick. Gravel lenses were mostly encountered near the top of the drill holes, except in MDH-11-01 where gravel was recovered in intervals from 1 to 5 feet at various depths. This was not unexpected since an increase in the percentage of gravel was anticipated as the investigations moved upstream.

Silty Sand comprises approximately 65% of the total volume of sediment in the Delta area. Silt, including Sandy Silt and Silt with Sand comprises approximately 13% of the total volume of sediment in this area. Gravelly soil comprises about 22% of the total volume of sediment in the

Delta area.

Based on field visual and laboratory analyses, major soil types have the following approximate compositions;

Silty Sand: 70% sand, 30% fines (silt). This represents an approximate average, Silty Sand encountered in this area is variable and with percent sand ranging from 50 to 95% (Figures 2 through 4 and 7 through 9).
Silt: 90% fines, 10% sand
Silt with Sand: 80% fines, 20% sand
Well-Graded Gravel with Silt and Sand: 70% gravel, 20% sand, 10% fines

Surface Conditions
Surficial deposits in the Delta area exhibit three zones of sediment size gradation. From the upstream edge of the reservoir, and extending for about 400 feet is a zone of silt, sandy silt, and organic material (Photo 36). Continuing upstream for another 400 feet (1800 to 2200 feet along section A-A') the surface sediments consist primarily of sand and silty sand with gravelly material near the margins of the active stream channels. From 2200 to 2900 feet along section A-A' is mixed zone of gravel, sand, silt, and some cobbles. Surface observations are limited in this zone because dense vegetation blankets most of this area.

GEOTECHNICAL CONSIDERATIONS
Approximately 2.47 million cubic yards of sediment is contained in the Delta area. This equates to about 42% of the total volume of sediment (5.89 million cubic yards) impounded behind Matilija Dam. Based on volume extrapolations from the four drill holes in the Delta area, roughly 1.61 million cubic yards (65%) of the sediment is Silty Sand, 321,000 cubic yards (13%) is Silt, and 543,000 cubic yards (22%) is gravel. Note: According to the Unified Soil Classification System (USCS), the soil classification used by Reclamation and others in all geotechnical applications, Silty Sand is defined as a coarse grained sediment containing from 50 to 89% sand and 11 to 49 percent fines. The following sand/silt ratios (% Sand/% Silt) are all examples of Silty Sand; 85% sand/15% fines, 70% sand/30% fines, and 55% sand/45%fines.

Characterization of the sediment, particularly gradation and toxicity analysis, will be essential to determine its end-use. Some of the current uses being considered for the sediment are: beach restoration, agricultural applications, concrete aggregate, and road base.

Since construction of the dam, beaches downstream in Ventura County have narrowed. Sediment trapped behind the dam has adversely affected the natural beach replenishment of the Ventura River system. One proposed use of the sand/silty sand, and possibly the gravel fraction, of the impounded sediments is to return it to the beach. Of major concern is the toxicity, or lack thereof, of the trapped sediments. Contaminated material would not be allowed to return to the beach. If the material is non-toxic then it may be suitable for beach replenishment.

The largest concentration of sandy material upstream of Matilija Dam is in the Delta area. An estimated 90% of the sandy material in the Delta is Silty Sand with a fines (silt) content ranging between 5 and 50 percent, and averaging approximately 30 percent. Only an estimated 10% of the sandy material in the Delta is clean sand with less than 10% fines. In regards to beach replenishment, the higher the percentage of fines that can be accepted, the larger the quantity of sediment that is available for this purpose. In order to evaluate the significance of this statement, three categories of sand are represented on sections A-A' and D-D' (the two sections located in part or entirely within the Delta): 1) sand with up to 15% fines; 2) sand with up to 30% fines; and 3) sand with up to 50% fines. By comparing these sections, it is readily apparent that the quantity of sand (represented by the green color) increases as the percentage of fines allowed increases and conversely, the quantity of sand decreases when a relatively small percentage of fines is allowed. Based on this brief analysis it is evident that a standard for sand as defined by fines content, and based on the realities of the soil conditions upstream of Matilija Dam, should be adopted instead of an arbitrary, one-size-fits-all standard if the goal of maximizing the amount of sand available for beach replenishment is to be achieved.

