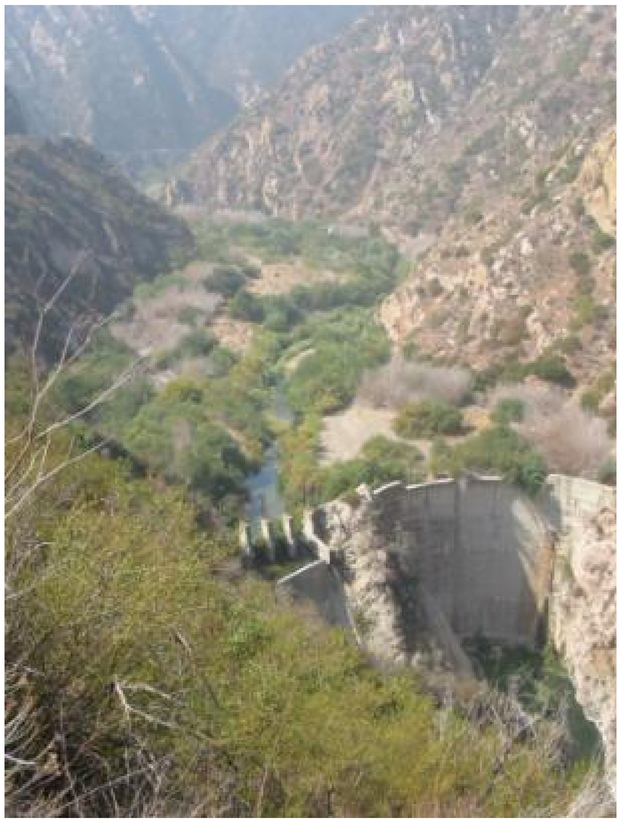
Malibu Creek Ecosystem Restoration Study

Los Angeles and Ventura Counties, California

Appendix D

Geotechnical Engineering



U.S. Army Corps of Engineers
Los Angeles District

November 2020

This page was intentionally left blank for duplex printing.

Table of Contents

Section Page

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Report Prepared By:

U.S. Army Corps of Engineers
Los Angeles District, Engineering Division
Geotechnical Branch
915 Wilshire Blvd., Los Angeles, CA 90017

Report Written By:
Staff
Geology and Investigations Section
Geotechnical Branch, Los Angeles District

Chris Spitzer
Civil Engineer
Soils Design and Materials Section
Geotechnical Branch, Los Angeles District

Report Reviewed By:
Mark McLarty, C.E.G.
Engineering Geologist
Chief, Geology and Investigations Section
Geotechnical Branch, Engineering Division, Los Angeles District

Douglas Dahncke, P.E., G.E.
Geotechnical Engineer
Chief, Soils Design and Materials Section
Geotechnical Branch, Engineering Division, Los Angeles District

James Farley, P.E.
Chief, Geotechnical Branch
Geotechnical Branch, Engineering Division, Los Angeles District

Report Edited By:
Brenna Smith
Technical Writer/Editor
Soils Design and Materials Section
Geotechnical Branch, Los Angeles District

This page was intentionally left blank for duplex printing.

1.0 INTRODUCTION

Concepts for ecosystem restoration of the Malibu Creek Watershed area are currently being considered by the US Army Corps of Engineers, Los Angeles District Planning Division, in conjunction with the local sponsor, the State of California, Department of Parks and Recreation. In conjunction with these efforts, a geotechnical study has been performed by the Geotechnical Branch of the US Army Corps of Engineers, Los Angeles District, to identify and evaluate geologic and geotechnical conditions within and around the Study Area and their potential impacts on existing and proposed improvements.

The results of the geotechnical study are described and discussed in this report. It is the intent of this report to provide a discussion of geologic and geotechnical conditions within and around the Study Area and to provide a basis of evaluating potential effects and constraints associated with these conditions. The study area is large (around 110 square miles), and focus of this report is on removal of an existing dam feature, disposal of associated debris, and the following:

- Removal of the dam;
- Modification of the dam and spillway;
- Removal of the impounded sediment;
- Removal of upstream barriers to fish passage;
- A cursory review of potential disposal sites and temporary storage sites;
- Stability of existing and future slope conditions, including bedrock and existing landslides;
- Compatibility with upland disposal sites and proposed swash zone, other nearshore and on-beach disposal sites;
- Construction of flood-risk management structures at the downstream end of the study area.

1.1 Project Location

The Malibu Creek watershed is located west of downtown Los Angeles, California in Los Angeles County and Ventura County. The watershed drainage area is approximately 110 square miles and is encompassed by the Santa Monica Mountains National Recreation Area (SMMNRA), managed by the National Park Service. Malibu Creek is approximately 10 miles in length, and runs from Malibu Lake to Malibu Lagoon, where the creek enters the Pacific Ocean.

1.2 Background

Rindge Dam is located approximately three miles from the mouth of Malibu Creek. The concrete-arch dam was built as a water supply reservoir on Malibu Creek in the 1920s for local ranching interests. The dam is a concrete arch structure 102 feet in height with an arc length of 140 feet at its crest (excluding the spillway and bedrock outcrop), and 80 feet at its base. To provide erosion protection, the adjoining spillway, cut into canyon-wall bedrock, was faced with concrete slabs at some point in time after the initial dam construction. Numerous feasibility study Alternatives under consideration refer to “spillway removal”. In each case “spillway removal” means “removal of the concrete slab facing over the cut bedrock “spillway”, not removal of the actual cut bedrock.

Another eight, much smaller fish-migration barriers exist upstream of Rindge Dam, ranging in scale from small earthen dams, to drainage culverts beneath roadways. These barriers also may be removed but only Rindge Dam has received geotechnical evaluation because of its relative size and location and its substantial impoundment of sediment. If the Rindge Dam obstacle cannot be avoided successfully, removal of the smaller blockages farther upstream becomes irrelevant.

The dam is located in a steep narrow canyon gorge that is difficult to access. The dam was decommissioned in 1967. The property was purchased by the Sponsor and is now part of Malibu Creek State Park. The Sponsor monitors and maintains the dam as part of state park property.

The dam was constructed without an outlet structure and filled with sediment over time. No reservoir currently exists behind Rindge Dam and the approximately 780,000 cubic yards (CY) of sediment impounded behind the dam has filled to the crest of the dam, about 100 feet above the elevation of the original streambed. A cursory level structural field investigation was conducted in the early years of the feasibility study.

1.3 Possible Improvements

The Malibu Creek watershed, and associated tributary drainages are the focus of this study. Within these drainages, numerous man-made barriers exist that prevent the natural migration of species, impound sediment, and decrease ecological connectivity. The single largest of these barriers is Rindge Dam. Other “upstream barriers” exist upstream of the dam on Malibu Creek and on its two main tributaries, Las Virgenes Creek and Cold Creek. These barriers range in size from culverts and dip crossings that are considered too smooth to allow fish passage, to the size of small dams. In order to formulate plans for ecosystem restoration different measures, each tied to a specific study objective, were considered and grouped into alternatives. The following sections discuss the measures, the alternatives, and the considerations necessary for the development of various concepts that are evaluated as part of this study. This report is focused on primarily the geology and the geotechnical conditions and their impact on the measures and proposed alternatives. Further details and additional context is provided in other appendices and documents.

1.3.1 Geotechnical Measures Considered

Numerous measures were developed over the course of this study for evaluation. These measures were tied to the study objective and were considered in part or in conjunction with other measures in developing alternatives. The measures requiring geotechnical consideration and assessment are described below.

- Removal of Sediment
    - Removal of the impounded sediment would be performed by natural transport, slurry and piping, conveyor systems, or by truck transport. Each of these sediment removal measure options would be coordinated with the dam removal processes listed above.
- Placement of Sediment
    - The sediment removed from behind the dam would be subject to several placement scenarios that include upland disposal on various sites, landfill disposal, direct beach placement, temporary storage, and subsequent beach and near shore placement.
- Removal of Upstream Barriers
    - At locations where upstream barriers restrict upstream fish migration and limit ecological connectivity, removal or redesign of the barriers was considered.

- Floodwall/Levee Construction
  - For some measures associated with natural transport, the need for flood risk management structures in the form of levees and/or floodwalls was recognized. Further discussion of the magnitude and frequency of the possible flood events is discussed in other appendices.
- Spillway Removal
  - Removal of spillway slab was considered for aesthetics, and was put forth by the local sponsor as a public safety consideration. Removal of the spillway slab and the supporting bedrock to create a fish passageway with the dam remaining intact was considered, but rejected due to dam stability concerns associated with the removal of the dam abutment for the concrete arch.
- Fish Ladders/Conveyors/Sluices
  - Fish ladders, conveyors and sluices were considered as part of this study but were rejected as a result of various supply, serviceability, and sustainability issues.
- Modification of Dam
  - Modification of the dam, including cutting of the concrete arch to create v-notch and construction of sediment bypass features, was considered, but was rejected due to various structural, serviceability, and sustainability issues.
- Restoration of water supply function
  - Restoration of the dam to its former water supply uses was considered, but was rejected due to the requirement of impounded sediment removal, recertification of the dam structure to hold water, and installation of the fish ladders (which were also rejected, separately).

The measures discussed above, with exception of the rejected measures, were determined to be viable, and were considered in combination with others, as well as part of the developed alternatives.

1.3.2 Alternatives Considered

There are twenty-one different iterations of the four main Alternatives that have been assessed as of October 2016. These alternatives are provided in **Table 1.3-1** and summarized as follows:

Alternative 1: “No Action;” i.e., the dam is not removed.

Alternatives 2, 3, and 4 involve varying degrees of dam removal, impounded sediment removal, dam spillway concrete facing removal, and upstream barrier removal. Each of these Alternatives has four “options,” designated “a,” “b,” “c,” and “d.” The “a” and “b” options include removal of Rindge Dam and spillway concrete slab facing, while “c” and “d” options are for dam removal only. Options “b” and “d” also include modifications to upstream barriers. Alternatives 2 and 4 include two additional options for beneficial reuse of the sand layer in the Malibu coastal area at one specific location (option “1”) or in the nearshore area off Malibu (option “2”). With Options 1 and 2, the non-sand layers of the impounded sediment are to be removed to one of several upland disposal sites.

The primary aspect of Alternative 2 is dam removal with trucking (or truck and barge) impounded sediment to shore and upland sites. Specifically, Alternative 2 is to remove Rindge Dam over a time period of 7 years while removing impounded sediment, truck all 780,000 cy of impounded sediment to Calabasas Landfill or to shoreline site(s), and to separate gravels from sand delivered to beaches and/or the nearshore zone placement. This is Alternative 2a. Alternative 2c adds removal of the spillway concrete facing to the measures of 2a. Alternative 2b has all the measures of Alternative 2a, plus modification or removal of four upstream aquatic habitat barriers along Las Virgenes Creek and Cold Creek, increasing the aquatic habitat reconnected to lower reaches of Malibu Creek. The locations of the upstream barriers can be found in the Integrated Feasibility Report.

The primary feature of Alternative 3 is dam removal in conjunction with utilization of natural sediment transport to remove the impounded sediment without excavating and hauling. There are uncertainties in the sediment transport model, particularly because this is a flashy drainage system. Significant erosion and deposition variances could occur, particularly in the downstream reaches of Malibu Creek, and could amount to up to several feet of sedimentation during short-duration peak events. For Alternative 3 options, the risk of changes to downstream creek bed elevations is considered significant enough to warrant inclusion of floodwalls as a co-measure.

The primary feature of Alternative 4 is combined natural sediment transport and trucking (or truck/barge) of impounded sediment in an effort to utilize intermittent winter stream flows to reduce the overall amount of trucking of sediment required to clear the area behind the dam of impounded sediment.

Table 1.3-1 Alternatives Considered

	Alternative 1	Alternative 2a Alternative 2c	Alternative 2b Alternative 2d	Alternative 3a Alternative 3c	Alternative 3b Alternative 3d	Alternative 4a Alternative 4c	Alternative 4b Alternative 4d
Description	No Action	Rindge Dam Arch Removal Mechanical Transport	Rindge Dam Arch Removal Mechanical Transport Upstream Barriers	Rindge Dam Arch Removal Natural Sediment Transport	Rindge Dam Arch Removal Natural Sediment Transport Upstream Barriers	Rindge Dam Arch Removal Mechanical Transport and Natural Sediment Transport	Rindge Dam Removal Mechanical Natural Sediment Transport Upstream Barriers
Alt. Summary	Rindge Dam 100-foot high arch (and spillway) would remain in-place without modification. Age of structure may be an integrity issue. Impounded sediment behind Rindge Dam to remain with some temporary deposition between storms. Risk of downstream flooding increases over time due to aggrading channel. Reach below Rindge Dam will degrade 5 to 10 feet reaching equilibrium in about 100 yrs. Approx 2 feet of deposition likely to occur in lower reaches below the Dam. Costs may be incurred to maintain dam safety and provide flood risk mgmt measures in downstream areas.	Remove Rindge Dam arch over 7 to 8 years depending on the alt] while removing impounded sediment to minimize downstream adverse impacts to habitat and flood risk. Truck all 780k CY of impounded sediment to Calabasas Landfill or to shoreline site(s). Separate gravels from sand delivered to beaches. Opens up about 5 miles of good to excellent aquatic habitat along Malibu Creek. **<u>Alt 2c</u>:** Adds spillway removal to Alt 2a features while removing arch to lessen habitat disturbance, improve safety, and aesthetic purposes. "Option 1" places unit 2 sand rich layer in the swash zone at Malibu. "Option 2" places the unit 2 sand rich layer in the deeper water nearshore zone off Malibu.	Same as 2a with the addition of modification or removal of upstream aquatic habitat barriers along Las Virgenes Creek (4) and Cold Creek (4), tripling the amount of good to excellent quality aquatic habitat reconnected to lower reaches of Malibu Creek. Opens up about 18 miles of aquatic habitat along Malibu, Las Virgenes and Cold Creeks. **<u>Alt 2d</u>:** Adds spillway removal to Alt 2b features. "Option 1" places unit 2 sand rich layer in the swash zone at Malibu. "Option 2" places the unit 2 sand rich layer in the deeper water nearshore zone off Malibu.	Incrementally remove Rindge Dam arch over decades (20-100 yrs) in 5 foot lifts, waiting for impounded sediment to be naturally transported downstream with winter storm flows, repeating until structure is completely removed. Assumed timeframe for removal: 30-50 yrs. No need for trucks to transport sediment to Calabasas Landfill or beaches. Trucks needed to transport dam/ spillway concrete to landfill. Floodwalls required for increased flood risk to Serra Retreat & City of Malibu: 10 feet high and 2,900 feet long, from Cross Creek Rd to PCH. After decades, reconnects about 5 miles of good to excellent aquatic habitat along Malibu Creek. **<u>Alt 3c:</u>** Adds spillway removal to Alt 3a features	Same as 3a with the addition of modification or removal of upstream aquatic habitat barriers along Las Virgenes Creek (4) and Cold Creek (4), tripling the amount of good to excellent quality aquatic habitat reconnected to lower reaches of Malibu Creek. Opens up about 18 miles of aquatic habitat along Malibu, Las Virgenes and Cold Creeks. **<u>Alt 3d:</u>** Adds spillway removal to Alt 3b features.	Similar to 2a, with allowance for controlled volume of natural sediment transport during winter storm seasons over 7-8 construction years timeframe depending on the alt. Remove Rindge Dam arch while removing impounded sediment and notch height of arch by additional 5 feet each year to allow for storms to mobilize sediment. May allow for up to 130K CY to naturally transport downstream. Remove spillway while removing arch for safety and aesthetic purposes. Truck at least 650K CY of 780k CY of impounded sediment to Calabasas Landfill or to shoreline site(s) Floodwalls required for increased flood risk to Serra Retreat & City of Malibu: 5 feet high and 2,900 feet long, from Cross Creek Rd to PCH. Opens up about 5 miles of good to excellent aquatic habitat along Malibu Creek. **<u>Alt 4c:</u>** Adds spillway removal to Alt 4a features. "Option 1" places unit 2 sand rich layer in the swash zone at Malibu. "Option 2" places the unit 2 sand rich layer in the deeper water nearshore zone off Malibu.	Same as 4a with the addition of modification or removal of upstream aquatic habitat barriers along Las Virgenes Creek (4) and Cold Creek (4), tripling the amount of good to excellent quality aquatic habitat reconnected to lower reaches of Malibu Creek. Opens up about 18 miles of aquatic habitat along Malibu, Las Virgenes and Cold Creeks. **<u>Alt 4d:</u>** Adds spillway removal to Alt 4b features. "Option 1" places unit 2 sand rich layer in the swash zone at Malibu. "Option 2" places the unit 2 sand rich layer in the deeper water nearshore zone off Malibu.

Recommended Plan

The recommended plan is Alternative 2d1. This plan includes the removal of the Rindge Dam arch concurrent with the removal of the estimated 780,000 cy of impounded sediment, placement of the compatible impounded sediment along the Malibu shoreline, temporarily\ utilizing upland Site F for some of the compatible sediments before delivery to the shore, use of the Calabasas Landfill for disposal of the remaining amount of non-compatible impounded sediment, and modification to eight partial aquatic habitat upstream barriers on Cold Creek and Las Virgenes Creek tributaries to Malibu Creek.

1.3.3 Beneficial Reuse and Disposal of Impounded Sediment

The geotechnical study also focused on potential areas to beneficially reuse or dispose of the impounded sediment and dam demolition debris associated with deconstruction of the dam. Ultimately, it was decided that swash zone or deeper nearshore placement of compatible impounded sediment (“ocean disposal”) and the use of Calabasas Landfill for permanent disposal (“upland disposal”) of non-compatible material was the best practice.

1.3.4 “Upland Disposal” of Impounded Sediment

Throughout the study, numerous potential sites were evaluated for permanent placement and stabilization of removed impounded sediment, and others were evaluated for short- and long-term temporary storage of removed sediments. Some of these sites are in Malibu Canyon, others out-of-canyon. In late 2011, USACE evaluated three specific sites (referred to as sites A, B, and C). After it became apparent that none of the three sites A, B, or C would be carried forward, an additional eight sites upstream of Rindge Dam were chosen for evaluation. Two of the sites, designated "E" and "F," are owned by the local sponsor. Southeast of the intersection of Malibu Canyon, Las Virgenes Road, and Mulholland Highway are another 6 sites, designated "G" through "M" (designation "I" was not used to avoid confusion with the numeral “1”). Negotiations by the local sponsor indicated that none of the landholders of sites G through M were willing to devote their land to sediment stockpiling. Site F was ultimately chosen for temporary storage and processing of materials. See **Figure 1.3-1** for location of sites E through M.

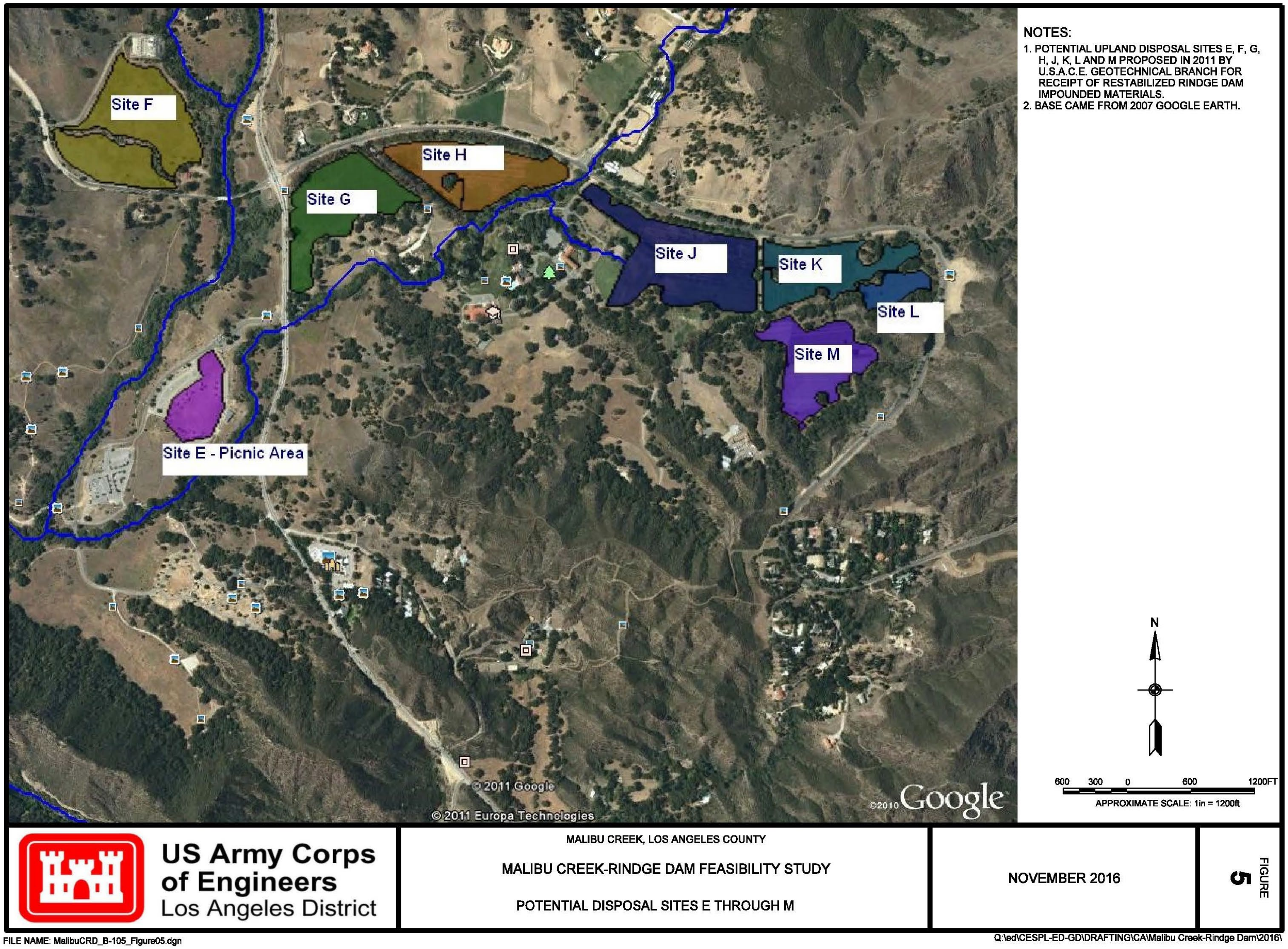


Figure 1.3-1 Potential Disposal Sites E through M

1.4 Available Information

Two previous studies related to the removal of Rindge Dam preceded the USACE:

- Bureau of Reclamation, 1995, Rindge Dam Removal Study, An Effort to Reduce the Decline of Malibu Steelhead Trout Population in Southern California, Appraisal Report: consultation report for California Dept. of Fish and Game by U.S. Dept. Interior, Bureau of Reclamation, Lower Colorado Region, Boulder City, NV, April 1995.
- Law Crandall, Inc., 1993, Report of Geotechnical and Environmental Study, Malibu Steelhead Restoration Project, Malibu area, Los Angeles County, California, for the State of California, Division of State Architect, 2661.40181.0001: private consultation report by Law / Crandall, Inc., Engineering & Environmental Services, 200 Citadel Dr., Los Angeles, CA, 23 May 1993.

1.5 Scope of Work

The Geotechnical Branch has supported this study since 1998. The investigation performed in conjunction with the feasibility study consisted of review of unpublished and published references, examination of the site and vicinity, field studies, review of air photographs, review of historical photographs, and geologic and geotechnical evaluation and analysis of the information obtained. A number of topographic and geologic maps were obtained and reviewed. These provided a basis for evaluation of the soils that have accumulated behind the dam and of the studies disposal sites. Specific tasks related to this study included the following:

- Compilation and assessment of published and unpublished geotechnical and geologic reports.
- Air photos were researched and examined. Historical photos were obtained and reviewed.
- The project site was examined by geologists and geotechnical engineers on a number of occasions. Pertinent features were observed, measured, and photographed. Representative photographs of selected areas have been incorporated in to this report.
- Structural field study of Rindge Dam including in-situ testing of the concrete through use of the Schmidt hammer.
- Excavation of eight borings.
- Evaluation of groundwater conditions.
- Laboratory assessment of impounded sediments and estimates of subsurface material characteristics.
- Desk top study of potential disposal and storage sites.
- Participation on team meetings and assistance with development of measures and alternatives.
- Development of geotechnical considerations and constraints.
- Development of recommendations pertaining to deconstruction of the dam and disposal of excavated materials.
- Preparation of this report, documenting the work performed to date, and presentation of conclusions and recommendations.

2.0 FIELD, LABORATORY, AND PREVIOUS STUDIES

USACE Geotechnical Branch detailed involvement began in 2001 with the focus of determining the quantity of impounded sediment, its gradation, and presence or absence of environmental contaminants, to allow some tentative initial decisions on disposition of the impounded material. That work is documented in the F-4 Geotechnical Appendix for this study (USACE, 2008), and is summarized below. Two previous studies were conducted on the impounded material by Law Crandall and the Bureau of Reclamation. Boring logs from all studies are included in Appendix D1, and laboratory test results are included in Appendix D2. A brief summary of those investigations is presented below.

2.1 Law Crandall

Law Crandall (1993) focused on evaluating the upper impounded sediment, composed of gravel and larger rock, seeking to evaluate the gravel as potential commercial concrete aggregate. Their work included bulk sampling with a large excavator, performing laboratory testing, and petrographic assessment of the gravels. Their conclusion was that the gravel is too soft to use as concrete aggregate. Law Crandall also drilled three borings into the impounded sediment and used the information to estimate that the impoundment holds 801,500 cy of sediment, ranging from silt and clay, through sand, to material as large as cobbles and boulders. A few sediment samples were tested for a limited array of hydrocarbons. This was essentially a test for gasoline, and none was detected. Logs of exploration are included in Appendix D1.

2.2 Bureau of Reclamation

The Bureau of Reclamation's 1995 desktop study utilized existing published topographic maps and estimated 1.6 million cy of impounded sediment were present behind Rindge Dam. Notably, this study placed the upstream end of impounded materials significantly farther upstream than does the USACE. The Bureau of Reclamation assessment did not include any site work, sampling, or testing.

2.3 USACE Studies

The USACE drilled eight borings into the impounded sediment in 2002, then sampled and tested the materials, reporting the findings in USACE (2008). Since vehicular access was blocked by the sum of regulatory constraints imparted on the site by California State Fish and Game in 2002, USACE dropped the drill rigs and equipment onto the impoundment surface by helicopter, assembled each drill rig at each drill site, drilled the hole, then ferried equipment to the next drill site by helicopter, and repeated the process. Regulatory constraints in effect prevented any bulk sampling of the upper gravel layer, and the USACE characterization of that layer is consequently of lessened precision.

Boring logs, sampling and testing results, and the USACE estimate of sediment quantity can be found in Appendices A and B. The array of the USACE 2002 borings and impounded sediment volume estimation blocks is shown in **Figure 2.3-1**, along with the locations of the 1993 Law Crandall test pits and borings. Methods used to estimate impounded sediment quantity are further detailed in USACE (2008).

The eight casing-advance method rotary drill holes that were completed are numbered TH02-01, TH02-02, etc. The prefix definitions are as follows: TH is test hole; the lead 02 stands for year 2002; the trailing -01, -02, -03, etc., through -08 is the individual hole number, "one" through "eight." A drill bit was used inside the casing advancer to perform the actual sediment cutting. The Burley 2500H drilled primarily with a tri-vane rotary wash bit, but there were exceptions when a switch was made to a tri-cone bit on the Burley 2500H rig. The advantages of the casing advance system are: 1) casing is advanced automatically as the hole is drilled and slightly ahead of the drill bit, allowing flawless advance through the loose materials, which included a difficult-to-drill mix of very loose and dry sand-gravel-cobbles on top, then sands and silts, and finally silts and clays at the lower depths, grading suddenly back to sands-gravel-boulders at the bottom of the reservoir; 2) water pressure and quantity through the annulus could be cut back as a sampling interval was approached, leaving an in-place and undisturbed horizon for obtaining a sample with split-spoon samplers (each rig was equipped with a cathead); if refusal was hit (by a boulder, for example), the rig was ready in minutes, converted to a diamond coring bit which fit down inside the in-place casing. Both rigs drilled HWT casing advance holes without refusal to depths that casing was available (approximately -75 feet). Below the depths where each rig ran out of casing, a 5.1-foot-long HQ core barrel was used to finish the holes. This barrel rapidly cut through sediments and through boulders and bedrock at the bottom of the reservoir. An inner, split barrel could be pulled out of the core barrel by wireline, speeding the operation, and preventing hole caving. Disadvantages are that the fines were washed away and could not be recovered in the core barrel, but spit-spoon sampling was continued through the core barrel, albeit with a smaller diameter split-spoon (2-inch as opposed to the 3-inch split-spoon sampler that could be used through the casing. The drilling of the eight boreholes was completed between 3 and 9 October 2002.

Samples were collected for two testing suites and purposes. One set of samples was collected in split-spoon samplers for determination of grain-size. Logging of sampled materials, cuttings, and mud supplemented the gradation tests and helped determine soil stratigraphy. Moisture content was derived for many of the samples and blow counts were taken with each driving of the samplers. Blow counts were recorded for California modified split-spoon samplers or other non-ASTM-standard split-spoon samplers (larger sampler used to increase sample volume).

The second set of samples collected was an environmental test suite. These samples were tested for a large number of potential contaminants that, if present, would raise warnings about sediment suitability for ocean disposal (including beach nourishment), or perhaps for application in upland disposal (which includes wasting in landfills, utilitarian use in landfills, and commercial applications such as use as agricultural soil and as aggregate). Absence of those potential contaminants would allow all those potential uses to remain open, viable alternatives for dealing with the sediment.

All holes were drilled until it could be determined that the reservoir sediment fill had been drilled through entirely and that pre-dam alluvium or bedrock was being intersected. Holes were logged and sampled by a USACE geologist and soils engineer. In-place samples were collected every 5 feet, immediately below the end of the casing advancer or coring bit (as applicable) with a split-spoon sampler, primarily 3-inch size, but in cases 2-inch were used. Between points of sampling, the cuttings-bearing mud was logged to help determine elevations of the sediment types' contacts. If needed for environmental test purposes or mechanical analysis, samples were collected variously in canvas sacks; in sealed, tared plastic bags, and pre-labeled, sealed, 16 oz. flint-glass jars, with Teflon-lined plastic lids.

Environmental test samples were collected by personnel wearing disposable rubber gloves and with stainless-steel sampling tools. Sampling tools, samplers, rings, and sampling shoe were double washed with a brush and creek water, and then rinsed with distilled water between sample collections. For composited environmental test samples, the sample materials from multiple holes or multiple horizons were homogenized with stainless steel mixing tools in a new, white, plastic bucket that was cleaned with distilled water prior to each mixing. After the requisite quantity of composited and mixed material was transferred to new, laboratory-clean glass lab jars, the mixing bucket and tools were scrubbed clean with creek water and a plastic brush, then rinsed with distilled water. In all cases, sample jars were packed as full as practicable to minimize head space and contaminant volatilization.

Environmental test samples were stored in the field during the work day on ice in coolers, at 4 degrees C., plus or minus 2 degrees C., then shipped to an environmental test lab with chain-of-custody. Samples were shipped from the field to the lab as quickly as possible, due to limited retention times with regard to some of the tests. Chain of custody was maintained and is documented in USACE (2008), as are the details of sampling methods, sample compositing, and testing.

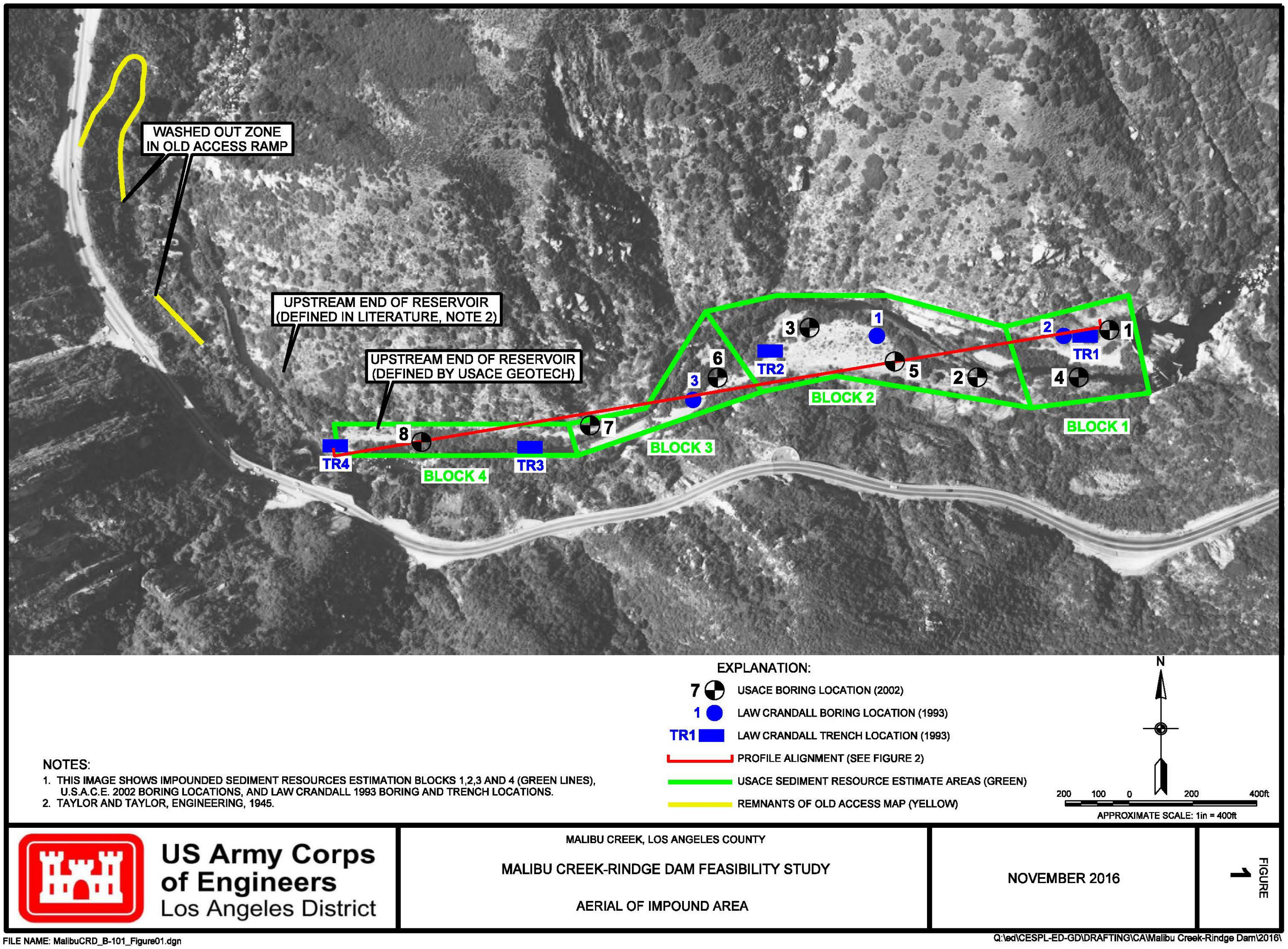


Figure 2.3-1 Aerial of Impound Area

2.4 Dam Evaluation

The USACE in 2005 conducted an examination of the parts of the dam that could be reached readily on foot. This inspection area constituted only a small part of the dam, mostly in the upper few feet of the face and the uppermost abutments, and the width of the crest. The remainder of the dam downstream face was examined only to the degree that could be seen by binoculars. The upstream face of the dam is buried, mostly, and is an unknown. Concrete and abutment bedrock surfaces that were accessed were subjected to recoil instrument readings (Schmidt hammer) to estimate soundness of the rock and the concrete. This work was not a complete assessment of the structural integrity of the dam. See the Civil Design report supporting the feasibility study for details.

3.0 SITE CONDITIONS

A resulting profile of the impounded sediment, and locations of cross-hole composited environmental samples from those borings are shown in **Figure 3.1-1**.

3.1 Surface Conditions and Topography

The Malibu Creek watershed is approximately 110 square miles, and is encompassed by the Santa Monica Mountains National Recreation Area. Malibu Creek is the main drainage, approximately 10 miles in length, and runs from Malibu Lake to Malibu Lagoon, where the creek enters the Pacific Ocean. Major tributaries of Malibu Creek include Cold Creek and Las Virgenes Creek. Malibu Canyon Road/Las Virgenes Road forms the primary north/south route through the watershed and generally parallels Malibu Creek in the lower portion of the watershed from Mullholland Hwy to the beach , and Las Virgenes Creek in the upper portion of the highway from Mulholland Highway to Highway 101.

Rindge Dam is located approximately three miles from the mouth of Malibu Creek. The dam is located in a steep narrow canyon gorge that is difficult to access. Slopes are highly variable and typically 1:1, increasing in the vicinity of the dam. The dam, built in the 1920s, is a concrete arch structure 102 feet in height with a cord length of approximately 144 feet at its crest and about 80 feet at its base. Sediment has impounded behind the dam to its crest elevation. Eight, much smaller fish-migration barriers exist upstream of Rindge Dam, ranging in scale from small earthen dams, to drainage culverts beneath roadways.

Utilities in the vicinity of the reservoir include overhead power lines, storm drains, and potential gas, water, and sewer lines. Retaining walls supporting roadway embankments are also present adjacent to the reservoir area.

Malibu lagoon is located at the mouth of Malibu Canyon. Residential and commercial developments are located near the mouth of the creek, in the City of Malibu. There is no such development in the immediate vicinity of the dam and the sediment impound. Calabasas Landfill is approximately 7 miles upstream of the impound.

The study area also includes shoreline and nearshore locations outside the watershed. Beach and nearshore areas within the study area are generally confined to the vicinity of Malibu.

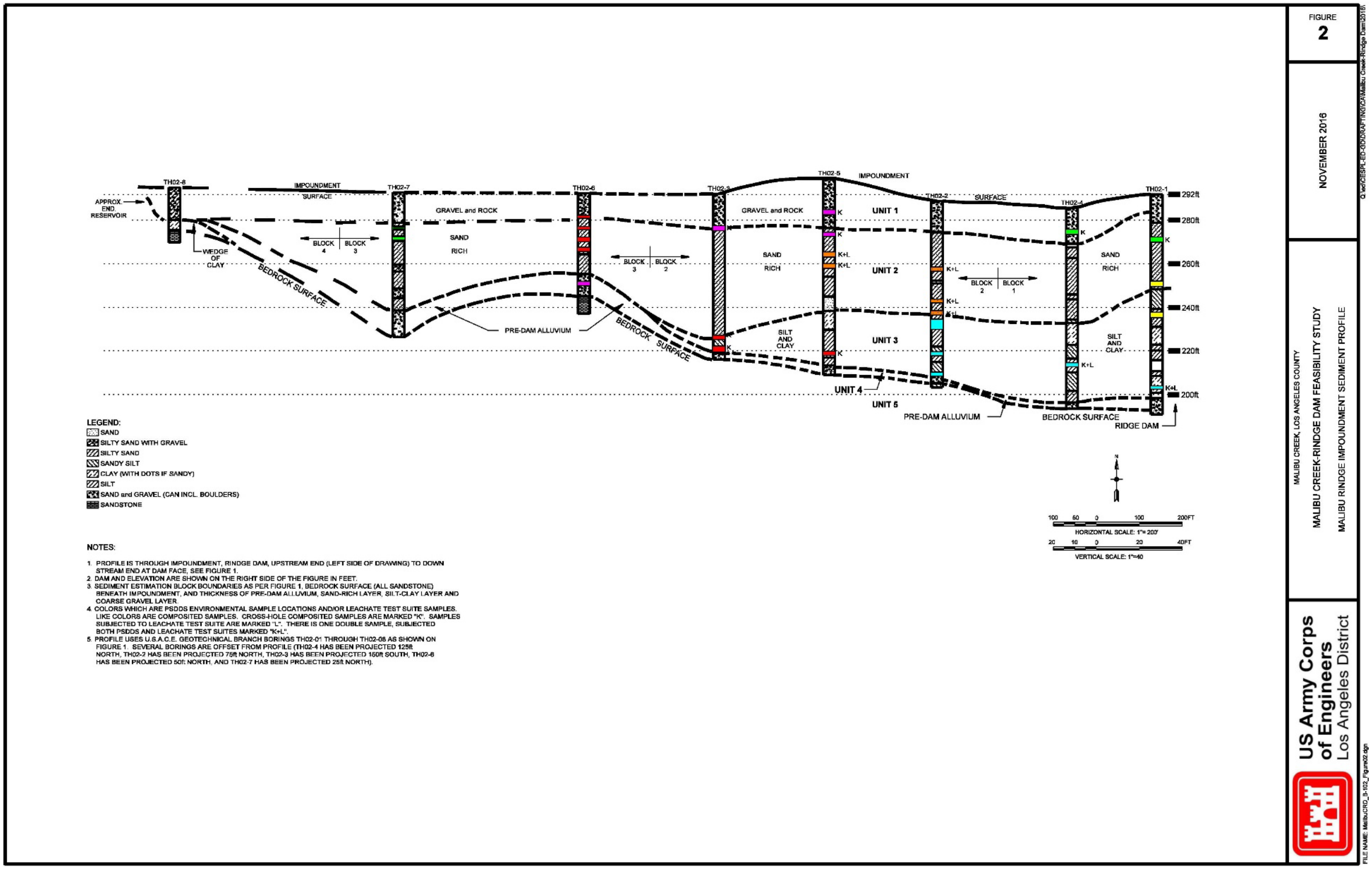


Figure 3.1-1 Malibu Rindge Impoundment Sediment Profile

3.2 Regional Geology

The study area, including the damsite and impounded sediment, are within the Santa Monica Mountains, part of the Transverse Ranges of California. The dominant geologic characteristic of the region is tectonic plate interaction between the North American Plate and the Pacific Plate along the San Andreas Fault zone, 80 miles north of the damsite. Because of the east-west orientation of this fault zone, the general strike-slip motion along the plate boundary is here transposed to include a significant compressional force, which, in turn, has resulted in rapid uplift of the Transverse Ranges (City of Malibu, no date, p. 4.5.1), and far-reaching thrust faulting of bedrock formations, with rock units moving from south to north, and, in some cases, continuing to the degree that formations have been overturned (Yerkes and Campbell, 1980, map). Normal faulting and some less extreme structural deformation of the uplifted rocks also occurred. In response to that deformation, a north-to-south oriented anticlinal structure formed 5 miles northeast of the damsite (NPS, 2007, map).

The primary impact of the tectonic forces described above has been uplift. This uplift formed the Santa Monica Mountains, an east-to-west trending, relatively low elevation range extending from the west side of City of Los Angeles to the Oxnard plain (Jones and Stokes, 2009, p. 3F-1). This uplift began about 16 million years ago and was expressed initially through uplifting and deformation of ocean floor (NPS, 2013) and its thick marine sediments, then continued with volcanic rock eruption, intrusions of molten rock (basalt and diabase dikes and sills), and concluded with erosion of uplifted rocks, which deeply incised them. Some of the eroded materials deposited in the region became lithified into new rock formations.

Ridge crests on either side of the Rindge Dam impoundment are nearly 1,400 feet above sea level, which is about 1,100 feet above the dam. In contrast, at one point in time, several millions of years ago, the overall Santa Monica Mountains were an estimated three times taller than they are now (NPS, 2013).

This rapid uplift of the young, shallow, not-well-indurated, largely marine sedimentary rock sequence, followed by rapid erosion, has imparted numerous landslides, some of them quite large, onto the landscape. Ancient landslides typical of those found on the seaward slopes of the Santa Monica Mountains were created during the last glacial epoch (roughly 15,000 years ago) when a significant volume of earth's water was trapped in the polar ice caps resulting in a lowering of sea level by as much as 300 feet. During this period, temperatures were significantly lower than they are today and rainfall was much higher. These conditions resulted in headward erosion of coastal drainage patterns, over steepening of canyon slopes, and saturation of the ascending hillside terrain. The relatively weak nature of the sedimentary bedrock, particularly along bedding surfaces and the rock discontinuities, shear zones, and faults, created by tectonic uplift and deformation has created potential failure surfaces along which sliding can occur. Headward erosion and over steepening of canyon slopes undercut many of the potential failure surfaces within the ascending slopes. Saturation of the bedrock lowered the strength of the weak clay materials positioned along the rock discontinuities and induced a buoyant condition that reduce the normal force acting on the base of the of the potential slide mass by as much as 50 percent. These conditions resulted in a driving force that that exceeded the available resisting force of a given rock mass and landsliding occurred.

At the close of the glacial epoch, 10,000 years ago, temperatures increased, the ice caps retreated and sea level rose to near current levels and the deeply eroded canyons were subsequently backfilled with sediment. Rainfall was also reduced to near current levels. Under these conditions the landscape, including the previously created landslides were largely fixed in place due to the limited occurrence erosion. In some cases the remaining landslides were buttressed by the sediment filled canyons and at other locations the existing landslides were left in a quasi-state of stability where their resisting and driving forces are roughly balanced. As a result, many of the ancient landslides are easily reactivated by minor undercutting and changes in moisture content.

3.3 Site Geology

The dam foundation and both abutments are set into bedrock, based on the original design drawings from the 1920s. Except on the canyon floor, bedrock was exposed at the surface of much of the damsite prior to construction of the dam, with rock concealment provided only by intermittent and very thin soils. That condition remains today on the canyon walls above the impoundment. The reservoir has fully filled with impounded sediment. That impounded sediment is 94+ feet thick at the dam face, thinning to less than 5 feet at the upstream end of the reservoir. This impounded sediment buries bedrock, thin soils, and pre-dam alluvium. Drilling of the impounded sediment revealed a thin (2- to 10-foot-thick) layer of pre-dam alluvium, including cobbles and boulders, along the Malibu Creek channel alignment, below the impounded sediment, and directly overlying bedrock. Considering pre-dam geomorphology and the widening of the canyon immediately upstream of the dam footprint, this 2- to 10-foot-thick layer likely is the thickest accumulation of pre-dam Malibu Creek channel alluvium within the site boundary.

Bedrock underlying the pre-dam alluvium is a light brown to gray, medium to fine-grained, weakly to moderately cemented Sespe Formation sandstone, with a minor amount of gravel-sized clasts. This sandstone was not observed to be fossiliferous at the damsite.

Yerkes and Campbell (1980, map) mapped the site geology as part of their much wider area effort in the Santa Monica Mountains. The section of that mapping covering the damsite, impoundment, and potential sediment-removal haul road footprints is reproduced as **Figure 3.1-1**.