One possible use for the silt portion of the sediments being considered is for agricultural applications, again toxicity results would be critical to its end-use for this purpose. It is possible that these sediments could be used for improving certain types of agricultural lands such as lands with shallow soils, lands affected by shallow groundwater, lands with coarse grained, or very fine grained soils, or low lying lands subject to flooding. Proposals have been made to evaluate the agricultural applications of this material.

The gravel, cobbles and boulders impounded behind the dam have potential uses as concrete aggregate and as road base material. Durability and Alkali/Aggregate reaction tests need to be performed on these materials to determine their suitability for this use.

An important factor to consider for all the potential applications of the sediment is the heterogeneous nature of the impounded sediments in the Delta area. During excavation it would not be practical or economical to target particular soil types or depth intervals because the materials are inter-layered and variable, the result of being deposited in a delta environment.

UPSTREAM CHANNEL

JUNE 2002 - INVESTIGATIONS

Field mapping and size fraction characterization of sediment within the Upstream Channel was conducted in June 2002. The results of this work are presented in Appendix E.

GENERAL DESCRIPTION

The Upstream Channel extends from about 2,900 feet upstream of the dam along section A-A' to more than 5,400 feet upstream (Figure 1). The Upstream Channel hosts approximately 1.30 million cubic yards of sediment or about 22% of the total volume of sediment behind the dam. A large volume of gravel and cobbles with minor boulders, sand and silt dominates the sediment in this area.

The Upstream Channel area is about 750 feet wide (ranges from about 500 to 1000 feet) and 3100 feet long. Sediment deposited since construction of the dam in 1947 ranges in thickness from 25.0 feet (MDH-14-01) to 41.2 feet (MDH-12-01) and eventually to zero at the upstream limit of the original reservoir.

The topography on both sides of the Upstream Channel area is very steep (Figure 1). Section E-E' shows the canyon walls extending beneath the sediment wedge and the pre-dam profile of the Upstream Channel area in 1947 (Figure 7).

Most of the Upstream Channel area is covered by dense vegetation except near the active creek channel. Adjacent to the active creek channel is an open area where coarse material has been deposited over time as the channel meandered and high flows have transported gravel- and cobble- size material. The thick vegetation is primarily arundo with some small willow trees, brush, and reeds. In most areas the arundo grows so densely it is very difficult pass through it on foot.

Vehicular passage into the Upstream Channel area was via the access road constructed prior to drilling operations and described earlier in the Delta section of this report.

INVESTIGATIONS

Three drill holes (MDH-12-01 thru MDH-14-01) were drilled in the Upstream Channel area for the purpose of characterizing sediment gradation, toxicity, and distribution (Figure 1). The three drill holes range in depth from 25.0 to 41.2 feet and were terminated in pre-dam Quaternary alluvium sediments (Table 1). Drilling operations in the Upstream Channel area began on 9/10/01 and ended on 9/14/01. MDH-14-01 was drilled about 3800 feet upstream of the dam (the farthest upstream drill hole). Investigations were not conducted further upstream due to the inaccessibility of the area. The Upstream Channel extends approximately 5,400 feet upstream of the dam. Post-dam sediment thickness upstream of MDH-14-01 ranges from 0 to 25 feet.

Drilling and Sampling Operations

The Upstream Channel area drill holes were drilled with a Central Mining Equipment 750 (CME 750) drill rig (Photo 38). The CME 750 is a truck mounted rig weighing approximately 35,000 pounds. It was mobilized from the U.S. Bureau of Reclamation's Pacific Northwest Region (Boise, Idaho) along with utility trucks, a rig tender, and other drilling equipment.

A 10-1/2 inch o.d. by 6-5/8 inch i.d. hollow stem flight auger system with a five foot long 5-3/4 inch i.d. split tube inner barrel for sample collection was used to retrieve continuous core samples from the Upstream Channel area (Photos 40 and 41). A spade and bullet auger bit was used to cut the core.

If the auger system refused, either in coarse material or when pre-dam Quaternary alluvium was encountered then drilling and sample collection proceeded using a diamond core system. Diamond core drilling employed the use of the HWD-4 core barrel and a face discharge diamond bit with a 3.9 inch o.d. and 3.0 inch i.d.

Sampling Procedures

The same sampling procedures described in the Delta section of this report were followed while sampling in the Upstream Channel area. Please refer to this section for details.

Materials Sampling

A total of fourteen samples for material testing were collected from drill holes completed in the Upstream Channel area. Five samples were collected from MDH-12-01, five from MDH-13-01, and four from MDH-14-01. Upstream Channel area material samples were analyzed for gradation and Atterberg limits by the USACE laboratory. The sampling protocol described earlier in this report also pertains to samples collected in the Upstream Channel.