3.3.1 Stratigraphy

The stratigraphic units discussed here are those underlying the dam and the impound area, and ascending / slopes immediately adjoining impound. The geology of upstream barriers was not investigated and is not reported here. The damsite bedrock is the **Piuma member** of the **Sespe Formation** (Tsp) and the **Vaqueros Formation** (Tv) (**Figure 3.3-1**). Those two bedrock units have long been recognized as interfingering formations. Strike and dip of both these bedrock formations, on canyon walls, beneath the impoundment, and within the dam abutments and foundation, is N.55°W. to N.65°W., with dips to the northeast at about 40° (**Figure 3.3-1**). The **Piuma member** of the **Sespe Formation** underlies the vast majority of the damsite and impoundment area, but the upstreammost quarter of the original reservoir length, including reservoir basin floor and south canyon wall of Malibu Creek is underlain by **Vaqueros Formation** (**Figure 3.3-1**).

Both formations are Lower Miocene in age (23.7 to 16.4 million years before present (Ma)). The Piuma member of the Sespe Formation is defined by Yerkes and Campbell (1980, map) as a grayish-red pebbly sandstone in the impound area, that has conglomeratic and mudstone units elsewhere. It grades laterally into non-subdivided parts of the Sespe Formation. It is thought to be possibly nonmarine in origin. The Vaqueros Formation is a marine sandstone, pebbly marine sandstone, and interbedded nonmarine mudstone. It has distinctive molluscan fossils in places (none seen in the study area) and wedges laterally into Sespe Formation (Yerkes and Campbell, 1980, map).

Intrusive rocks (Ti). A large sill of intrusive igneous rock is on the north reservoir canyon walls, beginning about 200 feet above the current surface of the impoundment (**Figure 3.3-1**). The intrusive rock is middle Miocene in age (16.4 to 11.2 Ma) (Yerkes and Campbell, 1980, map). Dibblee and others (1993, map) classify this intrusive rock unit as a diabase. Immediately upstream of the impoundment, Malibu Creek cuts across this sill perpendicular to its strike, then turns 90° to the east and parallels the sill. Downstream of this change in flow direction, the sill is far above the impoundment surface on the north canyon wall. The existing access ramp to the canyon cuts perpendicularly across this sill upstream of the impoundment area.

Two much thinner and smaller intrusive igneous dikes are found on: 1) the right (south) dam abutment, and 2) the south reservoir canyon wall, in the Vaqueros Formation section. The latter dike aligns with a thrust fault zone (Yerkes and Campbell, 1980, map). These structures can be seen in **Figure 3.3-1**.

Portions of the bedrock are covered by colluvium and residual soils, but they are not shown on the referenced, published regional geologic map, and they were not mapped in the course of this investigation. These materials in general are expected to be comprised of porous, unconsolidated, loose sands silts and clays with rock fragments that are derived from the underlying bedrock units. These materials are expected to be non-contiguous and to be thin.

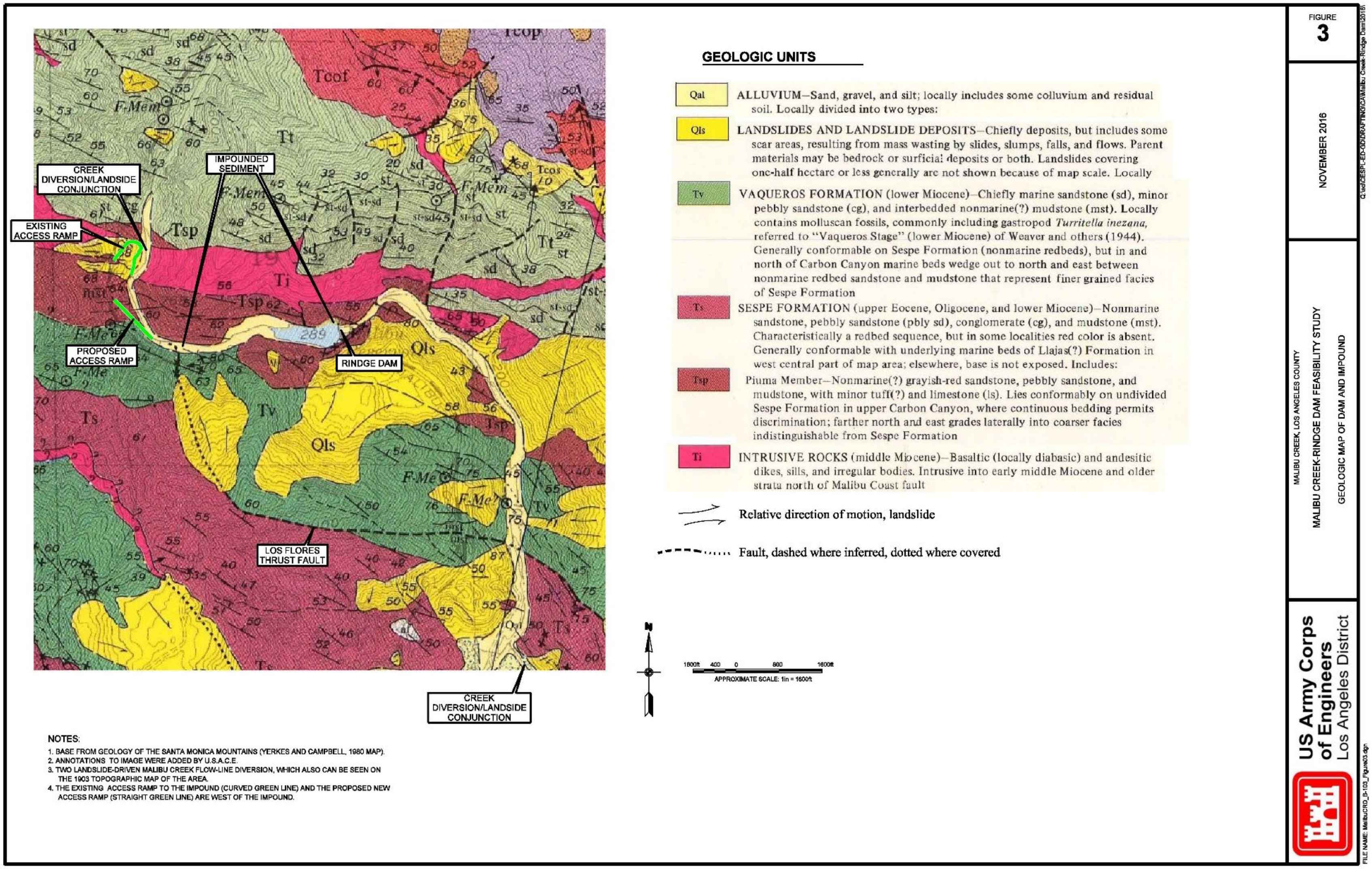


Figure 3.3-1 Geologic Map of Dam and Impound

3.3.2 Landslides (Qls)

The entire study area has been classified as a landslide risk zone (California Division of Mines and Geology, 2001, map). Quaternary landslides, some very large, are within and adjoining the study area. One such very large landslide is southeast of Rindge Dam but is not contiguous with it or with the impounded sediment. Two other landslides are on the canyon slopes above the southern reservoir canyon walls. Another landslide is beneath the existing canyon-bottom access ramp, a ramp which would have to be used to remove the impounded sediment. Other landslides may be identified during the design phase or during the process of impounded sediment removal. These landslides most likely developed during the last glacial epoch when sea level was as much as 200 feet lower than it is today and annual rainfall was much higher. During this period, soil and rock strength were at their minimum, and erosion had over steepened canyon slopes, resulting in slope instability and landsliding. Today, the recognized landslide features are generally considered in a state of quasi-equilibrium. Increased rainfall and localized erosion can and has resulted in the reactivation of the existing landslides. Two obvious Malibu Creek channel deflections align with landslides, one beneath the canyon-bottom access ramp and the other a mile downstream of the dam. Both stream deflections can be seen on the oldest topographic mapping available for the site (1903 US Geological Survey topographic map of the Calabasas 1:62,500 scale quadrangle map, by US Geological Survey). Geotechnical concerns on the potential for dam and impounded sediment removal to reactivate these slides are addressed below.

3.3.3 Alluvium (Qal)

Pre-dam alluvium largely is very coarse grained and includes boulders and cobbles, based on drill action and examination of recovered samples (see boring logs, Appendix D1). Pre-dam alluvium overlies sandstone bedrock.

There is a sharp difference in gradation between the bottom of the impoundment (silt and clay) and the pre-dam alluvium (rocky).

Rindge Dam impounded sediment is a thick alluvial deposit and it has, in the deeper parts of the impoundment, a sediment profile that reflects deposition in a deep pool of water, which was the former Rindge Dam reservoir. This profile consists of coarse material deposited where sediment-laden Malibu Creek flows first intersected and slowed at the upstream edge of the pool, with sand deposited farther downstream (moved farther downstream from the creek-pool interface before settling), and fine-grained sediment (silt and clay) deposited in what was the deepest water, over almost the entire reservoir floor, and continuously downstream to the dam face.

Based on the USACE exploration borings of 2002, the impounded sediment was subdivided into three units, as described below. They are shown on **Figure 3.1-1** and indicated on logs and test results in **Appendixes D1 and D2**.

Impounded materials, listed top-to-bottom.		
Unit	Material layer	Description
Unit 1	Fluvial deposition (i.e., not deposited in a reservoir pool)	Sand, gravel, cobbles, and larger rock
Unit 2	Shallow to intermediate depths reservoir pool deposition	Mainly silty sands with organic content; does contain silt layers, some gravel
Unit 3	Deeper depths of reservoir pool deposition	Sandy silts, lean clays, and silts (all with organic content); does contain some silty sand layers
Unit 4	Pre-reservoir alluvium	Coarse materials, gravel, cobbles, boulders
Unit 5	Sandstone	Bedrock.

Units 2 and 3 were deposited into the former reservoir pool, a reducing environment, and the sediments are mostly finer grained, black or gray in color, and have a sulfurous odor. There is some granular material like that which characterizes Unit 2 found in Unit 3, and there are some fines layers that characterize Unit 3 found in Unit 2, indicating depositional environment boundaries shifted for certain events, probably indicating sediment pulses from storm flows and periods of stability that allowed fines to be deposited on top of sand. Unit 1 represents the highest-energy storm flow deposition in a fluvial environment. These materials are notably *lacking* in the black-gray color and sulfurous odor, silt and clay content, and organic content. Fluvial sand layers at the boundary of Unit 1 and Unit 2 were grouped into Unit 2. There is evidence of scour events cutting down into the reservoir fill deposits in some of the USACE and Law / Crandall borings. At the upper end of the reservoir (around boring TH02-08 and upstream), there are little, if any reservoir pool deposits of the silty sand and finer materials. If they ever were present there in the upstream part of the reservoir, they since have been nearly or wholly scoured out and replaced with this upper, fluvial gravel and sand.

The reservoir basin has filled relatively rapidly with most of the sedimentation occurring in the last 20 years. As a result, the existing sediment profile is a reflection of the continuously changing depositional conditions. For example, the more recent sediment deposition occurred in a shallower pool, wherein sediment-laden waters did not slow sufficiently for silt and clay to settle in the reservoir. Those fine-grained materials washed over the dam or out the spillway, while the sand fraction moved farther downstream in the remaining pool, reaching the dam face and, burying previously deposited silt-clay. In time, the reservoir pool became so shallow that in-coming water velocities remained very fast and the sand fraction no longer was able to settle in the reservoir, and it too ceased to be deposited, and mostly washed over the dam during storms along with all the silt and clay. The coarse-grained material layer, comprised mostly of gravel, but with some cobbles and larger rock, moved closer to the dam face, burying the sand layer and finally reaching the dam face. This coarse material filled much of the remainder of the dam freeboard between 1998, when there were 10 feet of freeboard at the dam face, and 2001, when 3 feet of freeboard remained. Freeboard by 2005 reduced to essentially zero with additional deposition, and now, in large storm flows, the coarse material is reworked, typically with no net change in the amount of material in the impoundment.

While there can be hydraulic conditions in Malibu Creek that may allow additional material to be deposited within the confines of the impound and upstream, such conditions will occur only infrequently, and for purposes of sediment quantification in the near term, this reservoir basin is "full," i.e., reservoir pool capacity is now fully displaced by impounded sediment and there is no reservoir pool. Nevertheless, ideal, unlikely-to-occur-with-frequency hydraulic conditions of concurrent high sediment load and low scouring forces could exist in some future creek flows, and if they do occur more sediment could accumulate in the canyon upstream of Rindge Dam, including on top of the existing impoundment surface. Refer to the hydraulic engineering appendix of the Integrated Feasibility Report for details on the modeling that determined this.

3.4 Groundwater

Groundwater locally is two or three feet below the top of the impounded sediment surface, which is essentially at the same elevation as the former reservoir pool surface. Much of this groundwater actually is treated sewage effluent, released 1.3 miles upstream of the impoundment by the Tapia Wastewater Treatment Plant. The impact of this effluent release has been noticeable, increasing channel width and flow depth of Malibu Creek where it meanders across the surface of the impounded sediment, raising groundwater elevation in the impoundment, and supporting an explosion of thick vegetation growth, characteristics that did not exist in 1998, prior to the treatment plant coming on line. It has been reported this effluent release will not cease during any dam demolition and impounded sediment removal that may occur.

Of significance is that groundwater, post-dam-construction, has saturated some feet of the canyon bedrock walls below the impound-surface elevation and laterally outward to an undetermined extent from the impound, between the elevation of the top of the impound surface, and the top of the pre-dam alluvium. This is a significant change relative to pre-dam conditions. Most groundwater, pre-dam, would have been at and below the surface of the flowing creek and near surface saturation of the bedrock canyon walls above that elevation would not have been substantial. The degree of saturation of the currently buried, bedrock surface / canyon walls by this elevated groundwater level has not been determined. The geotechnical significance is that slope stability issues could arise due to dewatering of the impoundment and removal of the impounded sediments.

3.5 Faulting and Seismicity

The project site is located in the general proximity of several active and potentially active faults. The California region is known to be seismically active and much geologic and seismologic evidence is readily available. The potential for strong ground motion in this region is well established and seismic shaking resulting in strong ground motions could occur. The engineering study included the examination of local and regional faulting and review of existing historic earthquake data. The site is not located within an Earthquake Fault Zone.

The two closest regional faults to the study area are: 1) the San Andreas Fault, a major, active, tectonic boundary fault, with significant annual movement, and the capability to produce significant earthquakes in the future, and, 2) the east-west trending Malibu Coast Fault, which is about 2 mi south of the dam site, based on mapping by NPS (2007, map). The Malibu Coast Fault, which consists of multiple strands, apparently has not moved for an estimated 75,000 years (Jones and Stokes, 2009, p. 3F-3). Both characteristics diminish this fault as a seismic risk to the study area, although this risk is not reduced to zero. However, the Malibu Coast Fault is part of an extensive zone of tectonic deformation that defines the southern margin of the Transverse Ranges and the Los Angeles Basin to the south. This zone of faulting not only includes the Malibu Coast Fault but the Santa Monica, Hollywood, and Raymond Faults to the east and the Anacapa-Dume, Santa Cruz Island, and Santa Rosa Island Faults offshore and to the west. Segments of the Santa Monica, Hollywood, and Raymond faults are known to be active.

Essentially, there are three conditions which must be present at a site for liquefaction to occur; relatively loose, granular sandy soils, shallow groundwater (within about 50 feet of the ground surface), and potential for strong ground motion. Neither the dam nor the impoundment site are in an identified liquefaction risk zone according to State of California classifications made to date (California Division of Mines and Geology, 2001, map). However, examination of the site suggests that shallow groundwater exists onsite in a granular substrate that is sufficiently fine-grained to develop pore pressures (buried unit 2). Subsurface exploration indicates that shallow loose sandy soils are present at the site. Therefore, the potential for liquefaction is considered to be high for the impounded sediments.

4.0 GEOTECHNICAL AND GEOLOGIC CONSTRAINTS

A central concept of most study Alternatives, as re-configured in late 2016, is mechanical excavation and removal of the impounded sediment behind Rindge Dam, and subsequent transporting of the sediment out of Malibu Canyon by truck. Some variations of Alternatives include later transfer of the sediment to barges. Issues relevant to mechanical excavation and removal are many and are pertinent to all variations of Alternatives 2 and 4. The sequence and timing of the steps is particularly important. Geotechnical constraints associated with this study with respect to aspects of the alternatives are discussed below.

- The salient geotechnical aspects associated with dam demolition and removal are dissipation of pore pressures and stability of natural and impounded sediment slopes.
- Sediment removal will require significant dewatering of the impounded sediment, which is continually being re-saturated by upstream release of treated wastewater effluent. Dewatering methodologies and treatment of the discharge will need to be addressed.
- Removal of the dam materials and the impounded sediments will require the installation and use of temporary access ramps. The design of these ramps will require stability evaluation, including the ability of the natural ground to support the additional ramp embankment fills. Removal of the ramps and restoration of the terrain will require significant engineering stability evaluation as well.
- The geologic conditions within the project site and surrounding area are generally unfavorable. Canyon-wall landsliding potential may influence excavation methods and rates to be applied to impounded sediments, and likely will require application of stabilization measures yet to be determined.
- Configuration of restored topography has not been fully developed and will need to be determined. It is likely that a full determination can only be made at the time the impounded sediments are removed. Removal of the sediment may reveal natural barriers to fish migration that are currently not recognized. Consultation with other agencies to determine the final grades will be required.
- Assumptions made concerning the canyon sidewall configuration beneath the impounded sediment and their impact on the estimated quantity of impounded sediment are explained in USACE (2008) and have potential to have the largest net change on actual impounded sediment vs. the estimated quantity.
- Characterization of impounded materials is based on limited information, and subsurface conditions in the impound may vary from that determined by extrapolating the limited boring log data. Recommendations for further investigation and evaluation of the impounded sediments are presented in section 6 below. There is a high risk that selective grading and processing will be required in the event that direct placement of the sand-rich layer on local beaches is undertaken (such action is not currently a measure within any of the alternatives in this study).
- The stability of the existing canyon slopes and the slopes that are currently buried by the impounded sediments has not been evaluated. The complex canyonwall geology and the

buttressing effect of the impounded sediment will require extensive geologic evaluation. Removal of the impounded sediments will create a condition that is less favorable, from a stability standpoint, than the current configuration. The existing infrastructure, including retaining walls, utility lines, and roadways must be preserved.

- Upon removal of impounded sediment, Malibu Creek flow characteristics will be changed, which could result in localized scour and erosion along some segments of the creek, both in the current impoundment area and farther up and downstream. Such scour could destabilize segments of canyonwall slopes and re-activate landslides.
- Preliminary investigation indicates that hazardous waste is not a significant design consideration. However the potential for undiscovered waste remains.
- Downstream flood risks-following removal of the dam, sediment accumulation downstream will potentially require mitigation of increased flood risks. That condition will require the evaluation of either levees or floodwalls.
- Dam modification (removal) will comply with the dam safety requirements of ER 1110-2-1156, *Safety of Dams – Policy and Procedures*, as well as pertinent USACE design criteria. Although Rindge Dam has been taken out of California Division of Safety of Dams (DSOD) jurisdiction because it no longer impounds a pool, USACE will coordinate with DSOD to ensure that the dam removal plans are consistent with state requirements.
- Reference to project study documents indicates that the plunge pool and stream immediately downstream of the dam is considered habitat that is to be protected. However it is assumed that due to the nature of the depositional environment, the plunge pool will most likely fill with sediment following dam removal.
- During the multi-year excavation of impounded sediment, re-deposition of new sediment within the impoundment area is a possibility, via new sediment washing in from upstream locations (reference section 5.4.8 for discussion).

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 <u>Impounded Sediment Characterization and Potential Application</u>

The USACE was tasked in 2002 to quantify the impounded sediment behind Rindge Dam and determine any limitations to its use or disposal that could arise due to physical or chemical characteristics. Another objective was reconciling the difference in estimated impounded sediment quantity between the 1993 Law Crandall work and the 1995 Bureau of Reclamation work.
In addition, chemical contaminants testing performed by Law Crandall (1993) was essentially limited to a test for gasoline, and was the only environmental testing ever done on the impounded material. Considering a key project constraint was proper disposal of these sediments, it was essential the Corps obtain additional samples and conduct more extensive chemical testing to better determine whether the sediment could be utilized in the nearshore, on the beach, in other upland placement scenarios, and if there were any limitations on beneficial use or upland disposal applications.

The test results of collected samples indicate there are no chemical-contaminants limitations for beneficial reuse or disposal of the sediments, including all varieties of upland disposal, to include landfilling. Neither are there chemical-contaminants limitations to in-ocean disposal or on beach disposal for beach nourishment or ocean substrate enhancement, such as building rocky kelp forest rooting beds on the ocean bottom. The gradation of the silt-clay layer (unit 3) precludes its placement in the ocean. The gradation of the upper gravel-rich layer (unit 1) is much less than is sought for ocean substrate enhancement for rocky rooting bed construction; it is mostly gravel and what is sought is mostly cobbles. Only the sand-rich layer (unit 2) has enough sand content to be utilized for on-beach placement. The gradation of the sand –rich layer is within an acceptable range, but minimally so, to the EPA and the SC-DMMT (Southern California Dredged Material Management team), which provides regulatory oversight on beach and ocean (nearshore and offshore) placement of materials. The gradation of unit 2 is far less than local beach management requires for southern California beaches (73% sand vs. minimum 90% sand) and as a result no measures within this study include direct on-beach placement.

5.1.1 Quantity and Gradation

The USACE in 2002 estimated 780,000 cy of impounded material behind the dam, divided into three layers, with 210,000 cy of gravelly material on top, 340,000 cy of sandy material in the middle, and 230,000 cy of silt and clay on the bottom. The recoverable part of the sand-rich layer (unit 2) is estimated to be 276,000 cu yds. The total is reduced because some would be used to construct haul ramps and some (in block 4) would not be excavated. In the estimation process, some assumptions were made concerning the configuration of the buried canyon / reservoir walls. If the actual configuration of the buried canyon walls varies from those presumptions, quantities of impounded sediment will vary.

None of the three sediment layers in the impoundment (gravel, sand, and silt-clay) constitute a perfectly uniform gradation or soil type. The upper gravel layer has a sand component, and is estimated to include 60,000 cy of sand. The silt and clay layer on the bottom has some sand content. The sandy layer is not 100 percent sand. In addition, organics are identified in the deeper parts of the impoundment profile.

The weighted average sandy layer gradation, based on the 2002 USACE samples, is 73 percent sand, 5 percent gravel, and 22 percent silt and clay. Improving the average sandy layer gradation (reducing fines) has a number of geotechnical considerations, chief among them the inefficiency inherent with removing all the non-sand material.

Only the sandy layer in the impounded sediment behind Rindge Dam has applicability for beach nourishment. Some sand, as much as 60,000 cy, is present in the gravel-rich upper layer, and should be recoverable, although not economically. The silt and clay layer has some sand content, none of which is recoverable, because it is too dispersed.

5.1.2 Chemical (Contaminant) Characteristics

Regulatory leachate testing was performed on the sampled impound materials in 2002 in part to determine if the materials were objectionable for upland disposal. Leachate test results are favorable (Appendix D2). In addition to favorable performance on the leachate tests, it also must be demonstrable that the sediment is not toxic waste, as defined in the Code of Federal Regulations, 40 CFR, part 261. The sediment has no observable characteristics nor any test results indicative of characteristics of ignitability, corrosivity, reactivity, or toxicity, nor any history of specific industrial processing that would indicate such characteristics. The impounded sediment is not hazardous waste (additional detail in Appendix D2), a finding that opens all options of upland disposal for the sediment, in the context of conceptual planning. Upland disposal includes all non-ocean placement of the sediment, such as on-beach placement, stabilized artificial fills within or outside of the canyon confines, agricultural soils enhancement, commercial aggregate, landfill daily cover, and wasting in a landfill.

Other specific suites of chemical constituents and their concentrations also are a vital consideration related to potential on-beach and nearshore placement of impounded sediment. The geochemical sampling and testing suite applied in 2002 was the then non-regulatory sediment quality guidelines in place at the time, specifically, the Puget Sound Dredged Disposal System (PSDDS), a test suite of 89 analytes and physical-chemical characteristics used by the Corps and other agencies to determine whether dredged materials, or any terrestrially originating excavated materials, are suitable for placement in the ocean. At that time, had a final plan been readied, and target placement sites selected, the EPA would have been petitioned for a decision on whether it was permissible to place any part of Rindge Dam impounded sediment on specific beaches, specific nearshore locations, etc.

Following 2002, this study was in hiatus for many years, and in the interim, there was significant formalization of the regulatory oversight and review process for impounded materials placement in or near the ocean, including the adoption of regulatory test suites. Yet, the rigorous testing regime applied in 2002 to this impoundment (Appendix D2) remains relevant and applicable, because, while the PSDDS, a scientific, yet non-regulatory system for determining presence or absence of chemicals and elements that could be harmful to aquatic species has been replaced, the current analytical suite used by the SC-DMMT, is very similar. SC-DMMT requirements on placement of specific sediment on specific beaches or nearshore zones are based not only on the gradation of the sediment, but also on its chemical constituents. As of February 2013, the SC-DMMT, utilizing the USACE 2002 chemical constituent analyses, reported that it will continue, in concept, to consider allowing both on-beach and nearshore placement of Rindge Dam impounded sand-rich layer. As per standard procedures, regular, confirmatory sampling and testing for deleterious materials will be necessary as excavation of the impoundment proceeds (this does not represent a change from 2002; such confirmatory testing was required in 2002, as today). Based on the chemical constituents (contaminants) testing of samples, and leachate testing, there are no limitations to potential application of the impounded sediments in any form of upland disposal. On-beach placement is a form of upland disposal. The only caveat is that direct on-beach is subject to additional SC-DMMT ruling, as discussed above. All other upland disposal applications are subject only the already successfully completed leachate testing (must be "not hazardous waste"). The impounded material is not hazardous waste, based on its test results and characteristics.

5.2 Sediment Disposal

Geotechnical issues discussed immediately below in bulleted statements are not relevant to any of 2016 Alternatives 1, 2, 3, or 4, but the issues received considerable stakeholder and technical team interest during development of the measures, so the completed geotechnical assessment and decision processes are recorded here to maintain completeness of the geotechnical record. The USACE was tasked in 2008 to provide general, conceptual level geotechnical evaluation of alternatives that included:

- • stabilizing impounded sediment on the sides of steep Malibu Canyon walls, away from the damsite (a form of upland disposal);
- • sluicing or conveyor transport of impounded sediment down Malibu Creek to the ocean;
- • natural transport of all the sediment to the ocean, a concept based on incremental dam demolition, occurring over many years, with all sediment movement via intermittent Malibu Creek storm flows.

The field work consisted only of a walk through at three potential in-canyon re-stabilization sites for impounded sediment. All the other alternatives were evaluated on a desk-top basis.

Excavating and re-stabilizing impounded sediment away from the damsite, on steep Malibu Canyon walls, would require detailed and site-specific assessment of the foundation conditions at each proposed location for re-stabilizing. Sliding and slumping potential in both the soils and underlying bedrock are the major issues. Foundation conditions at proposed re-stabilizing sites on steep Malibu Canyon walls were not investigated but must be, if this portion of the sediment disposal process were to move forward.

Sluice transport was not considered viable due to lack of adequate water supply and no access points in the canyon for final trucking to the beaches. Elimination of sluicing as an alternative was primarily from lack of water. Absence of work space in the canyon, away from the damsite, to move materials from the sluice system to the beach or ocean is an additional complicating issue because no such land was or is available.

Natural transport of impounded sediment to the ocean was the alternative most favored by the team early in the feasibility phase due to minimizing of the handling of the sediment. Water supply is not an issue because the concept allows for years of low flows and will simply extend the time needed to remove the sediment if more low-flow years occur than were projected. Geotechnical concerns relate to the long term dam stability. Alternative 3 remains in the study as of 2016 as the ‘natural transport” Alternative and is discussed below.

The conveyor transport concept did not survive the planning process due to unacceptable elements of cost, habitat impact downstream of the dam that would occur from building the conveyor, and lack of access points in the canyon for the conveyor product outlet for final trucking to the beaches or ocean. Large rock, confined mostly to the upper coarse layer of sediment, must be removed from the conveyor input to prevent conveyor system damage, should that method for sediment disposal be taken forward in the planning process. The large rock removal would most likely be accomplished by placing a crusher in the canyon bottom.

5.3 Impounded Sediment Upland Disposal Sites (Permanent Storage)

Hydraulic modeling done by the USACE after 2008 demonstrated that natural transport of sediment would impact downstream habitat, infrastructure, and properties along Malibu Creek on its way to the ocean, all of which was unacceptable. Consequently, relocating impounded sediment at various potential disposal sites in the canyon became the team-favored concept, even though no site investigations had been done. Numerous sites were chosen at various stages of the planning process and were named alphabetically to maintain consistency. Sites A, B, and C were selected as part of the initial set of sites. Site A was not carried forward for consideration as a permanent storage site after it was verified the Local Sponsor would not be able to obtain the land from private ownership for use in this study.

5.3.1 Sites A through D

In late 2011, USACE performed a more in-depth assessment concerning re-stabilizing impounded sediment on the sides of steep canyon walls at two specific local-sponsor-owned sites (sites B and C, see **Figure 5.3-1**); the sites had not been assessed for site conditions, including slope stability. The sites had been promoted for use by stakeholders solely because they are close to the damsite and are local-sponsor-owned land. All the sites are on or partially located on landslides, based on previous published and unpublished geologic mapping by several different geologists. The presence of slides was then confirmed via a USACE study of aerial photographs and a subsequent site visit. The proposed placement area likely is much nearer to the toe of these landslides than to the head, but the potential does exist that these uncharacterized landslides may have deep toes, even extending across the width of Malibu Creek. Site A, located on the crest of a geomorphologic terrace, and near the impoundment area, is not owned by the local sponsor. It too was shown to contain a landslide, both in existing literature and via a subsequent USACE field verification, including in the area where impounded sediments conceptually would be placed. That conceptual placement area likely was much nearer the head of the landslide than to toe at site A, although the slide remains uncharacterized.

A 'site D' was considered briefly (**Figure 5.3-1**). The concept considered at that location was to permanently dispose of excavated and recompacted impoundment materials of all gradations (units 1, 2, and 3) in the Malibu Creek channel, about 1 mile downstream of Rindge Dam. Under the concept, these recompacted impound materials would be placed at site D to a height of over 130 feet. The concept was rejected due to the necessity of revetting the materials, long term maintenance of that revetment, incompatibility of a massive revetted area with the natural setting, and the impact of any failure of the revetment during a flood event, which would lead to rapid and extensive mobilization of sediment into Malibu Creek flows, sedimentation issues downstream, etc.

Concerning area A, B, and C, the USACE advised the study team on the presence of the slides, the potential for landslide reactivation by loading it with sediment, the large expense of investigating such sites to find the base of the slide plane (a necessity prior to attempts to stabilize it), and the technical difficulty in preventing such reactivation, even after having completed a site investigation. The USACE study team determined the cost of the investigation and lack of a guaranteed favorable outcome were unacceptable and sites B and C were eliminated from this study, their subsurface conditions having never been investigated. Site A was determined to be unobtainable for use in this study and was dropped from further consideration; it never was part of the study area. .

In this process of initial site evaluation, another constraint became apparent: stakeholder-defined prime fisheries waters immediately downstream of the dam and for a considerable distance downstream of the dam along Malibu Creek. Protection of that habitat was to be based on controlling turbidity in the stream. Minimizing turbidity adjacent to large earthworks, which is what hauling and stabilizing sediment to either sites B or C would have been, was another deterrent. It seemed unlikely that this constraint of turbidity control could be met while transporting and handling such large quantities of material as would be required to utilize sites B and C.

Further complicating the matter is that no one site was large enough to contain all the impounded sediment. Investigation and engineering costs to assure site stability would be multiplied by the total number of sites to be used.

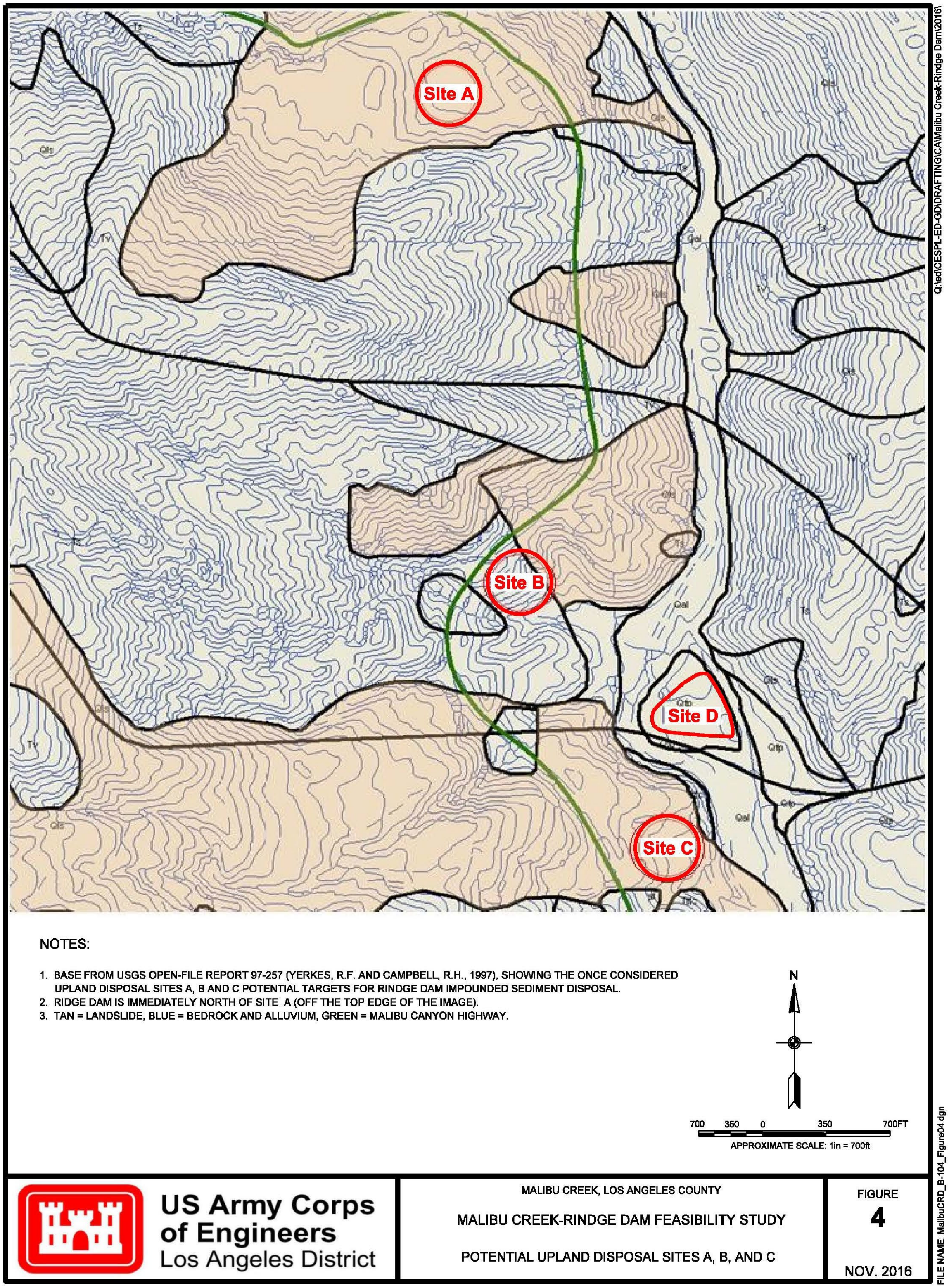


Figure 5.3-1 Potential Upland Disposal Sites A, B and C

5.3.2 Sites E through M

After it became apparent that none of the four sites A, B, C, or D would be carried forward in this study as potential upland disposal sites, the concept continued to be favored by stakeholders, i.e., in-canyon, or near-canyon, short-haul upland stabilization sites still was the team-favored concept and additional sites of this type were wanted by the team for assessment. The Geotechnical Branch was tasked with initial screening of permanent storage sites and aiding in proposing the additional sites. Driving constraints in site selection were:

- The site should be a relatively level area, and not on a mapped or suspected landslide and
- The site should be far from the prime fisheries habitat of Malibu Creek, yet close to the study area to reduce sediment haul distances, and to possibly allow more efficient means of sediment transport besides hauling in trucks.

Within those constraints, the USACE in 2011 chose eight specific sites upstream of Rindge Dam for evaluation (see **Figure 0-1**). All the sites are relatively flat, out-of-canyon tracts, near Malibu Creek Canyon, approximately 3.5 miles north of the damsite. Two of the sites, designated "E" and "F," are owned by the local sponsor. Southeast of the intersection of Malibu Canyon, Las Virgenes Road, and Mulholland Highway are another 6 sites, designated "G" through "M" (designation "I" was not used to avoid confusion with the numeral “1”), subdivided from each other based on topography, roads, and visible land use. The intent was to grossly rank the most promising or suitable sites on their observable geotechnical characteristics, then inquire about site availability.

Site E, a small site near the Malibu Creek State Park Administrative Building, currently used as a picnic area and general open space for day visitors, was not considered available by the local sponsor because of its current uses, which will prevail over use for upland disposal. The site area is capable of holding less than a quarter of the impoundment. Site E was eliminated.

Site F, a relatively flat field owned by the local sponsor, is at a major road intersection north of the State Parks Administration Building, has a historic building on its grounds, and abuts a power transformer station. This site showed the most promise for upland disposal and visualizations were generated to aid in discussion with adjacent landowners and evaluation (any upland disposal of this type has aesthetics issues concerning the visual impact of the resulting product, which essentially will be a stabilized, vegetated, massive landfill, because the region has prime vistas; disrupting those vistas is an issue). After this preliminary visualization rendition was created, a Division of the local sponsor's hierarchy stated that this use of site F would interfere with their plans for both restoration of the historic building and with other, shorter-term objectives. The site was eliminated for permanent disposal purposes based on these higher-priority concerns.

Negotiations by the local sponsor indicated that none of the landholders of sites G through M were willing to devote their land to sediment stockpiling, and were eliminated.

The stakeholders in this study then proposed another approximately six sites and all those too were eliminated on stakeholder concerns, combinations of constraints, or both. The rejection of the latter set of sites was even more rapid than that of the first eight sites, and occurred before any received an initial site survey from USACE.

In 2011, it was reported to the study team that NASA and Boeing Inc. were co-operating on mitigation of a construction project site which might require a large amount of clean sediment as a cap or fill. The location is northwest of the damsite in the direction of Ventura, CA, and north of Highway 101 Freeway. By January of 2012, the study team had determined that the gradation of the impounded materials does not match what the NASA/Boeing project sought and the project schedule does not mesh with the projected time-frame of this feasibility study. Consequently, the site was dropped from further consideration.

Other nearby potential projects, such as a stabilization of a private development near Las Flores Drive, were discussed by the team. Brief investigation of each found that no such project had passed the conceptual stage and thus could not be depended on as a site to accept part of the Rindge Dam impounded sediment.

5.3.3 Sites N through U

For the enhancement of Alternative 2, the team sought both permanent and temporary stockpiling sites for impounded sediment near the swash zone and nearshore zone in Malibu. Sites N through U were considered (sites shown in an illustration in the IFR, section 4.4.2) for this concept, which is based on mining unit 2 impounded sediment, the sand-rich layer, during the summer season, when the creek was not at flood stage, and during that time trucking it to Malibu and stockpiling the mined material at various locations close to the swash zone for later rehandling and mobilization into the ocean, for beach nourishment purposes. The delay in placement was due to the seasons and a desire to not disrupt local beach use and associated businesses. The movement of the sand into the ocean by truck and bulldozer would be done only during the winter when beach use is somewhat slower. This concept lost support, primarily due to land unavailability and City of Malibu objection to this use of lands so close to the business district of the City and the prime beach areas. Of this group of sites, only sites O and P ever were considered for permanent placement of impounded material. Site P was so considered because it is a deep gully. Site O had potential to hold a thin layer of impounded sediment recompacted as a building pad. Owners of site O had no interest in this activity. Site P was doubly problematic, as it would require a complex drain system to be built through it, and through the impounded sediment (and maintenance of that system), and was of very small capacity, such that engineering such a drain system was not cost effective. In addition, the City of Malibu was not in favor of such permanent upland disposal at this site.

The focus returned to only site F, for temporary storage (discussed above) after these conceptual sites were briefly evaluated and rejected. None of sites N through U received any geotechnical site investigation.

5.4 Sediment Removal, Excavation Considerations, and Transport

5.4.1 Sequencing of Dam and Sediment Removal

The targets for receipt of that impounded material have changed markedly over the past five years but the impounded material is marginally suitable for all of the targets, considering its gradation, and is suitable for all of them considering its general lack of environmental/chemical contaminants and lack of leachable contaminants.

Regardless of the sediment recipient target, site preparation will consist of one year devoted to pre-work sensitive species surveys, ramp construction to provide truck access, brushing and clearing (once it is assured no sensitive species will be impacted), drilling and installation of dewatering wells, dewatering the sediment, and building a cofferdam that will capture Malibu Creek flows, including Tapia Water Treatment plant effluent, and installing a pumping and piping network to move this water around the work site.

Under this mining scenario seven years would be required to complete the impound removal, including the previously-described one year for site preparation, then six years of excavating and hauling impounded sediment. Of those six years, parts of three of those years would be required to remove the sand-rich layer of the impounded materials. The time total includes demolition and hauling away of the haul ramp material, which will be slow and time-consuming, requiring more than one year to achieve. All sand hauled to the temporary stockpile, site F, would be re-trucked to take it to the swash zone over the first three winters following the three years devoted to extracting the sand rich layer. The swash zone is the extreme landward part of the nearshore zone where it joins the beach along the foreshore, and immediately seaward of the shoreline.

Under all scenarios, the dam will be cut down as the work season (the sediment removal season) progresses from 1 April through 15 October , and removed in 6 foot by 6 foot by 7 foot sized cut concrete blocks, lifted by a crane, and truck-hauled to landfill disposal. Through the life of the project about 435 cut blocks of the dam will be produced to completely remove the dam, at a rate of approximately two blocks per work day. This set of two concrete blocks per day will weigh approximately 80,000 pounds, combined, and will have a volume of less than 20 cy.

Under this removal scenario, it is essential that the crest of the dam be cut down to match the elevation of the top of the remaining impounded sediment. This cutting progresses during sediment removal and would continue, if needed, into late October. The concrete cutting will start one month after the initiation of sediment removal each year, with the lead month devoted to removing sediment at the dam face so as to clear sediment away from the face and provide room for working on the concrete. Vertical length that will be cut off the dam is estimated in the design appendix of the Integrated Feasibility Report. It will vary by year, due to the variance in sediment production per year, a factor of sediment-target and target availability constraints applied by stakeholders, the varying width of the impound (becomes much more narrow, deeper in the impound, as the canyon v-shaped), of different materials types and physical array (some types and some locations are more efficient to excavate and haul than others), and of the haul destinations (some are farther away). Diamond wire cutting is expected to be used to cut the blocks, including the rebar. Concrete cutting method is addressed in more detail in the structural appendix to the Integrated Feasibility Report.

Many feasibility measures in this study and some of the alternatives focus on concurrent removal of the concrete slab facing that has been built over the bedrock spillway cut. This is a post-dam-construction site improvement, intended to minimize erosion on the bedrock spillway cut. Little is known about the design of the facing. It is presumed doweled into the smooth-cut bedrock spillway face. The Local Sponsor is particularly in favor of including this measure within the Plan for a number of ecological reasons, and it is currently (fall 2016) a key part of the Locally Preferred Plan. If this spillway facing is removed, it would be removed in stages, concurrently with cutting down the face of the dam, unless the doweling or other means of attachment to the bedrock spillway cut face is shown during demolition to be unstable if left partially cut and partially in place. If that is shown to be the case, the concrete spillway facing would be removed in one stage, ahead of full removal of the dam.

The use of explosives as an aid to removal of the concrete spillway structure (separate concrete slab from bedrock) has been suggested. Also suggested has been the potential use of explosives to augment, in part, demolition of the concrete dam arch. Neither concept has been coordinated with the Geotechnical Branch and would have to be prior to implementation. The concern should be to minimize the size of charges used so as to eliminate the possibility of fracturing the bedrock beneath the concrete slabs. Microblasting technology does exist that could achieve this goal. Use of larger charges carries greater risk of slope destabilization. Details of such operations would have to be developed, tailored to this site.

Use of explosives for demolition of at least some of the dam arch raises additional issues. The dense network of railroad steel rails embedded in the concrete arch during its construction does not initially appear well suited for reduction by blasting and blasting alone would not be sufficient to bring down the structure: cutting of the steel network would have to follow breakage of the concrete. The goal of habitat protection of the prime fisheries immediately downstream of the dam face, which caused such potential measures as on-site impounded sediment sorting to be eliminated in years past, does not appear to be well served by blasting of the dam arch, as blasting of an arch networked throughout with large gage, interlocking steel will form the maximum number of small particles and dust, all of which will reach the fisheries habitat below. In comparison, the much older recommendation to saw cut the dam would eliminate the need for blasting, cut both steel and concrete, and much of the wash water from the saw cutting could be trapped and prevented from entering the watercourse.

Overhead clearance allows passage of heavy equipment, such as flat-bedded drilling equipment, but clearance issues may arise for some large cranes that may be needed to demolish the dam. Utility line clearances, for gas, water, and sewer lines will also need to be considered.

5.4.2 Excavation Characteristics

Based on the information that has been compiled to date, it appears that the impounded sediments can be excavated by heavy earthwork equipment typically utilized in Southern California for grading operations. Factors that will have a limiting effect on earthwork production will include saturated soils (mitigated by dewatering) and the possible presence of many large boulders. Exploration performed to date by two firms (Law Crandall and USACE) suggest no extensive accumulation of boulders. If the subsurface conditions revealed under actual site excavation are counter to those suggested by site exploration, then the first avenue of approach would be to segregate the boulders and arrange for them to remain as post-project canyon substrate or for their transport to the offshore in specific areas where various environmental oversight agencies seek to improve ecological characteristics of the ocean substrate. The general fine-grained nature of the substrate is not conductive to species proliferation. This study has been contacted in the past in the hope that it could provide large quantities of large rock for this purpose. Large quantities are not thought to be present, based on past exploration (see Appendix D1).

In the scenario of removing the dam and accumulated sediment, the lower layer of alluvium that existed prior to dam construction would not be removed, as it provides a necessary natural substrate on the creek bottom, just as it once did prior to the dam construction. No quantity estimates of this layer have been attempted, nor are they relevant to this study, as the material would be left in place if the dam were to be removed.

Sediment deposits are expected to be in an under consolidated condition, soft to loose, and saturated.