Sediment Toxicity Sampling

Four sediment toxicity samples were collected from the drill holes in the Upstream Channel area. One sample was collected from MDH-12-01, one from MDH-13-01, and two from MDH-14-01. Results from the toxicity analysis will be used to evaluate various removal options, and end-use of the impounded sediments.

GEOLOGY

The Upstream Channel extends from about 2,900 feet upstream from the dam along section A-A' (Figure 1) to about 5,400 feet upstream (Appendix B). The upstream end of this area (el. 1,127.6-ft.) demarcates the approximate high water mark of the original 7000 acre feet reservoir. The Upstream Channel holds approximately 1.30 million cubic yards of sediment, about 22% of the total volume of sediment behind the dam. A large volume of gravel and cobbles with minor boulders, sand and silt dominates the sediment in this area.

Surface Conditions

Sediments in the Upstream Channel area were deposited in a relatively high energy, fluvial, braided stream environment. The present-day stream channel, and previous channels in this area are characterized by coarse sediments, primarily cobbles and boulders up to four feet across, believed to be transported during major flood events (Photos 51 and 52). Adjacent to the channels are stream bar deposits consisting mainly of sand, gravel, and cobbles (alluvial sediments) that were formed were a decrease in stream velocity induced deposition. Upstream Channel area deposits are very similar to sediments exposed in the creek channel and flood plain of Matilija Creek upstream of the original 7000 acre feet reservoir.

Subsurface Conditions

Continuous soil samples recovered from three drill holes (MDH-12-01 thru MDH-14-01) show subsurface geologic conditions in the Upstream Channel area to consist primarily of coarse grained material. Gravel and cobbles with boulders were encountered in all three holes, and accounted for nearly all the recovered sediment.

The first ten feet of each drill hole in this area was not sampled because the flight auger system refused on the coarse grained material. A pilot bit had to be used penetrate this material. No core was recovered in this interval but stream cut channel deposits adjacent to MDH-13-01 and MDH-14-01 exposed gravel, cobbles, and boulders with minor sand (by volume). The outcrop exposed approximately seven feet of coarse material. The CME 750 drill rig had difficulty boring through these shallow, coarse sediments, the rig rocked up and down on its outriggers and the augers screeched violently while drilling this interval. Coarse material broke several teeth on the auger bit and had to be replaced after each hole.

Based on three drill holes in the area, gravel lenses account for approximately 80% of the sediment in the Upstream Channel area. Lenses of gravel range in thickness from about 4 to 21 feet thick. Minor lenses of Silty Sand range in thickness up to five feet and comprise roughly 15% of the total volume of sediment in the area. Caving or sloughing of the hole may have washed sand into the boring and caused increased sand thicknesses. Very minor amounts of silty fines were encountered in the Upstream Channel area drill holes and comprise about 5% of the total volume of sediment in the area.

Based on field visual and laboratory analyses, the major soil types in the Upstream Channel area have the following compositions;
Well-Graded Gravel with Sand, (GW)s: 75% Gravel, 20% Sand, 5% Fines
Silty Sand with Gravel, (SM)g: 70% Sand, 20% Gravel, 10% Fines

Gradation results from the laboratory are slightly skewed because coarse grained material in the gravel to cobble range was under represented in samples sent to the lab. This is because the sample bags are limited in size and amount of material it can support.

GEOTECHNICAL CONSIDERATIONS

Approximately 1.30 million cubic yards of sediment is contained in the Upstream Channel area. This equates to about 22% of the total volume of sediment (5.89 million cubic yards) impounded behind Matilija Dam. Based on volume extrapolations from the three drill holes in the area roughly 1.04 million cubic yards (80%) of the sediment is gravel, 200,000 cubic yards (15%) is silty sand, and 65,000 cubic yards (5%) is fines.

Some of the current uses being considered for the sediment, provided the material is uncontaminated, are: beach replenishment, agricultural applications, concrete aggregate, and road base. Most of the material in this area is coarse gravel and larger and therefore not likely to be used for beach restoration. However, Ventura County beaches contain some material of this size and it is possible some of this sediment could be used for beach replenishment. So far, there have been no restrictions set on the size of material that would be acceptable for beach replenishment. It would be possible to crush the material into smaller pieces to make it acceptable for the beach