5.4.3 Sediment Transport Options

Options considered for removal of sediment behind Rindge Dam included trucking, slurry, and conveyor. There were no detrimental geotechnical constraints identified that would limit the usefulness of either alternative. Other constraints influenced the project team to identify trucking as the desired alternative. However, it is suggested that the use of conveyor systems be considered in further detail during project design as a method a contractor may identify for construction. Issues considered as detrimental to conveyors were the need for a maintenance road and particle size limitations. Both of those issues could probably be addressed by a contractor. This report focuses on the geotechnical considerations associated with haul ramp construction only.

5.4.4 Haul Ramp Construction and Deconstruction

Impounded material was anticipated to be used to construct and enlarge the ramps. The ramps, combined, will require about 100,000 cy of impounded material, material that will be diverted from other applications, such as beach nourishment.

Any new ramps built down into the canyon bottom have the potential to load, and thus to potentially destabilize bedrock slopes. No related slope stability exploration or study has been funded or undertaken but must be done prior to any placement of material.

Existing landslides in the vicinity of the site could become unstable by implementation of the planned alternatives that involve excavating and hauling impounded sediment. The existing access ramp is wholly on landslide debris and loading of the slope with additional ramp fill will likely make the slope unstable. The proposed ramp would be more than doubled the size and mass to make a haul ramp large enough to remove impounded sediment in the prescribed 20 cy trucks. Much in the same way as discussed for general bedrock slope instability, instability (in the form of creep or slide) of landslides also is a concern and could potentially be activated if existing slopes are undercut or are inadvertently loaded with fill.

No related slope stability exploration or study has been funded or undertaken but must be done prior to the design of the access ramps or placement of any material.

5.4.5 In-Situ and Off-site Processing

Initially, the uppermost impounded layer, a coarse sediment comprised of mostly gravel, would be transported to a landfill. There is no modeled processing to segregate sand or large rock; the layer would be excavated and hauled en-masse. End users would have to undertake segregation, which will vary depending on the intended use of the material. The only end-users identified to date want only the largest rock.

Once the coarse upper layer is removed and the underlying sandy layer is exposed, the effort will shift to excavating and hauling the sandy layer to approved locations.

<u>Gravel Removal</u>

Early in the feasibility study, under certain measures, stakeholders assumed USACE was committed to processing sand from the impoundment to remove all gravel. Due to the continued expectation of this being done, it was modeled. There are some geotechnical issues involved.

The 276,000 cy of sandy material (the amount left after using some of the material to construct haul ramps, and after subtracting the material recommended to be left in place in “block 4”, as shown in **Figure 2.3-1and Figure 3.1-1**) that would be hauled to the target recipients has an average gravel concentration of 5 percent, which amounts to 13,800 cy of gravel. That much material would have to be separated at some location, then hauled to a disposal site. The mining operation modeled is focused on rapid sediment removal, to minimize the years needed to complete the excavation. Meeting a rigorous mining speed negates processing the sand at the damsite. This would necessitate hauling the sand to the target beach(es) and screening it at the beaches to remove the gravel or finding another processing site. No other in-canyon processing sites for any purpose have been made available for material processing in past iterations of this study. The target beaches have not been an option for such available work space.

Trying to accomplish gravel removal at the damsite will encounter conflicts with other constraints and lengthen the life of the project in a manner stakeholders have stated is not acceptable. A processing site has to be selected or provided. However, there is no regulatory necessity to remove the gravel. The SC-DMMT stated in February 2015, based on the gradation data from the impounded materials investigation of 2002, that it will consider approving use of the sand-rich layer without any removal of gravel. The Geotechnical Branch offered to make a comparison between the amount of gravel and size of gravel in the impound gradation and what gradations actually have been placed on the specific target beaches in the recent past, but did not receive any information with which to make the comparison. This comparison should be done.

The 2016 preferred Alternatives (swash zone or nearshore placement) bypass this issue because in those scenarios, the ocean would remove the gravel and it would not reach the beaches or sand bars. Wave action and near shore currents within are likely to refine or further segregate the sediments that are subjugated to the swash zone. In general, the silts and clay fraction of the sediments will remain suspended and readily transported by longshore currents to submarine canyons and subsequent deposition in the off shore-deep water environment. In time some of the finer sand will also make its way to deeper water. It is likely that the gravels will remain in the near shore swash zone for the longest period of time.

<u>Fines Removal</u>

High levels of stakeholder interest have been expressed in processing of the entire sandy layer to develop a higher sand content and reducing fines content. Processing to reduce the percentage of fines requires consideration of several factors, discussed below.

The process ultimately generates substantial quantities of fines that will need to be removed from the location, which involves additional haulage. The amount of fines to be removed from 276,000 cy (the amount left after using some of the material to construct haul ramps, and after subtracting the material recommended to be left in place in “block 4”, as shown in **Figure 2.3-1and Figure 3.1-1**) is estimated at 30,360 cy to take out 50 percent of the fines (11 percent of the total). All would be silt and clay, and would have to be trucked to the landfill, and disposed of, with applicable tipping fees. To reduce the fines content from the sand layer triggers the necessity to remove all 5 percent gravel first, in order to re-process the material to remove very fine particle divisions that are the fines.

There are dry processes and wet processes that could be used, each with its own unique complications. For the dry process, the main issue is the remaining in-situ moisture content of the sand after it is removed from the impoundment. It will be dewatered prior to excavation at the damsite so that it can be handled, hauled, and so that the substrate remains stable under the equipment, but that dewatering does not equate to dry. Oven drying 276,000 cy of material, the amount to be taken to the beaches, composite, life of job, is prohibitive, in terms of both logistics and costs. Infrastructure, power, and workspace needs cannot be met. Workspace needed for sun drying is not available at sediment recipient targets, at the damsite, or elsewhere in the canyon. Should a means to sufficiently dry the sand be innovated in the future, processing at the damsite would remain at fundamental cross-purposes with the study constraint of protecting the stakeholder-defined prime fisheries habitat that occurs immediately downstream of the dam from excessive turbidity. In this case, dust (from dry processing) equates to turbidity. The fines consist of all material smaller than sand size, or smaller than the 200-mesh sieve (0.074 mm). To separate materials at such a small screen size, multiple screenings of the material would have to be done, first to remove any gravel, then to separate coarse sand, and medium-grained sand. The actual removal of fines would not begin until the onset of a 4th level of screening, which would separate 0.074+ mm size particles (the sand) from 0.05 mm and 0.06 mm sized particles, which are the clays and smaller silt particles. To attempt such small particle size separations without first removing all larger materials would damage and clog the extremely fine screens needed to separate the fines. Even if successfully dried, the dust that would then result from subsequent processing steps (shaking over screens to segregate the fines from the sand) would be unacceptable for meeting the study constraint on habitat protection at the damsite. If processing is attempted at the beach, tenting of the operation could be done to control dust, but the moisture reduction must be resolved first. Workspaces other than at the beaches or damsite have not been made available to this study. Overall, dry mechanical separation technical issues appear unlikely to be overcome. This leaves water separation as a means to remove the fines.

For the wet process, water separation of fines from sand has been tried on an experimental basis at a local southern California beach with approximately 1,500 cy of material processed. The current study, if undertaken as modeled, would deliver over 1,500 cy of sand for water processing per day to target beaches. The test operation used a water cyclone separator, sea water, and filtering tanks to clean the wash water for reuse or placement back in the ocean. Such a system has an approximately 50 by 10 foot footprint, a 12-foot height, and requires a power supply of approximately 480 volts and 125 amps. The system runs into issues when considering this study's constraints, as outlined below:

- The processing rate would be substantially less than what is modeled for optimum rate of sand delivery to the beach from the impound; needing 1.7 days to process a typical day's composite truck transport of sand to a beach; the total length of time available for sediment removal is a very high ranking study constraint; doubling the footprint and power requirements could overcome this issue;
- The use of water will be very large (2.5 million gallons of ocean water per day); this would have to be doubled to 5 million gallons per day to match the projected rate of sand delivery to a scenario target beach;
- The amount of water needed coupled with the study constraint to complete the impound removal rapidly eliminates settling tanks as a feasible element to the work, and filtering of the water will have to be done instead;
- Filtering is substantially more complex than settling of suspended fines, and will add additional cost to the work;
- Filtering rate maximums have not been determined, will vary with actual fines content, and could become another process bottleneck, requiring additional equipment on site; no test of filtering at a rate of 5 million gallons per day has been done;
- The volume of available water onsite isn't enough to consider using this process at the damsite.

There is no regulatory need to remove the fines. The SC-DMMT stated in February 2015, based on the gradation data from the impounded materials investigation of 2002, that it will consider approving use of the sand-rich layer without any removal of the fines.

The 2016 preferred Alternatives (either swash zone or deeper-water nearshore placement) bypass this issue. In those scenarios, the ocean currents would remove the fines and it would not reach the beaches or sand bars.

5.4.6 Temporary Stockpiles

Site F was identified as the temporary storage site. On a preliminary basis, from a brief site inspection in 2013, the site is expected to be stable under normal temporary stockpiles. The maximum height of excavated sediment that would be placed there is ten feet. Importantly, it also was determined by developing various dam deconstruction scenarios, that Site F would not be overwhelmed by temporarily stockpiled sediment. An assumed maximum capacity was determined for the space, based on the determined maximum stockpile height limit and the area available within the confines of site F, less room for the creek to meander through the middle, and less room for adequate offsets from surrounding roadways. Considering all road use and disposal site use constraints, the amount of material that could be excavated yearly was calculated. That quantity would not exceed the site F temporary storage capacity. Considering all road use and disposal site use constraints, the amount of material that could be excavated from site F and absorbed by the swash zone at Malibu pier was calculated. For some years of the operation, a residual amount would be left behind at site F, but never so much that site F’s storage capacity would be exceeded in the subsequent years of sediment removal. Site F has the necessary capacity to serve this purpose.

Under all scenarios, the final part of the mechanical excavation and removal is the silt-clay layer in the bottom of the impoundment, and its disposal as landfill waste. Currently, no landfill within a reasonable haul distance has interest in beneficial use of this material as landfill daily cover, on the basis that it isn't needed.

5.4.7 Diversion and Dewatering

Diversion of the active stream channel will be required during grading operations. Diversion recommendations would typically be provided by the project civil and hydraulic engineers. Of geotechnical concern would be minimizing the potential to recharge the groundwater within the sediments behind the dam. As such, any diversion structure and conveyance system should be designed to limit infiltration of surface water. It is understood that a temporary cofferdam or diversion structure will likely have to be built to control Malibu Creek inflow upstream of the work area. The model includes cofferdam removal at the end of each sediment removal season to eliminate potential of over-winter sediment accumulation behind the cofferdam. Nevertheless, some sediment could be trapped in the cofferdam basin depression without the cofferdam being present. Minimizing the basin depth or filling it with cofferdam material could control this potential problem. The plan is to temporarily set pipe and pump or gravity flow/siphon the inflow around the work site and over the dam. The cofferdam will be used to collect this water. Pumps and piping will have to be removed each year, else they may be destroyed by turbulent winter creek flows. Consideration should be given to keeping the diversion in-place year round to minimize the groundwater recharge within the sediments.

No pumping tests have been done, so there are uncertainties as to the effectiveness of dewatering. As a result, the rate of dewatering and turbidity of the water from the impoundment remain unknown. Permeability of the impounded sediment, including the deep, silty sediment, likely will be high, based on the soft to loose consistency of the impounded sediment that was observed during 2002 drilling, including in the deepest layers of the sediment. Unwanted particulates may be sufficiently filtered and removed to control the turbidity, by applying sophisticated dewatering well construction techniques.

Water from dewatering the site may have to be pumped into the cofferdam basin for settling, or filtered, depending on its turbidity, relative to the existing turbidity of Malibu Creek. If turbidity is low, the water from dewatering wells may not have to be decanted or filtered.

Construction dewatering will become problematic once excavation has reached the top of the silt and clay layer positioned at the bottom of reservoir. Multiple dewatering methodologies will likely be necessary at this point to provide an effective working surface. The use of a dragline system may be necessary if dewatering becomes ineffective. The remaining nuisance water will need to filtered or passed through a system of settling tanks to reduce turbidity prior to downstream discharge. Consideration should be given to discharge through ports cut in the dam to minimize the need for pumping. Passive dewatering systems would be expected to be the choice. Most likely dewatering would be accomplished by a system of trenches and gravity flow over the dam. In addition, it should be expected that the contractor will evaluate the potential of breaching lower portions of the dam to facilitate drainage.

5.4.8 Re-Deposition of Sediments

The plan for sediment removal includes numerous features to counteract re-deposition of new sediment in the impound area. This plan includes: cutting down the dam at the same rate as sediment is removed so that the top of the remaining sediment is never lower than the top of the reconfigured dam; having a cofferdam in place at all times during sediment excavation at the upstream end of the reservoir to act as both a sediment and a water inflow trap; and removal of the cofferdam as each winter season approaches (and sediment extraction from the impound ceases until winter storm season has passed). Nevertheless, ideal, unlikely-to-occur-with-frequency hydraulic conditions of concurrent high sediment load and low scouring forces could exist in some future creek flows, and if they do occur more sediment could accumulate in the canyon upstream of Rindge Dam, including on top of the existing impoundment surface (refer to the hydraulic engineering appendix of the Integrated Feasibility Report for details on the modeling that determined this). If this occurs, disposal of additional sediments must be considered.

5.5 Dam Stability during Deconstruction

The geotechnical issue of long-term structural stability of Rindge Dam is pertinent to Alternative 1 more than any others, because Alterative 1 is based on no action, and thus, leaving the dam in place. The issue also is relevant to all the variations in Alternative 3 because they are based on reliance on natural transport to remove the impounded material, a method that will require decades to run to completion. If the variations within Alternative 3 are to be successful, for those decades, the remaining dam would have to remain structurally stable.

Failure of the dam would lead to uncontrolled release of at least some part of the impoundment, and consequently, the objectives of Alternatives 1 and 3 would not be met. There is no obvious collapse or deterioration in the exposed downstream face of Rindge Dam or along its abutments, but it should be recognized that no detailed, scientific inspection of the dam has occurred for many decades. The dam was decertified by the State over 45 years ago, thereby ending its regular dam condition inspections. The USACE in 2005 examination of the dam is discussed in the Civil Design report supporting the study. This work was not a complete assessment of the structural integrity of the dam.

The dam is under a larger static load than the load for which it was designed, because the Rindge Dam reservoir is filled with sediment, slightly above the height that once represented the reservoir pool crest. While there is no documentation to verify the original engineering calculations, it seems unlikely that the dam was built for forces this large. Those forces are greater than would be applied by an identical height of water. Rindge Dam is about 90 years old, and therefore was not built to current seismic standards. There is no detailed evaluation or documentation verifying the structural integrity of the dam, but brief examinations from a distance over the years do not suggest problematic deterioration has occurred.

Seismic stability of the dam also must be assessed.

If any of Alternatives 1 or 3 become the favored alternative as a result of this study, assuring the structural integrity of the dam will become a necessary and on-going process. A plan for structural integrity assessment will need to be prepared and funded, and a schedule for subsequent inspections developed and met.

Structural evaluation of Rindge Dam would be addressed during design of a removal plan for Alternatives 2 through 4. Constructability evaluation per ER 1110-2-1156, *Dam Safety – Policy and Procedures* will also be performed during PED.

5.6 Stability of Canyon Slopes

The removal of the lateral force and vertical force loads now being maintained by the mass of the impounded sediment could potentially destabilize canyon walls (bedrock) surrounding the sediment basin as the sediment and dam are removed. Instability in the form of creep or sliding is a concern and could potentially be activated if existing slopes are undercut or are inadvertently loaded with fill.

The removal of the lateral force load from the dam arch could potentially destabilize canyon walls, which have to some extent been supported by the dam for nearly 100 years. No related slope stability exploration or study has been funded or undertaken. This evaluation will have to be done prior to the onset of sediment removal. Additional concern is stability of the canyon walls related to changes in groundwater characteristics. The bedrock under the impound area has been unnaturally saturated continuously (or intermittently) by groundwater at an elevation as much as 100 feet higher than would occur naturally (if the dam were not present). Ground water that remains within the ascending slopes has a destabilizing effect. Elevated pore pressures create a buoyant effect that reduces internal friction and hence the resisting forces within the lower portion of the slope. Elevated groundwater levels also reduce the strength of the clay material typically found along joint fractures and clay seams within the rock. The net effect is landsliding which is most likely to occur when groundwater levels are high and the excavation of impounded sediment has removed lateral support at the base of slope or toe. No related slope stability exploration or study of this potential condition has been funded or undertaken. This evaluation will have to be done prior to the onset of sediment removal.

In conjunction with the stability of the canyon slopes, retaining walls associated with Malibu Canyon Road and utility lines may be impacted by canyon slope instabilities. If slope instabilities impact the retaining walls and/or utilities or cause failure of them, significant cost and schedule impacts would occur so that repairs can be made. The current configurations of the retaining walls and their foundations are currently unknown and would need to be evaluated at future stages. Utility lines and foundations are also unknown and would need to be evaluated at future stages as well. This evaluation would be in conjunction with and along similar lines of investigation as those required for the canyon slopes.

Erosion and scour that may occur in localized parts of the canyon, after the dam and impounded sediment are removed could provide additional sources of slope and infrastructure instability.

Seismic stability of the slopes also must be assessed.

5.7 Levees and Floodwalls

Levees and floodwalls (**see Appendix C**, **Figure 8.1-1**) are a measure within numerous variations of Alternatives 3 and 4. It was determined by hydraulic analysis that natural transport would cause flooding in downstream Malibu Creek, about 3 miles downstream from the damsite in the City of Malibu. Floodwalls extending for approximately 0.57 miles, from the Cross Creek Bridge to PCH, would be necessary to prevent that flooding. The floodwall on the west bank of Malibu Creek would be contiguous, while the floodwall on the east bank would tie into high ground at appropriate locations and would not be contiguous, In addition, if subsequent flood risk and sediment studies for Alternative 2 indicate increased flood risks, then similar measures would need to be implemented. Appendix C of the Integrated Feasibility Report contains details of the conceptual design of the floodwalls. The conceptual design of the pile type and depth for the floodwall was in development at the time of this writing.

There remains some uncertainty on the potential effects of floodwalls on sediment deposition in the lower reaches of Malibu Creek. Construction of floodwalls would require additional modeling to determine the extent of possible changes to sedimentation, and whether dredging would be required for operations and maintenance.

No geotechnical assessment has been performed concerning the foundation conditions of the tentatively chosen floodwall sites, so little can be drawn in terms of conclusions until such a time as that site evaluation is done. What can be said is that use of pile-support systems for the walls is assumed and the deeper the pile, the more likely that bedrock will be intersected by the foot of the pile in this location. The general expectation for foundation geologic conditions, with available information, is:

- Thick alluvial sediments, 75 to 100 feet thick, and bedrock below;
- Intergrading lenses of fines grained (silt-clay) and sandy alluvium;
- Upstreammost floodwall sections may cross strands of the Malibu Coast Fault zone (discussed in section titled “Regional Geology”); search for strands of that fault zone would be part of the geotechnical site investigation.

No testing has occurred to assess the degree of difficulty of the pile penetrating the bedrock, or to determine if bedrock will be encountered in the foundation.

Floodwall foundation investigation should not occur until design phase, and then, only if the alternatives relying on floodwalls are carried forward. If floodwalls are a concept to be used, the foundation must be explored and a geotechnical evaluation completed.

5.8 Removal of Upstream Barriers

Removal or reconfiguration of upstream barriers in the watershed so as to improve fish passage are measures within several variations of Alternatives 2, 3, and 4. Most barriers are small dams or smooth-lined culverts under roadways that obstruct or prevent fish passage. Actual number of barriers to be removed included twelve barriers in 2012, was reduced to nine by early 2013, and to 8 currently. Consult the Integrated Feasibility Report for the most up-to-date array of upstream barriers. In some instances, barriers simply are to be removed, but in other cases, a barrier and some form of infrastructure, such as a road crossing, are interlinked, and the infrastructure will have to be replaced or duplicated in some manner after the barrier is removed.

USACE did not do any assessment of the upstream barriers as part of this feasibility study and therefore, no conclusions can be reached. Delay of this work was done to stay within limited feasibility study costs.

6.0 RECOMMENDED ADDITIONAL STUDIES

6.1 Beach Compatibility Transect Studies

As per standard procedures, prior to any placement, transect sampling is required to verify gradation compatibility with both the nearshore and onshore targets for placement. If shown to be compatible, in this particular instance, regular, confirmatory gradation sampling of the material at the damsite will be required as excavation of the impoundment proceeds, to assure the gradation remains within a tolerable range. In addition, any approved placement scenario will be subject to continued testing for deleterious materials as excavation of the impound proceeds.

Considering the gradation, both nearshore and direct on-beach placement remain options for use of the sandy layer, but with caveats. SC-DMMT will require transect sampling at each target beach and adjoining nearshore area, which will include sampling to 36 feet below MLLW, and subsequently will assess the findings and make a ruling on whether the material can be placed. Such sampling requires a barge or some ocean-going vessel to complete the sampling and would cost the study an amount not currently available to address gradation compatibility with potential recipient areas.

6.2 Chemical Testing

The 2002 testing results suggest that when confirmatory sampling is undertaken, the following three sediment characteristics should receive particular attention:

- Oil and grease and TrPH. Content of petroleum hydrocarbons (TrPH) and Oil & Grease should be monitored during additional testing because the 2002 tests of several samples have measurable quantities of TrPH and of Oil & Grease. There were no regulatory standards for either analyte, in 2002, with regard to beach nourishment. Yet these substances are the only ones of the test suite found in much over trace quantities. The potential sources are plentiful. Tar balls, ¼-inch to 1-½-inches in diameter were found at -22 foot depth a sandy silt of hole TH02-07 (sample no. 6). Construction and maintenance of the highway above the creek is the likely source of tar. Over a period of years, several cars reportedly have landed in the reservoir area, following accidents on Malibu Canyon Highway. One such accident was observed by the geotechnical team just 120 days before the drilling. Collectively, these accidents could have contributed to hydrocarbons in the impoundment. Considering the heavy highway use and the number of runoff drains, Malibu Canyon Highway runoff has to be considered as a potential contributor to hydrocarbons present.

- Organic content. The sand-rich layer in the impoundment has 1- to 6-percent volatile solids, an indicator of the vegetative content. In the silts and clays, percent volatile solids was higher, 6 to 7 ½ percent. The SC-DMMT will want to be advised of these concentrations.
- Gradation, focusing on percentage of fines. The percentage of fines, which is material smaller than sand, is in or nearing the lower end of the acceptable spectrum for nearshore placement and is at the lower end of applicability for on-beach placement. Documentation of the quantity of fines will continue to be important, and if inconsistent, could hamper application of the material under an excavate-and-place scenario.

6.3 Permanent and Temporary Sediment Storage Site Investigations

No locations have received a geotechnical site evaluation to date, and it must be recognized that such sites ultimately will require a geotechnical site assessment prior to any placement of materials. Such geotechnical characterization and assessment would include evaluation of:

- Foundation stability, soil, and rock;
- Groundwater conditions;
- Compressibility of the soils in the foundation, in the context of the amount of material to be stabilized there;
- Drainage and drainage control;
- Erosion risks (e.g., from nearby tributary streams or possibly sheet runoff);
- The quantity of material that can be stabilized on the site;
- Slope stability of the placed material;
- Seismic stability.

The main objectives of this work will be obtaining detailed analysis of foundation conditions to assure that the sediment will remain stable where placed, and assuring that internal stability of the placed materials can be maintained. Sites on flat land may have some sliding and slumping stability concerns, as the surcharge could in turn surcharge descending slopes. This will have to be evaluated with regard to compression under the weight of the material to be stabilized. In-canyon, steep-walled sites and any sites with a sloped base additionally will have increased sliding and slumping stability concerns.

In particular, a geotechnical assessment of the foundation of Site F must be undertaken prior to its use for this purpose, as it is the only such site that appears likely to be carried forward as an alternative. The assessment must consist of the site foundation being drilled, logged, and sampled to verify subsurface and soils properties conditions prior to the onset of construction, something beyond the budgets available for this feasibility study. Site F is the only site currently under consideration as a temporary storage site. No permanent, in-canyon, upland disposal sites are under consideration, currently, other than a commercial landfill, which will not require additional study.

6.4 Detailed Site Investigation and Material Characterization

A detailed Rindge Dam site study will be required to support final development of plans and specifications. Items that will require further investigation include material characterization of the sediment deposits, engineering characteristics, materials handling and processing, and geologic mapping of the canyon walls. Of particular concern is the stability of the slopes adjacent to the dam in the impoundment area. The slopes will need to be evaluated as they are effectively buttressed slopes and may contain landslides. As the sediment is removed, instabilities may develop and will need to be studied. These are extensive and expensive studies; large landslide studies can exceed well over $ ½ million alone. Mobilizing heavy earth moving equipment into the bottom of the canyon for the purpose of large scale sediment characterization is a concern. Assuring stability of the haul ramps under this load, and under the load of their own masses will have to be achieved by additional site investigation.

6.5 Upstream Barrier Investigations

Any upstream barriers, must, prior to onset of construction, receive geotechnical assessment of foundation and materials. Issues to investigate include stability of the creek bed after the barrier is removed and foundation assessment of any new or replacement infrastructure that would be built in conjunction with barrier removal. Geotechnical investigation will be done on a site-by-site basis.

6.6 Post Dam Removal

Rindge Dam has essentially functioned as a debris dam since construction. Sedimentation that would have been discharged further downstream has been captured behind the dam and continues to be captured. Preliminary analysis described in the Hydrology, Hydraulics, and Sedimentation Report suggests that sediments will continue to be captured for an additional approximate 500,000 cy sediment capacity for a total of about 1,300,000 cy. Under ideal conditions that the team hydraulic engineer considered unlikely to occur. Once the dam is removed, that additional sediment, if actually deposited, that would have been captured with the dam in place, will now discharge further downstream. In order to provide for no increase in flood risk, as stated as a project constraint, a detailed evaluation will be warranted during project design.

6.7 Blasting

Several methodologies that the utilize high explosives have been suggested, at least in part, for demolition of existing concrete structures or for separation of these structures from the supporting bedrock. The use of high explosives for these purposes has not been evaluated from a geologic or rock mechanics perspective. The improper use of explosives can have a profound effect on structural discontinuities within the bedrock and adversely impact the stability of the ascending slopes. The use of inappropriate blasting methodologies will lead to unintended consequences that could be catastrophic. As such, it is the opinion of the Geotechnical Branch that detailed site-specific geologic investigations be completed prior recommending any specific blasting methodologies.

7.0 LIMITATIONS AND RISK

7.1 General

As part of the project study, geotechnical issues were identified that are considered a risk to the ultimate completion of the proposed measures and alternatives. Many of these risks have been discussed previously in this report and are discussed below for completeness.

The findings, conclusions, and recommendations for this study are based on the current knowledge. Studies that will be required during the design phase may warrant the evaluation of measures currently rejected or not yet considered.

7.2 Elevation datum used by USACE-Geotechnical

Geometries and special discussions in this report are based on topographic survey done several years after the USACE exploration was completed. Elevations of USACE boring logs and those shown on the impoundment profile map (**Figure 3.1-1**) were updated using the survey done for this study and the subsurface log data. . Pre-dam site datum from the historical files were used to understand the pre-dam configuration of the bottom of Malibu Creek in the vicinity of the abutments and across the dam footprint. The primary benefit of that footprint information was in assuring a reasonable configuring of impounded sediment estimation block 1 (**Figure 2.3-1**). No other pre-dam topography is known. The 1903 US Geological Survey topographic map has a large contour interval and is not informative concerning pre-dam conditions.

7.3 Sediment Processing for Disposal

The current sediment disposal concept is based on an idealized subsurface profile which, in turn, is based on a limited data base. Subsequent studies during design may result in a change in concept that could differ from the existing concept. A more chaotic material deposition pattern than is indicated by the exploration logs as a result of canyon side slope or reservoir slope mass wasting not readily observable may warrant the use of processing plants to meet gradational requirements for disposal in the swash zone (unit 2 material), but this would be dependent on transect sampling and evaluation of those results by the SC-DMMT. Gradation variance in the other layers (units 1 and 3) would not be relevant provided their disposition remains as modeled (disposed of in a landfill), unless oversize rock so large that it could not be handled by a truck and excavator is encountered. Such rock, if found, much more likely would be set aside for a final canyon bottom configuration, or taken to offshore zones for habitat construction by other agencies.

7.4 Flood Risk to Downstream Properties

Current flood risk assessment and sediment behaviors are based on preliminary studies. Considering that the dam has acted as a long term debris dam, removal of the dam does have an associated risk that will warrant detailed studies during design. Considering the stated constraint as no increase in flood risk, there is potential that meeting that constraint will require the use of flood protection structures such as levees and/or flood walls. Any such structures would become infrastructure subject to the USACE Levee Safety Program.

7.5 Limited Geotechnical Studies

The only field studies conducted as part of this project were the limited subsurface exploration of the sediments impounded behind Rindge Dam. Remaining information was developed through the use of published maps. Detailed exploration and engineering during design will be necessary and undiscovered adverse geologic conditions may be encountered. Due to the complexity of issues, cost estimates should have high contingency levels if based on standard multiples of construction costs.

7.6 Current Haul Ramp Concept

The details of the haul ramp construction will not be complete until the design phase. Current haul ramp concepts could change. Issues not addressed include slope stability. Removal of the ramps following construction is addressed conceptually in the Cost Engineering Appendix. The basic parts of the operation are: 1) the ramp remaining after construction will not exceed the number, size, or volume of the lone pre-project access ramp down into the creek bottom; 2) the ramp to be newly constructed for this impoundment removal would be excavated and removed entirely when the project is nearing completion, using the pre-project ramp and the egress route; 3) the pre-project ramp would be cut down to its pre-project size and the excess removed with excavators and hauled out on the remaining part of the ramps by trucks. It will be a time consuming process, as reflected in the Cost Engineering Appendix. The ramp design is not complete and must be made so prior to the onset of a project.

7.7 Stability of Canyon Slopes

The impounded sediments buttress the canyon slopes. Ancient landslides are in close proximity to this area and there are no data to suggest these slides do not comprise the canyon slopes. Therefore, additional studies may indicate that extensive mitigation would be required to maintain current slope stability.

Malibu Creek flows along the exposed downslope extents of landslides a short distance downstream of the dam. It has not been established if this area is the landslide toe, but it could be the toe. Some examples are sites B and C on **Figure 5.3-1**. After the dam is removed, increased flow velocity in creek flows should be expected to result in localized erosion and scour. Should that erosion and scour occur adjacent any of the landslides, some of them could be remobilized, possibly triggering landslides.

7.8 Establishment of Final Grades

There is limited available topographic mapping, and of limited contour interval, of the canyon bottom prior to dam construction. This limited topographic data presents the potential that features with vertical relief of the magnitude as large as the contour interval may exist and be masked by the contour interval. Keeping this limitation in mind, it is important to recognize that waterfalls or other features not in keeping with the idea of removing barriers to fish passage may be encountered. As such, a final contoured grading plan should be developed that meets the project needs. Required grading could necessitate rock removal and associated expenses.

7.9 Costs and Constructability

This project is a complicated work which requires coordination of multiple disciplines and has been in process for 18 years. Many of the considerations, such as methodologies and costs associated with those methodologies, that have been made over that time may be re-evaluated during future phases of the project to reduce costs and minimize impacts.

The most effective way to reduce costs is to find different and more economical disposition of all three of the main divisions of impounded sediment. Landfill tipping fees for the entire unit 1, gravel rich layer, and the entire unit 3 silt and clay layer, are reflected in the study cost estimate and are very high. Finding another user of the material, where the material would be trucked directly to the user, and not to a landfill would reduce the high disposal costs. Since local beaches have rejected the unit 2 sand rich layer for direct beach placement due to more than 10% fines and gravel content, finding other users that would take this material directly from the site to a beneficial end use would eliminate the high cost of trucking the sand to Ventura Harbor, then barging it back to the Malibu coast for nearshore placement.

Bidders on this project might take a different view of many of the PDT assumptions made during evaluation of measures regarding construction. It is a possibility that a contractor's preferred construction methods would include the use of innovative conveyor transport systems, differing dam demolition methods, and other dewatering methods. Innovative contractor proposed options for sediment removal, provided they comply with NEPA requirements, may significantly reduce costs and/or reduce scheduled durations for sediment removal. All of these factors will need to be considered moving forward.

8.0 REFERENCES

Bureau of Reclamation, 1995, Rindge Dam Removal Study, an effort to reduce the decline of Malibu steelhead trout population in southern California, appraisal report: consultation report for California Dept. of Fish and Game by U.S. Dept. Interior, Bureau of Reclamation, Lower Colorado Region, Boulder City, NV, April 1995.

California Division of Mines and Geology, 2001, Seismic Hazards Zone Map, Malibu Beach Quadrangle: California Division of Mines and Geology, 1:24,000-scale map.

City of Malibu, no date, Trancas Canyon Park final EIR: document posted on-line at City of Malibu web site, accessed 12 February 2013 at this url: http://www.malibucity.org/index.cfm/fuseaction/detailgroup/navid/452/cid/13106/.

Dibblee, T.W., Ehrenspeck, H. E., ed., and Bartlett, Wendy, ed., 1993, Geologic map of the Malibu Beach quadrangle, Los Angeles County, California: Dibblee Geological Foundation Map DF-47, published scale 1:24,000.

Jones and Stokes, 2009, Malibu Legacy Park Project Environmental Impact Report: consultation report prepared for City of Malibu by Jones and Stokes, 811 W. 7th St., Ste. 800, Los Angeles, CA 90017, document posted on-line at City of Malibu web site, accessed 12 February 2013 at this URL: http://www.malibucity.org/index.cfm/fuseaction/detailgroup/navid/452/cid/13106/.

Law / Crandall, Inc., 1993, Report of Geotechnical and Environmental Study, Malibu steelhead restoration project, Malibu area, Los Angeles County, California, for the State of California, Division of State Architect, 2661.40181.0001: private consultation report by Law / Crandall, Inc., Engineering & Environmental Services, 200 Citadel Dr., Los Angeles, CA, 23 May 1993.

National Park Service, 2007, Geology of the Santa Monica Mountains: geologic map posted online at the National Park Service website, accessed 6 February 21013 at this URL: http://www.nps.gov/samo/naturescience/geologicformations.htm.

National Park Service, 2013, Santa Monica Mountains - geologic formations: descriptive information posted on line at the National Park Service website, accessed 6 February 2013 at this URL: http://www.nps.gov/samo/naturescience/geologicformations.htm.

Taylor and Taylor, Engineers, 1945, Rindge Dam Improvement, sheet 1 of 2: original drawings for Marblehead Land Company, retrieved from archive of State of California, Dept. of Water Resources, Div. of Dam Safety, microfilm sheet nos. S73 and 773.

USACE, 2008, Geotechnical Appendix-F4 Milestone Report, Malibu Creek Environmental Restoration Feasibility Study, Rindge Dam Impounded Sediment Studies, Malibu Creek, Los Angeles County, CA.

Yerkes, R. F., and Campbell, R. H., 1997, Preliminary geologic map of the Malibu Beach 7.5' quadrangle, southern California -- a digital database: U.S. Geological Survey Open-File Report 97-257.

Yerkes, R. F., and Campbell, R. H., 1980, Geologic map of east-central Santa Monica Mountains, Los Angeles, County, California: Us Geological Survey Miscellaneous Field Investigations Series map, I-1146, 1:24,000 scale (1988 reprint).

References cited solely in the Appendices to this report:

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Caldert, 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Environmental Management, vol. 19:81-97.

PSSDA, 2000, Dredged material evaluation and disposal procedures, a user's manual for the Puget Sound Dredged Disposal Analysis (PSSDA) Program: unpubl. manual, U.S. Army Corps of Engineers, Seattle District, U.S. Environmental Protection Agency, Region 10, Washington Department of Natural Resources, and Washington Department of Ecology, February 2000.

Other Reference Consulted

Loel, Wayne, 1924, Malibu Dam Site, Malibu Ranch, Los Angeles County, California: original plane table map for J. L. Ewing, California Bank Building, 629 Spring St., Los Angles, retrieved from archive of State of California, Dept. of Water Resources, Div. of Dam Safety, microfilm sheet no. 773.

This page was intentionally left blank for duplex printing.

Appendix D1
Boring and Test Pit Logs

Contents:

1. Borings TH02-01, -02, -03, -04, -05, -06, -07, and -08 from USACE-Geotechnical work, October 2002.
2. Borings 1, 2, and 3 from Law / Crandall exploration in 1993 (1).

This page was intentionally left blank for duplex printing.

FIELD LOG SHEET

PROJECT Rindge dam	HOLE No. TH02-01		DATE DRILLED 10-3-02 & 10-4-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 2500 H component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME On 10-3-02, From 1600 hrs To 17300 hrs; On 10-4-02. From 0745 hrs to 1630 hrs
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 291.915 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 101.5	DEPTH TO GROUNDWATER 9.6 ft	INSPECTOR US Army Corps- Geotech- Chatman

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 3	**Unit 1**. POORLY GRADED GRAVEL WITH SAND. Dry, loose, light brown. A cobble layer, 10% to 60% by volume, on the surface was not included in sample). . Sample is from surface.	No cementation G, M	n/a	no test	
2	~ 3 - ~ 8	**Unit 1.** Sand with gravel. Tan, free draining. Small amount of gravel by volume; gravel as much as ¼ inch diameter Sample cut from interval 4.9 ft to 6.4 ft	Bouncing drill action so lost most of sample; switched to more flexible sand catcher M (sample too small for G)	N = 7 5" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 4 3
3	~ 8 - ~ 13	**Unit 2.** POORLY GRADED SAND. Tan, wet. Sand fraction is mostly medium grained . Particles subangular.	Removed every other tooth from sand catcher	N = 9 9" recovery	top 6"	3

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sam ple No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
		Sample cut from interval 9.9 ft to 11.4 ft	M, G	18" driven 2" split spoon used	mid 6" last 6"	5 4
4	~ 13 - 19	**Unit 2.** WELL GRADED SAND WITH SILT. Tan, wet. The angular gravel on top of sampler assumed to be slough and was not included with sample (1/2- to 1-inch gravel). Sample cut from interval 14.9 ft to 16.4 ft	M, G	N = 5 8" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 3 2
5	19 - ~ 22	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT. Tan to gray, moist. Sample cut from interval 19.9 ft to 21.4 ft	Some sand heaving at 19.9 ft M, G HTW, composited with boring TH02-04 sample 2a for the test	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	12 11 16
6	~ 22 - 29	**Unit 2.** SILTY SAND. Gray-black, free-draining. Leaves (brown, formerly dried(?)) are half the sample, by volume in the field, but the leaves are dried out and discarded in the soil classification process. Sample cut from interval 24.9 ft to 26.4 ft	M, G	8" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	12 11 16
7	29 - 34	**Unit 2.** AS ABOVE, SILTY SAND. Gray-black, wet. No leaves. Sample cut from interval 29.9 ft to 31.4 ft	Large gravel with a drill-cut edge blocked the sample barrel, reducing recovery. M, G, A	12" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 4 7

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sam ple No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
8	34 - 39	**Unit 2.** AS ABOVE, SILTY SAND. Gray-black, wet. Organic-rich lenses, composed of twigs and woody roots. Sand fraction is mostly fine-grained but ranges from fine to medium grained. Sample cut from interval 34.9 ft to 36.4 ft	M, G, A	10" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	4 6 8
9	39 - ~ 44	**Unit 2.** As above, silty sand. Sample cut from interval 39.9 ft to 41.4 ft	M, HTW, composited with sample 12, this boring, for the test	13.5" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 5 7
10	~ 44 - 49	**Unit 3.** SILT WITH SAND. Black-gray, with organics (leaves). Some coarse sand and fine gravel assumed to be slough from above and was discarded in the field. Sample cut from interval 44.9 ft to 46.4 ft	Fast drilling M, G, A (G, A samples combined with sample 11 below due to small sample size)	5" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 5 4
11	49 - ~ 53	**Unit 3.** AS ABOVE, SILT WITH SAND. Black-gray, with organics (leaves). Some coarse sand and fine gravel assumed to be slough from above and was discarded in the field. Sample cut from interval 49.9 ft to 51.4 ft	G, A (G, A samples combined with sample 10 above due to small sample size)	5" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 4 5
12	~ 53 - ~ 59	**Unit 3.** Sand with silt. Black-gray, wet to moist, enriched with organics (wood, roots); sulfurous odor. Some coarse sand and fine gravel assumed to be slough from above and was discarded in the field. Sample cut from interval 54.9 ft to 56.4 ft	0.8 ft of slough from above had to be washed out of the hole before driving sample. Drill action suggests wood branch or log at -52.5 ft	12" recovery 18" driven 3" split spoon	top 6" mid 6"	3 4

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
			HTW, composited with sample 9, this boring, for the test	used	last 6"	4
13	~ 59 - 61	**Unit 3.** SILT. Black-gray, moist to wet. Sand fraction is fine-grained. Grading to finer material downward in sampled horizon. Bottom 4 inches is clay and was discarded; this bottom 4 inches verifies soil type change between sample 13 and sample 14. Sample cut from interval 59.9 ft to 61.4 ft	M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	1 3 4
14	61 - ~ 68	**Unit 3.** ORGANIC CLAY. Gray to black, moist. Include green organics partings and fine-grained sand partings. Grading to finer material downward in sampled horizon. Bottom 4 inches is clay and was discarded; this bottom 4 inches verifies soil type change between sample 13 and sample 14. Sample cut from interval 64.9 ft to 66.4 ft	Easy drilling M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 3 4
15	~ 68 - 72	**Unit 3.** SILTY SAND. Black-gray, wet. Gravel, medium-grained, round, oxidized in sampler shoe was discarded in the field, assumed to be slough from above. Sample cut from interval 69.9 ft to 71.4 ft	Fast drilling M, G	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 6 8
16	72 - 76.4	**Unit 3.** ELASTIC SILT. Black-gray, with some brown-black lenses, moist. Some partings of fine-grained sand. Sample cut from interval 74.9 ft to 76.4 ft	Moderately fast drilling M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 3 5
n/a	76.4 - ~ 81.5	**Unit 3.** No recovery from coring. Considering drill action and soil types above and below, this interval also may be a lean clay.	Extremely fast drilling			

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
17	~ 81.5 - ~ 84	**Unit 3.** ORGANIC SILT. Gray-black, moist. Organic-rich. Sample cut from interval 81.5 ft to 83.5 ft	M, G, A	24" recovery 24" driven 2" split spoon used	top 6"	1
					up. mid 6"	2
					lower-mid 6"	2
					last 6"	3
18	~ 84 - 91.5	**Unit 3.** LEAN CLAY WITH SAND. Black, moist. Sample cut from interval 87.7 ft to 89.5 ft. 1.2 ft rod drop at the sampling point (material was washed out below the bottom of the core barrel) reduced recovery of this driven sample.	No core recovery, 87.7 - 91.5 ft M, G, A HTW, composited with boring TH02-04 sample 14 for the test	8" recovery 24" driven 2" split spoon used	top 6"	3
					up. mid 6"	4
					lower-mid 6"	4
					last 6"	5
19	91.5 - 93.5	**Unit 3.** ORGANIC SILT WITH SAND. Black with green blebs, organic-rich, sulfurous odor. Sample cut from interval 91.5 ft to 93.5 ft. Bottom of reservoir is -93.5 ft.	M, G, A	24" recovery 24" driven 2" split spoon used	top 6"	1
					up. mid 6"	2
					lower-mid 6"	6
					last 6"	16
n/a	93.5 - 99	**Unit 4.** Pre-reservoir alluvium. Gravel, boulders	no lab tests core run from 91.5 ft to 96.5 ft recovered 8 inches	no SPT	n/a	n/a

Project: Rindge dam Drill hole number: TH02-01		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sam ple No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
n/a	99 - 101.5	**Unit 5.** Sandstone bedrock. Sespe formation. Contact elevation determined by mud logging.	no lab tests 96.5 ft recovered 8 inches; core run from 96.5 ft to 101.5 ft recovered	no SPT	n/a	n/a

ADDITIONAL REMARKS:

Water was added at 0-feet.
After 17 hours of stabilization, groundwater level in the boring was at -9.6 ft.
A three-vane rotary wash bit was used during the intervals of casing-advancer-rotary wash drilling system use. Switched from casing advancer-rotary wash system of drilling to coring at -76.4 ft because there was no more supply of casing-advancer-size casing.
SPT tests done while samplers were being driven (140 lb hammer, cathead).
Brass sleeves were used on the 3" split-spoon sampler; no sleeves were used on the 2" split-spoon sampler.

Logs of other borings continue on next page ....

FIELD LOG SHEET

PROJECT Rindge dam	HOLE No. TH02-02		DATE DRILLED 10-6-02 & 10-7-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 2500 H component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME On 10-6-02, From 1620 hrs To 17300 hrs; On 10-7-02. From 0725 hrs to 1410 hrs
LOCATION	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 288.678 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 86.5	DEPTH TO GROUNDWATER ~ -3 ft	INSPECTOR US Army Corps- Geotech- Chatman
Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests Notes: sand catchers used throughout			

Project: Rindge dam Drill hole number: TH02-02		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 4.9	**Unit 1.** POORLY GRADED GRAVEL WITH SAND. Dry, loose, tan, oxidized, subrounded to subangular. A cobble and boulder layer, 30% by volume, on the surface was not included in sample. Sample is from uppermost 6 inches.	G, M	n/a	no test	
n/a	4.9 - 6.4	**Unit 1.** Sand with gravel. Based on mud logging only, which suggests medium- to coarse-grained, oxidized sand	No usable sample was recovered. Sand matrix was washed out of sampler. Sampler blocked by sandstone piece	2" recovery 18" driven 3" split spoon used	top 6"	10
					mid 6"	11
					last 6"	11
2	6.4 - ~	**Unit 1.** POORLY GRADED SAND WITH SILT AND GRAVEL. Oxidized, free-draining. Sand fraction is medium- to coarse-grained. Gravel fraction is subrounded, as large as 2-in.	G (remember some fines may have been washed	7" recovery 18" driven	top 6"	3

Project: Rindge dam Drill hole number: TH02-02		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	14.25	diameter. Sample cut from interval 9.9 ft to 11.4 ft	away as sampler full of water) No M sample due to sample condition	3" split spoon used	mid 6" last 6"	5 5
3	~ 14.25 - 16.4	**Unit 2.** WELL GRADED SAND WITH SILT. Green-black, saturated. Sand fraction is medium- to coarse-grained. Sample cut from interval 14.9 ft to 16.4 ft	G (remember some fines may have been washed away; will cut back on water for next sample interval) No M sample due to sample condition	6" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	5 5 6
4	16.4 - ~ 23	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT. Gray-black, loose, free draining. Sample cut from interval 19.9 ft to 21.4 ft	M, G	10" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 5 8
5	~ 23 - 30.8	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT. Black-gray, loose, wet- to free-draining. Sample cut from interval 24.9 ft to 26.4 ft	Fast drilling. M, G	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	10 12 11
6	30.8 - 34.9	**Unit 2.** SILTY SAND. Green-gray, free-draining. Sand fraction is medium- to coarse-grained. Sample cut from interval 29.9 ft to 31.4 ft	M, G	14" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 5 16

Project: Rindge dam Drill hole number: TH02-02		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
7	34.9 - 36	**Unit 2.** AS ABOVE, SILTY SAND. Bottom 5 in. driven into underlying soil horizon (see sample 8,below). This lower layer segregated as sample #8, see below. Sample cut from interval 34.9 ft to 36.4 ft	Very fast drilling M, G	16" recovery 18" driven 3" split spoon used	top 6"	4
					mid 6"	6
					last 6"	6
8	36 - ~ 38	**Unit 2.** SILT WITH SAND. Sample cut from interval 36 ft to 36.4 ft	M, G, A Small sample	refer to above interval		
9	~ 38 - 44.9	**Unit 2.** SILTY SAND. Gray-green, wet. Sand fraction is medium- fine-grained. Sample cut from interval 39.9 ft to 41.4 ft	M, G	18" recovery 18" driven 3" split spoon used	top 6"	2
					mid 6"	2
					last 6"	6
n/a	44.9 - 45.5	**Unit 2.** As above, silty sand. Lower part of this interval cut was segregated as two different layers (see next two intervals below). Sample cut from interval 44.9 ft to 46.4 ft	No sample taken; same material as above interval	18" recovery 18" driven 3" split spoon used	top 6"	2
					mid 6"	3
					last 6"	8
10	45.5 - 46.0	**Unit 2.** SANDY SILT. Black, wet, enriched with organics (rotting leaves); approaching a peat composition. Sample cut as part of interval above.	M, G, A Small sample	refer to above interval		

Project: Rindge dam Drill hole number: TH02-02 Sample No.	Top & bottom of soil or rock unit (ft)	Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts: Depth	Blow counts: Blows
n/a	46 - 46.4	**Unit 2.** Sand. Gray-green, wet- to free-draining. Sand fraction is medium-grained. Sampler driven through this interval as part of above two horizons.	No sample taken; too thin of an interval. See interval below (no. 11) for representative gradation test of this same material at a lower elevation.	refer to above interval		
11	46.4 - 51	**Unit 2.** WELL GRADED SAND WITH SILT. Gray-green, wet- to free-draining. Sand fraction is mostly medium-grained, with some coarse-grained material. Lower part of this interval cut was segregated as soil intervals #12, see below). Sample cut from interval 49.9 ft to 51.4 ft	M, G	8" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 4 6
12	51 - ~ 52	**Unit 2.** SILTY SAND. Gray-green, free-draining. Sand fraction is fine- to medium-grained. Sampler driven through this interval as part of above horizon.	M, G	refer to above interval		
13	~ 52 - 55	**Unit 3.** Organic silt. Black-to-green, silty, some sandy intervals, organic-rich. Sand fraction is fine-grained. Sampler driven through a sandier interval (segregated as interval #14, see below). Sample cut from interval 54.9 ft to 56.4 ft	HTW sample, combined with samples 15, 18, 21 from this boring for the tests.	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 4 5
14	55 - 56.4	**Unit 3.** ELASTIC SILT. Gray-green, sandy. Sand fraction is fine-grained. More sandy than interval #13 .	M, G, A	refer to above		

Project: Rindge dam Drill hole number: TH02-02		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
		Sample cut from interval 54.9 ft to 56.4 ft		interval		
15	56.4 - ~ 58.4	**Unit 3.** Lean clay. Sample cut from interval 56.4 ft to 58.4 ft	HTW sample, combined with samples 13, 18, 21 from this boring for the tests.	24" recovery 24" driven 2" split spoon used	top 6"	1
					up. mid 6"	2
					lower-mid 6"	3
					last 6"	3
16	~ 58.4 - ~ 64	**Unit 3.** SILTY SAND. Green-gray, free draining. Sand fraction is medium- to fine-grained. Sample cut from interval 59.9 ft to 61.4 ft.	M, G	14" recovery 18" driven 3" split spoon used	top 6"	5
					mid 6"	7
					last 6"	11
17	~ 64 - ~ 67	**Unit 3.** AS ABOVE, SILTY SAND. Gray-green, wet, organic partings (2 - 3 mm thick, each) of roots and leaves. Organic content is notable from above horizon (#16), which lacks the organics. Sample cut from interval 64.9 ft to 66.4 ft.	M, G	18" recovery 18" driven 3" split spoon used	top 6"	5
					mid 6"	6
					last 6"	6
18	~ 67 - 71.4	**Unit 3.** Silt, sandy and clayey. With clayey zones and sandy lenses of 1- to 2" thicknesses. Sample cut from interval 69.9 ft to 71.4 ft.	M. G, A HTW sample, combined with samples 13, 15, 21 from this boring for the	18" recovery 18" driven 3" split spoon	top 6"	5
					mid 6"	6

Project: Rindge dam Drill hole number: TH02-02		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
			tests.	used	last 6"	6
19	71.4 - 74	**Unit 3.** SILTY SAND. Gray-green, loose, wet - to free-draining. Sand fraction is medium-grained. Sample cut from interval 71.4 ft to 73.9 ft.	M, G	16" recovery 18" driven 3" split spoon used	top 6"	3
					mid 6"	4
					last 6"	4
20	74 - ~79	**Unit 3.** SILT WITH SAND. Gray, wet to moist. Sand fraction is fine-grained and has some organic content. Sample cut from interval 74.9 ft to 76.4 ft.	M, G, A	18" recovery 18" driven 3" split spoon used	top 6"	3
					mid 6"	4
					last 6"	6
21	~79 - 80.5	**Unit 3.** Clay. Gray-black, wet, silty. Sand fraction is fine-grained and has some organic content. A 1-in.-thick mat of peat at 80.5 ft was discarded in the field. Sample cut from interval 79.9 ft to 81.4 ft.	HTW sample, combined with samples 13, 15, 18 from this boring for the tests.	12" recovery 12" driven 3" split spoon used	top 6"	3
					mid 6"	42
					last 6"	50 / 6 inches
22	80.5 - 81.4	**Unit 3.** WELL GRADED GRAVEL WITH SILT AND SAND. Green-gray, free-draining. Sand fraction is medium-grained; gravel fraction coarsens downward, with rounded particles to 2.5 in. diameter. Sample cut from interval 79.9 ft to 81.4 ft.	M, G	see above test		
n/a	81.4 - 81.5	**Unit 4.** no recovery				

<table>
<tr><td colspan="2">Project: Rindge dam
Drill hole number: TH02-02</td><td rowspan="2">Description and Condition of Material
ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only</td><td rowspan="2">Excavation Remarks
Lab tests for this sample</td><td rowspan="2">Sample recovery, SPT results</td><td colspan="2">Blow counts</td></tr>
<tr><td>Sample No.</td><td>Top & bottom of soil or rock unit (ft)</td><td>Depth</td><td>Blows</td></tr>
<tr><td>23</td><td>81.5 - 83.5</td><td>Unit 4. POORLY GRADED GRAVEL WITH SILT. Pre-reservoir alluvium. Gravel, sandstone boulder.

Bottom of reservoir is 81.4 ft</td><td>G (of gravel only; note fines have been washed away)

core run from 81.5 ft to 86.5 ft recovered 4'10" and the lowest 36 inches of that was sandstone bedrock (see below)</td><td>no test</td><td></td><td></td></tr>
<tr><td>n/a</td><td>83.5 - 86.5</td><td>Unit 5. Sandstone bedrock. Sespe formation. Conglomerate, pink.</td><td>no lab tests

logged from core (see above interval)</td><td>no test</td><td>n/a</td><td>n/a</td></tr>
<tr><td colspan="7">ADDITIONAL REMARKS:

Water and Dry Polymer "mud" was added at 0-feet.
A three-vane rotary wash bit was used during the intervals of casing-advancer-rotary wash drilling system use. Switched from casing advancer-rotary wash system of drilling to coring at -81.5 ft because there was no more supply of casing-advancer-size casing.
SPT tests done while samplers were being driven (140 lb hammer, cathead).
Brass sleeves were used on the 3" split-spoon sampler; no sleeves were used on the 2" split-spoon sampler.</td></tr>
</table>

Logs of other borings continue on next page ...

FIELD LOG SHEET

PROJECT Rindge dam	HOLE No. TH02-03		DATE DRILLED 10-5-02 & 10-6-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 5500 component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME On 10-5-02, From 1610 hrs To 1740 hrs; On 10-6-02. From 0745 hrs to 1330 hrs
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 292.799 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 80.1	DEPTH TO GROUNDWATER approx -3 ft based on creek level	INSPECTOR US Army Corps- Geotech- B. Rathbun

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-03		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 6.6	**Unit 1.** WELL GRADED SAND WITH SILT AND GRAVEL. Brown and red, loose, wet. Cobbles and a 3-ft-diameter boulder on the surface layer, 30% by volume, on the surface was not included in sample. Sample cut from interval 5.1 to 6.6 ft. Supplemented with grab from surface.	Slow drilling, 22 min. for 5 ft M, G	N = 4 4" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 2 2
2	6.6 - 11.6	**Unit 1.** AS ABOVE, WELL GRADED SAND WITH SILT AND GRAVEL. Brown and red, loose, wet. Cobbles and a 3-ft-diameter boulder on the surface layer, 30% by volume, on the surface was not included in sample. Sample cut from interval 10.1 to 11.6 ft.	Slow drilling due to continued presence of cobbles; lost circulation at -7.7 ft; returned at -15 ft; gravel stuck in shoe, reducing recovery G	N = 7 2" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	5 4 3
3	11.6 -	**Unit 1.** As above, Sand with gravel. Brown, wet, loose. Gravel as large as ¾ inch diameter. Sand fraction is medium-grained.	HTW sample, combined with TH02-05 samples 4	N = 6 14.5"	top 6"	7

Project: Rindge dam Drill hole number: TH02-03		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	16.6	Sample cut from interval 15.1 ft to 16.6 ft	and 6 for the tests	recovery 18" driven 2" split spoon used	mid 6" last 6"	3 3
4	16.6 - 23.1	**Unit 2.** WELL GRADED SAND WITH SILT. Brown, wet, loose. Sand fraction is medium-grained. Gravel as large as ¾ inch diameter. Sample cut from interval 20.1 ft to 21.6 ft	M, G	N = 8 16" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 3 5
5	23.1 - 26.6	**Unit 2.** SILTY SAND. Dark gray and black, wet, loose, soft. Interlayered sand and sandy silt and possibly organics. Upper contact determined through mud logging Sample cut from interval 25.1 ft to 26.6 ft	G	N = 7 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 3 4
6	26.6 - 31.6	**Unit 2.** As above, silty sand. Dark gray, wet, loose. Sand fraction is fine- to medium-grained. Gravel occasionally seen (as large as ¼ in. diameter). Sample cut from interval 30.1 ft to 31.6 ft	M HTW, combined with samples 9, 10 this boring and TH02-05, samples 8, 9 for the tests	N = 6 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 2 4
7	31.6 - 36.6	**Unit 2.** WELL GRADED SAND WITH SILT AND GRAVEL. Sample cut from interval 35.1 ft to 36.6 ft	M, G	N = 18 17" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	5 7 11

Project: Rindge dam Drill hole number: TH02-03		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
8	36.6 - 41.6	**Unit 2.** WELL GRADED SAND WITH SILT. Gray, wet, loose. Occasional gravel as large as ½ inch diameter (apparently none of this gravel was actually in the material cut for the lab tests sample). Sample cut from interval 40.1 ft to 41.6 ft	M, G	N = 9 6" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	6 3 6
9	41.6 - 46.6	**Unit 2.** SILTY SAND. Dark gray, wet, loose. Gravel fraction is fine grained. Sample cut from interval 45.1 ft to 46.6 ft	G HTW, combined with samples 9, 10 this boring and TH02-05, samples 8, 9 for the tests	N = 8 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 3 5
10	46.6 - 51.6	**Unit 2.** As above, silty sand. Sample cut from interval 50.1 ft to 51.6 ft	HTW, combined with samples 9, 10 this boring and TH02-05, samples 8, 9 for the tests	N = 11 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 5 6
11	51.6 - 56.6	**Unit 2.** POORLY GRADED SAND WITH SILT. Dark gray, wet, loose. Sand fraction is fine grained. Sample cut from interval 55.1 ft to 56.6 ft	M, G	N = 8 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 4 4
12	56.6 - 61.6	**Unit 2.** AS ABOVE, POORLY GRADED SAND WITH SILT. Sample cut from interval 60.1 ft to 61.6 ft	M, G	N = 12 18" recovery 18" driven	top 6" mid 6"	3 5

Project: Rindge dam Drill hole number: TH02-03		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
				2" split spoon used	last 6"	7
13	61.6 - 66.6	**Unit 2.** Silty sand. Sand is gray. Silty sand is black, cohesive, medium dense. Organics on top of sampler tube. Sand fraction is fine-grained. Sample cut from interval 65.1 ft to 66.6 ft	HTW, combined with sample 14 this boring and TH02-05, sample 15 for the tests	N = 12 14" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 5 7
14	66.6 - ~ 73.3	**Unit 3.** SILT WITH SAND. Sample cut from interval 70.1 ft to 71.6 ft	G HTW, combined with sample 13 this boring and TH02-05, sample 15 for the tests	N = 8 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 4 4
n/a	73.3 - 80.1	**Unit 4.** Gravel and boulders. Large rocks are sandstone. Sampler driving attempted at -75.1 ft (refusal). **Pre-reservoir alluvium surface at -73.3 ft.**	SPT sampler bounced on rock; cored 75.1-80.1 no lab test sample	N = refusal 0" recovery 0" driven 2" split spoon used	top 6" mid 6" last 6"	

ADDITIONAL REMARKS:

Water and *EZ Mud* added at 0-feet.
A tri-cone bit was used during the intervals of casing-advancer-rotary wash drilling system use. Switched from casing advancer-rotary wash system of drilling to coring at -75.1 ft because of drilling resistance.
SPT tests done while samplers were being driven (140 lb hammer, cathead).
Brass sleeves were used on the 3" split-spoon sampler; no sleeves were used on the 2" split-spoon sampler.

Logs of other borings continue on next page ...

FIELD LOG SHEET

PROJECT	HOLE No.		DATE DRILLED
Rindge dam	TH02-04		10-5-02 & 10-6-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 2500 H component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME On 10-5-02, From 1225 hrs To 17300 hrs; On 10-6-02, From 0745 hrs to 1138 hrs
LOCATION 285.928 ft, from topographic survey completed several years after the exploration	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION boring at creek level, or 326.8 ft, using spillway crest as 326.8 ft	TOTAL DEPTH (Feet) 91.7	DEPTH TO GROUNDWATER 0 ft	INSPECTOR US Army Corps- Geotech- Chatman

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-04		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 5.0	**Unit 1.** WELL GRADED GRAVEL WITH SAND. Very loose to loose, light gray, moist. Gravel is rounded. Sand fraction is mostly coarse- to medium-grained but ranges from coarse to fine-grained. Sample is from uppermost 12 inches.	Fast drilling G, M	n/a	no test	
2	5.0 - 8	**Unit 1.** AS ABOVE, WELL GRADED GRAVEL WITH SAND. Free draining. Sample cut from interval 5.0 ft to 6.5 ft	Fast drilling G Too saturated for M to be of value	12" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	6 4 4
2a	8 -	**Unit 1.** Sand with gravel. Tan-gray, loose, free-draining. Sand fraction mostly medium- to fine-grained, but ranges from coarse- to fine-grained.	Fast drilling	10" recovery	top 6"	4

Project: Rindge dam Drill hole number: TH02-04		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	~ 16.25	Sample cut from interval 10 ft to 11.5 ft	HTW, combined with sample 5 from TH02-01 for the tests	18" driven 3" split spoon used	mid 6" last 6"	5 5
3	~ 16.25 - ~ 18	**Unit 2.** SILTY SAND. Black-gray, free draining. Sand fraction is medium- to fine-grained. All but bottom 4" of sampler is gravel slough from above (all slough discarded in the field). Sample cut from interval 15 ft to 16.5 ft	M, G Small sample	15" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	5 4 3
4	~ 18 - ~ 23	**Unit 2.** ELASTIC SILT TO ORGANIC SILT. Interlayered fine-grained sand and infrequent organic material (leaves). Sample cut from interval 20 ft to 21.5 ft	M, G, A	17" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	1 1 2
5	~ 23 - 30.2	**Unit 2.** SILTY SAND. Black-gray, wet. Sand fraction is fine- to medium-grained. Sample cut from interval 25 ft to 26.5 ft	M, G	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 4 6
6	30.2 - 31.2	**Unit 2.** FAT CLAY. Black-gray, wet to moist, soft to medium-firm. This lean clay overlain above and below by sand (not part of this sample #6). Sand within this sample is contamination from above! The gradation test shows that 1% of this contaminant sand remained in the sample #6. Sample cut from interval 30 ft to 31.5 ft	M, G	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	4 5 6
7	31.2 -	**Unit 2.** SILTY SAND. Black-gray, wet-to-moist, , organic material. Organics are 1/8 to 1/6-in.-thick layers and less than 5% by volume of the total sample.	M, G	18" recovery	top 6"	4

Project: Rindge dam Drill hole number: TH02-04		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	39.7	Sample cut from interval 35 ft to 36.5 ft		18" driven 3" split spoon used	mid 6"	5
					last 6"	6
8	39.7 - ~ 42	**Unit 2.** ORGANIC SILT. Black, moist, organic material (mats of decomposed leaves, twigs. All or nearly coarse sand within this sample is contamination from above! The gradation test shows that 2% of this contaminant coarse sand remained in the sample #8. Sample cut from interval 40 ft to 41.5 ft	M, G, A	18" recovery 18" driven 3" split spoon used	top 6"	2
					mid 6"	3
					last 6"	4
9	~ 42 - 51.1	**Unit 2.** SILTY SAND. Black-gray, loose, wet. Sand fraction is medium- fine-grained. Sample cut from interval 45 ft to 46.5 ft	M, G	16" recovery 18" driven 3" split spoon used	top 6"	4
					mid 6"	7
					last 6"	9
10	51.1 - ~ 53	**Unit 2.** Silt, sandy, with some clay. Gray-to-black, soft, moist-to-wet. Sand fraction is fine- to very-fine-grained. Sample cut from interval 50 ft to 51.5 ft	M No G sample taken because only a thin interval of this soil type seen	15" recovery 18" driven 3" split spoon used	top 6"	2
					mid 6"	3
					last 6"	3
11	~ 53 - 56.5	**Unit 3.** SILT. Gray, soft- to medium-firm, wet to moist. Sample cut from interval 55 ft to 56.5 ft	M, G, A	18" recovery 18" driven 3" split spoon used	top 6"	2
					mid 6"	3
					last 6"	4

Project: Rindge dam Drill hole number: TH02-04		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
12	56.5 - ~ 63	**Unit 3.** FAT CLAY. With silt. Silt is black, clay is gray, both are moist-to-wet. Clay is soft to medium-firm. A seam of sand (4" thick) is medium- to fine-grained. It was not included in the sample. Sample cut from interval 60 ft to 61.5 ft.	M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 6 5
13	~ 63 - ~ 69	**Unit 3.** SANDY SILT. Black-gray-green, moist-to-wet. Sand fraction is loose, intermixed with silt. Silt is soft. Fine root fibers. Sample cut from interval 65 ft to 66.5 ft	M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 6 8
14	~ 69 - ~ 73	**Unit 3.** ORGANIC SILT. Black-gray, moist-to-wet, soft-to-medium-firm, organic material (rotting leaves). Sand fraction is fine- to medium-grained Sample cut from interval 70 ft to 71.5 ft	Very fast drilling M, G, A HTW sample, combined with TH02-01, sample 18 for tests	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 6 6
15	~ 73 - ~ 75	**Unit 3.** ELASTIC SILT TO ORGANIC SILT. Gray-to-black, moist-to-wet, soft. Sand fraction is fine-grained. Sampler driven through a ore sandy interval **(segregated as interval #14, see below)**. Sample cut from interval 75 ft to 76.5 ft	Very fast drilling M, G, A	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 4 5
16	~ 75 - ~ 84	**Unit 3.** SANDY SILT. Gray-to-black, moist-to-wet, soft. Organic particles to ¼ inch across (bark?) Sample cut from interval 80 ft to 81.5 ft	M, G, A Core run from 81.5 ft to 86.5 ft (no recovery)	18" recovery 18" driven 3" split spoon	top 6" mid 6"	3 4

Project: Rindge dam Drill hole number: TH02-04 Sample No.	Top & bottom of soil or rock unit (ft)	Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts Depth	Blows
				used	last 6"	5
17	~ 84 - 88.9	**Unit 3.** ORGANIC SILT. Grey-black, wet, w/ occasional 1/8-in.-thick seam of peat or decomposed vegetation Sample cut from interval 86.5 ft to 88.5 ft	M, G, A Core run from 81.5 ft to 86.5 ft (no recovery)	inches of recovery not recorded 24" driven 2" split spoon used	top 6" up. mid 6" lower-mid 6" last 6"	1 2 2 5
18	88.9 - 91.5	**Unit 4.** POORLY GRADED GRAVEL. Free draining, round to angular. As large as ¾-in. diameter. Some of the gravel was cut by the core bit, so could be larger. Sample cut from interval 86.5 ft to 91.5 ft (cored), plus bottom 3 inches of above interval SPT test included in this sample. **Pre-dam alluvial surface at -88.9 ft,** based on mud logging (color change from gray to tan) and presence of a cored cobble at approx. that same elevation.	G (remember that fines have been washed out during coring) Small sample Core run from 86.5 ft to 91.5 ft (1 ft recovery)	see interval above	top 6" mid 6" last 6"	
n/a	91.5 - 91.7	**Unit 4.** As above, pre-dam alluvium. Siltstone cobble. Discarded in the field. Sample cut from interval 91.5 ft to 91.7 ft.	no sample no recovery in last SPT split spoon sampler except for chips of siltstone	0.5" recovery 0.2 ft" driven 2" split spoon used (24" long)	top 6" mid 6" last 6" mid 6" last 6"	50 blows / 3 inches 6 n/a n/a n/a

Project: Rindge dam Drill hole number: TH02-04		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
ADDITIONAL REMARKS: Water and Dry Polymer "mud" was added at 0-feet. A three-vane rotary wash bit was used during the intervals of casing-advancer-rotary wash drilling system use. Switched from casing advancer-rotary wash system of drilling to coring at -81.5 ft because there was no more supply of casing-advancer-size casing. SPT tests done while samplers were being driven (140 lb hammer, cathead). Brass sleeves were used on the 3" split-spoon sampler; no sleeves were used on the 2" split-spoon sampler.						

Logs of other borings continue on next page ...

FIELD LOG SHEET

PROJECT	HOLE No.		DATE DRILLED
Rindge dam	TH02-05		10-4-02 & 10-5-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 5500 component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 299.675 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 89.8	DEPTH TO GROUNDWATER approx. -5 ft based on creek level	INSPECTOR US Army Corps- Geotech- B. Rathbun

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-05		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - ~ 4	**Unit 1.** POORLY GRADED GRAVEL WITH SAND. Light brown, dry, loose. Cobbles (15% by volume at the surface) excluded from the sample. Sample collected by shovel from top 6 inches.	M, G	no test	top 6" mid 6" last 6"	
2	~4 - ~ 8	**Unit 1.** POORLY GRADED SAND WITH SILT AND GRAVEL. Brown, moist. Sand fraction is medium-grained. Sample cut from interval 4.7 to 6.2 ft.	Easy drilling M, G	N = 11 6" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	9 6 5
3	~ 8 - 11.2	**Unit 1.** POORLY GRADED SAND WITH GRAVEL. Sample cut from interval 9.7 ft to 11.2 ft	Easy drilling. Rock fragment blocked sampler, reduced recovery M, G	N = 10 6" recovery 18" driven 2" split spoon	top 6" mid 6"	5 5

Project: Rindge dam Drill hole number: TH02-05		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sam ple No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
				used	last 6"	5
4	11.2 - 16.2	**Unit 1.** Sand with gravel. Brown, wet, loose. Sand fraction is medium-grained. Gravel as large as ¾ inch diameter. Sample cut from interval 14.7 ft to 16.2 ft	M HTW, combined with sample 6, this boring, and with TH02-03, sample 3, for the tests	N = 3 17" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 2 1
5	16.2 - ~ 23	**Unit 1.** POORLY GRADED SAND WITH SILT AND GRAVEL. Brown, wet, very loose. Sand fraction is medium-grained. Sample cut from interval 19.7 ft to 21.2 ft	M, G	N = ? 12" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 drop 2
6	~ 23 - 26.2	**Unit 2.** WELL GRADED SAND WITH SILT. Brown, wet, loose. Sand fraction is medium-grained. Gravel seldom seen (as large as 3/4 in. diameter). Some fine-grained black sand seen in cuttings. Sample cut from interval 24.7 ft to 26.2 ft	G HTW, combined with sample 4, this boring, and with TH02-03, sample 3, for the tests	N = 6 17" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 2 6
7	26.2 - 33.7	**Unit 2.** POORLY GRADED SAND WITH SILT AND GRAVEL. Brown to black. Sand fraction is coarse- to medium-grained. Gravel seldom seen (as large as 1.5 in. diameter). Sample cut from interval 29.7 ft to 31.2 ft	Drilling time for this interval: 9 min. M, G	N = 11 5" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	10 7 4
8	33.7 -	**Unit 2.** SILTY SAND. Black Sand fraction is fine-grained. Upper contact from mud logging. Gravel seldom seen (as large as ½ inch diameter).	G	N = 8 18"	top 6"	4

Project: Rindge dam Drill hole number: TH02-05		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	~ 38	Sample cut from interval 34.7 ft to 36.2 ft	HTW, combined with sample 9, this boring, and with TH02-03, samples 6, 9, 10 for the tests	recovery 18" driven 2" split spoon used	mid 6"	2
					last 6"	6
9	~ 38 - 41.2	**Unit 2.** SILT. Black, layered. Gravel fraction is fine-grained. Sample cut from interval 39.7 ft to 41.2 ft	Drilling time for this interval: 8 min. G HTW, combined with sample 8, this boring, and with TH02-03, samples 6, 9, 10 for the tests	N = 12 17" recovery 18" driven 2" split spoon used	top 6"	3
					mid 6"	4
					last 6"	8
10	41.2 - ~ 48	**Unit 2.** AS ABOVE, SILT. Sample cut from interval 44.7 ft to 46.2 ft	M, G	N = 9 6" recovery 18" driven 2" split spoon used	top 6"	4
					mid 6"	4
					last 6"	5
11	~ 48 - 51.2	**Unit 2.** WELL GRADED SAND WITH SILT. Black to dark brown. Sand fraction is fine- to medium-grained. Gravel seldom seen (as large as ¾ in. diameter). Sample cut from interval 49.7 ft to 51.2 ft	M, G	N = 19 11" recovery 18" driven 2" split spoon used	top 6"	6
					mid 6"	10
					last 6"	9
12	51.2 - 56.2	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT. Dark brown to gray. Interlayered medium- and fine-grained sand. Gravel seldom seen (as large as ¾ in. diameter). Sample cut from interval 54.7 ft to 56.2 ft	Drilling time for this interval: 11 min. M, G	N = 6 8" recovery 18" driven 2" split spoon used	top 6"	3
					mid 6"	2
					last 6"	4

Project: Rindge dam Drill hole number: TH02-05		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
n/a	56.2 - ~ 63	**Unit 2.** Sand. Fine-grained, brown. Seen in cuttings only. No sample recovery. Sampler driven from 59.7 ft to 61.2 ft	no sample recovered	N = 3 0" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	2 1 2
13	~ 63 - ~ 70	**Unit 3.** Fat clay. Dark gray, cohesive. Sample cut from interval 64.7 ft to 66.2 ft	Water loss at -64 ft. Wire line stuck; had to flush hole. G, A	N = 17 1.5" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 5 12
n/a	~ 70 - ~ 72	**Unit 3.** Silt (?) with organic material, based on mud logging. Organics in the cutting from -70 to -72+ ft. No sample recovery. Sampler driven from interval 69.7 ft to 71.2 ft	No sample Piece of wood in sampler	N = 10 0" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	4 4 6
14	~ 72 - ~ 78	**Unit 3.** SILT. Dark gray, cohesive, with fine-grained sand. Sample cut from interval 74.7 ft to 76.2 ft	M, G, A	N = 6 18" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 3 3
15	~ 78 - ~ 83	**Unit 3.** Sandy silt. Dark gray with black interlayers, moderately cohesive. Sample cut from interval 79.7 ft to 81.2 ft	Sampler dropped 15 ft during recovery M	N = 6 18" recovery 18" driven	top 6" mid 6"	3 2

Project: Rindge dam Drill hole number: TH02-05		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
			HTW, combined with TH02-03, samples 13, 14 for the tests	2" split spoon used	last 6"	4
16	~83 - 85.7	**Unit 3.** FAT CLAY. Dark gray, cohesive, sandy, interlayered with sandy silt. Sample cut from interval 84.7 ft to 86.2 ft	SPT sampler bouncing on rock at end of SPT test run interval; this explains elevated blow counts. M, G, A	N = 27 11" recovery 18" driven 2" split spoon used	top 6" mid 6" last 6"	3 3 24
n/a	85.7 - 89.8	**Unit 4.** Pre-reservoir alluvium. Gravel and rock. Upper contact from drill action. Sampler driven from interval 89.7 ft--bouncing on rock. **Pre-reservoir alluvium surface at -85.7 ft.**	hard drilling no recovery	N = refusal 0" recovery 1" driven 2" split spoon used	top 6" mid 6" last 6"	50 blows / 1 in. -- --

ADDITIONAL REMARKS:

Water, Condet cleanser, and *EZ Mud* added at 0-feet.
A tri-cone bit was used with casing-advancer-rotary wash drilling system.
SPT tests done while samplers were being driven (140 lb hammer, cathead).
No sleeves were used on the 2" split-spoon sampler.

Logs of other borings continue on next page ....

FIELD LOG SHEET

PROJECT	HOLE No.		DATE DRILLED
Rindge dam	TH02-06		10-7-02 & 10-8-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 5500 component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME on 10-7-02, from 1330 hrs to 1740 hrs; on 10-8-02, from 0730 to 1100 hrs
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 292.887 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 55.3	DEPTH TO GROUNDWATER not determined	INSPECTOR US Army Corps- Geotech- B. Rathbun; Sespe Fm lith log by M. Chatman

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-06		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 6.8	**Unit 1.** WELL GRADED SAND WITH SILT AND GRAVEL. Brown, wet, medium dense. Sand fraction is medium- to coarse-grained. Gravel as large s 1.5 in. diameter. Sample collected by shovel from top 6 inches.	Slow drilling due to gravelly soil M, G	8" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	8 7 5
2	6.8 - ~ 12	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT AND GRAVEL. Wet, medium dense. Sand fraction is medium- to coarse-grained. Gravel as large as 2 in. diameter. Sample cut from interval 10.3 to 11.8 ft.	Slow drilling due to gravel M, G HTW, combined with samples 3, 4, this boring for the tests	9" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	9 8 8
3	~ 12 - 16.8	**Unit 2.** WELL GRADED SAND WITH SILT. Brown, wet, medium dense. Sand fraction is medium-grained. Gravel as large as 1 in. diameter. Sample cut from interval 15.3 ft to 16.8 ft	M, G HTW, combined with samples 2, 4, this boring for the tests	14" recovery 18" driven 3" split spoon	top 6" mid 6"	7 7

Project: Rindge dam Drill hole number: TH02-06 Sample No.	Top & bottom of soil or rock unit (ft)	Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts: Depth	Blow counts: Blows
				used	last 6"	9
4	16.8 - 23.9	**Unit 2.** AS ABOVE, WELL GRADED SAND WITH SILT. Wet, medium dense. Brown and black particles in the sand (organics?). Sand fraction is medium-grained. Gravel as large as ½ inch diameter. Elevation of lower contact based on mud logging. Sample cut from interval 20.3 ft to 21.8 ft	M, G HTW, combined with samples 2, 3, this boring for the tests	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	7 9 11
5	23.9 - ~ 28	**Unit 2.** SILTY SAND. Dark gray, wet, medium dense. Sand fraction is fine-grained. Rock fragments to 1.5 in. diameter seen occasionally Sample cut from interval 25.3 ft to 26.8 ft	G HTW	18" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	7 5 8
6	~ 28 - ~33	**Unit 2.** CLAYEY SAND. Dark gray, wet, loose. Sand fraction is medium-grained. Gravel seldom seen (as large as 3/4 in. diameter). The most cohesive clay interlayer (-31.3 to -31.6 ft) was segregated for the Atterberg limits determination. Sample cut from interval 30.3 ft to 31.8 ft	Faster drilling than above soil horizons M, G, A	17" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	3 3 5
7	~33 - ~ 37	**Unit 2.** POORLY GRADED SAND WITH SILT. Gray, wet. Sand fraction is fine- to medium-grained. Gravel seldom seen (as large as 1.5 in. diameter). Sample cut from interval 35.3 ft to 36.8 ft	M, G	12" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	5 6 8
8	~ 37 - 41.8	**Unit 4.** SILTY GRAVEL WITH SAND. Pre-reservoir alluvium. Gray, wet, dense Sand fraction is fine-grained. Silty-clayey fraction is cohesive. Red-brown rock fragments in bottom of sampler probably from rocks drilled through, this interval. These drove up the blow counts.	Hard drilling and rock drilled through at -37 ft. Another rock drilled through at -39.9 ft	15" recovery 18" driven 3" split spoon	top 6" mid 6"	5 15

Project: Rindge dam

Drill hole number: TH02-06

Sample No.	Top & bottom of soil or rock unit (ft)	Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts: Depth	Blow counts: Blows
		Sample cut from interval 40.3 ft to 41.8 ft. **Pre-reservoir alluvium surface is at or near -37 ft.**	M, G HTW	used	last 6"	25
n/a	41.8 - 46.8	**Unit 4.** Pre-reservoir alluvium. Cuttings turn to red color at -43.8 ft. Sampler driven from interval 45.3 ft to 46.8 ft. Only a few fragments of broken rock in sampler; no sample taken for classification.	no tests	0" recovery 2" driven 3" split spoon used	top 6" mid 6" last 6"	50 blows / 2 in. -- --
9	46.8 - 50.3	**Unit 5.** Sespe Formation bedrock. Sandstone conglomerate, gray with red clasts. Fragments classify as a SILTY SAND WITH GRAVEL, information that is of limited use, but it does reveal that not all the fines are washed way in the coring process. Coring run from -46.8 to -50.6 ft. Recovered 13 inches. **Bedrock surface is at or near -46.8 ft.**	G	no test	top 6" mid 6" last 6"	-- -- --
n/a	50.3 - 55.3	**Unit 5.** Sespe Formation bedrock. Sandstone conglomerate underlain by a sandstone-siltstone. The contact between the two rocks is conformable. The lower rock is interlayered fine-grained sandstone to siltstone, red to green, with calcite veinlets to ½ mm width. Coring run from -50.6 to -55.3 ft. Recovered 35 inches	no sample for lab tests	no test	top 6" mid 6" last 6"	-- -- --

ADDITIONAL REMARKS:

Water and *EZ Mud* added at 0-feet.
A tri-cone bit was used with casing-advancer-rotary wash drilling system; coring below -46.8 ft..
SPT tests done while samplers were being driven (140 lb hammer, cathead).
Brass sleeves were used on the 3" split-spoon sampler.

Logs of other borings continue on next page ....

FIELD LOG SHEET

PROJECT Rindge dam	HOLE No. TH02-07		DATE DRILLED 10-8-02
EQUIPMENT USED casing advance rotary wash & tri-cone bit on Burley 2500 H component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer 4" OD for tri cone bit HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME From 0830 hrs To 1530 hrs
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 292.590 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 65.7	DEPTH TO GROUNDWATER -0.5 ft	INSPECTOR US Army Corps- Geotech- Chatman
Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests Notes: sand catchers used throughout			

Project: Rindge dam Drill hole number: TH02-07		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 3	**Unit 1.** WELL GRADED GRAVEL WITH SAND. Dry, loose, tan. Top of a gravel bar in Malibu Creek. Gravel is subrounded. 15 to 20% by volume of the surface material is cobbles (all excluded from the sample). Gravel is rounded. Stone as large as 6 inches in diameter. 1 boulder in this horizon (4 ft diameter). Sample is from uppermost 6 inches.	Slow drilling (1 hr for 5 ft) G, M	n/a	no test	
n/a	3 - 4	**Unit 1.** Boulders. Based on mud logging, drill action.	Switched to tri-cone bit instead of wash bit and used tri-cone for remainder of the hole; no sample	n/a	no test	
2	4 - 6.25	**Unit 1.** WELL GRADED GRAVEL WITH SAND. Free draining. Gravel is subrounded, ½ to 3-inch diameter. A boulder was fragmented in this interval by the bit, and so over-represents	M, G	14" recovery	top 6"	4

Project: Rindge dam Drill hole number: TH02-07		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
		the coarse sand and fine gravel sizes in this G sample. Sample is from 5 ft to 6.5 ft	see description note concerning applicability of G test results; fines likely washed out	18" driven 3" split spoon used	mid 6" last 6"	9 6
3	6.25 - 13.8	**Unit 1.** AS ABOVE, WELL GRADED GRAVEL WITH SAND. Red, tan, gray, green, oxidized active stream deposit. Fines may have washed away, under -representing the -sand size fraction in this G sample. Sample cut from interval 10 ft to 11.5 ft	M, G see description note concerning applicability of G test results	8" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	10 10 10
4	13.8 - 16.5	**Unit 2.** Silty sand. Black-gray, coarsening downward. Sand fraction is fine- to medium-grained. Upper contact determined by mudlogging. Sampler top 3 inches filled with gravel slough from above (discarded in the field). Sample cut from interval 15 ft to 16.5 ft	HTW, combined with sample 5, this boring for the tests	10" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	5 3 5
5	16.5 - 21.5	**Unit 2.** As above, silty sand. Green-black, free draining, loose, fining downward. Silty layers have organic material in 3- 5-mm thick layers and small, fine roots. Sand fraction is medium-grained. Sampler top 3 inches filled with gravel slough from above (discarded in the field). Sample cut from interval 20 ft to 21.5 ft	HTW, combined with sample 4, this boring for the tests	7" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	4 4 2
6	21.5 - ~ 28	**Unit 2.** SILTY SAND. Green-black, wet to free draining, loose, fining downward. Organic layers 5 mm thick (rotting leaves). Sand is interlayered with silt. Small amounts of subrounded gravel as large as 2.5-in. diameter. Sample cut from interval 25 ft to 26.5 ft	M, G	13" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 5 5
7	~ 28 -	**Unit 2.** AS ABOVE, SILTY SAND. Green-black, wet to free draining, loose. Lacks organic material found in interval #6, above. Sand fraction is fine - to medium-grained. Wash out of	M, G	14" recovery	top 6"	4

Project: Rindge dam Drill hole number: TH02-07		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
	~ 33	1.1 ft of material at the bottom of the hole alters the elevation of the sampled interval. Sample cut from interval 31.1 ft to 32.6 ft		18" driven 3" split spoon used	mid 6" last 6"	4 6
8	~ 33 - 36	**Unit 2.** SILTY SAND WITH GRAVEL. Green-black, free draining. The gravel is oxidized, fine, mixed with coarse sand. This likely caused the caving experienced above this sample interval and the loss of circulation below it. Six inches of sand slough on top of the sampler was discarded in the field and not counted toward "recovery". Sample cut from interval 35 ft to 36.5 ft	M, G	9" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	8 7 9
9	~ 36 - ~ 44	**Unit 2.** SILTY SAND. Green-black, wet to free-draining. Sand fraction is medium-grained. Sample cut from interval 41.4 ft to 42..9 ft	Sloughed at 40 ft (2.6 ft tall column in the borehole). This was flushed before sampling. M, G	recovery not recorded 18" driven 3" split spoon used	top 6" mid 6" last 6"	6 8 11
10	~ 44 - ~ 48.5	**Unit 2.** POORLY GRADED SAND WITH GRAVEL. Gray-to-tan, oxidized, free-draining. Sand fraction is medium- to coarse-grained. Sample cut from interval 45 ft to 46.5 ft	Heaving sands M, G	10" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	5 7 9
11	~ 48.5 - ~ 53	**Unit 2.** SILTY SAND. Green-black, free draining, interlayered materials. Includes a 3-in.-thick gravel layer (subrounded ½-in. diameter gravel) and a 2-in.-thick silt, organic-rich layer, immediately below the gravel layer. Below the silt is a fine-grained green-gray sand layer Sample cut from interval 50 ft to 51.5 ft	M, G	11" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 3 4

Project: Rindge dam Drill hole number: TH02-07		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
12	~ 53 - 53.9	**Unit 2.** AS ABOVE, SILTY SAND. Green-black, free-draining, with interspersed organic material (rotting vegetation). Sand fraction is medium- to fine-grained. Sample cut from interval 55 ft to 56.5 ft.	M, G	12" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	2 4 5
n/a	53.9 - 60.2	**Unit 4.** no recovery. possibly rock SPT test from interval starting at -60.2 ft **Elevation 53.9 ft likely is the pre-dam alluvial surface, based on what was found below.**	increased drilling resistance at 53.9 ft; no cuttings returned from -55 ft and below (clay-silt plug in barrel); cored 53.9 - 60.2 ft; no recovery no sample	0" recovery 1" driven 3" split spoon used	top 6" mid 6" last 6"	50 blows / 1 in. -- --
n/a	60.2 - 60.5	**Unit 4.** no recovery. washed out ?		no test	top 6" mid 6" last 6"	
n/a	60.5 - 65.7	**Unit 4.** Pre-reservoir alluvium. Most of the core recovery was feldspathic sandstone cobble and boulders; one quartzite cobble in recovered interval. Gravels are rounded to angular, although angular pieces may be fragmented cobbles or bounders from this interval. Gravel comp. varies: feldspathic sandstone, siltstone, quartzite. Fines will have washed away in the coring process	cored this interval and recovered 47 inches no sample taken for lab	no test	top 6" mid 6" last 6"	

Project: Rindge dam Drill hole number: TH02-07		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sam ple No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
ADDITIONAL REMARKS: Water and Dry Polymer "mud" was added at 0-feet. CON DET (Baroid) "soap" added at -40 ft to improve circulation. A three-vane rotary wash bit was used during the intervals of casing-advancer-rotary wash drilling system use. Switched from rotary wash bit to tri-cone bit at -3 ft through 53.9 ft. Switched to coring at -53.9 ft. SPT tests done while samplers were being driven (140 lb hammer, cathead). Brass sleeves were used on the 3" split-spoon sampler; no sleeves were used on the 2" split-spoon sampler.						

Logs of other borings continue on next page ....

FIELD LOG SHEET

PROJECT	HOLE No.		DATE DRILLED
Rindge dam	TH02-08		10-8-02
EQUIPMENT USED casing advance rotary wash & coring on Burley 5500 component rig	DIAMETER (Inches) HWT (4.5-in. OD, 4-in. ID) for casing advancer HQ3 (3.782-in. OD, 2.406-in. ID) for coring		DRILLING TIME on 10-8-02, from 0730 to 1100 hrs
LOCATION reservoir surface	CONTRACT NO. Group Delta		CONTRACTOR Group Delta (lead); Crux Subsurface (sub and driller)
SURFACE ELEVATION 295.864 ft, from topographic survey completed several years after the exploration	TOTAL DEPTH (Feet) 25.3	DEPTH TO GROUNDWATER not determined	INSPECTOR US Army Corps- Geotech- B. Rathbun; Sespe Fm. lith log by M. Chatman

Symbols for samples taken: G = gradation; M = moisture content; A = Atterberg limits; O = other (see remarks at bottom); HTW = environmental tests
Notes: sand catchers used throughout

Project: Rindge dam Drill hole number: TH02-08		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
1	0 - 7	**Unit 1.** POORLY GRADED GRAVEL WITH SILT AND SAND. Brown, wet, dense. Sample cut from interval 5.5 to 7.0 ft.	Slow drilling time: 25 min. for 5 ft M, G	9" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	12 16 10
2	7 - 14.9	**Unit 1.** AS ABOVE, POORLY GRADED GRAVEL WITH SILT AND SAND. Gravel as large as 1 in. diameter in the sampler. Sample cut from interval 10.5 to 12.0 ft.	Slow drilling time: 25 min. for 5 ft; drill action indicates gravel M, G	6" recovery 18" driven 3" split spoon used	top 6" mid 6" last 6"	11 9 5
3	14.9 - 19.9	**Unit 3.** SILTY SAND. Upper layer (4 inches of sample) is cohesive silt and clay (segregated for Atterbergs); lower layer (9 inches of sample) is gray, fine- to medium-grained sand. Organic layer on top of sampler (1 inch). Upper and lower contacts determined from drill action.	Drilling speed increases at -14.9 ft G, A	14" recovery 18" driven 3" split spoon	top 6" mid 6"	2 5

Project: Rindge dam Drill hole number: TH02-08		Description and Condition of Material ALL CAPITAL LETTERS for soil type denotes type from USC lab classification. Lower case letters indicates field (visual) description only	Excavation Remarks Lab tests for this sample	Sample recovery, SPT results	Blow counts	
Sample No.	Top & bottom of soil or rock unit (ft)				Depth	Blows
		Sample cut from interval 15.5 ft to 17.0 ft		used	last 6"	5
n/a	19.9 - 22.0	**Unit 4 or 5.** Sandstone, either pre-reservoir alluvial surface (boulder or cobbles) or Sespe Formation bedrock. Broken pieces of sandstone in the sampler. Sampler driven from 20.5 ft to 22.0 ft	Drilling slows at -19.9 ft no sample	0" recovery 3" driven 3" split spoon used	top 6" mid 6" last 6"	50 blows / 3 in. -- --
n/a	20.9 - 25.3	**Unit 5.** Sespe Formation bedrock. Orthoquartzite sandstone, fin-to medium grained, well sorted, without cross bedding. Pale green to light gray; occasional gray quartzite fragments (coarse sand to fine gravel sizes, and angular to subangular). One rounded gray quartzite pebble (2.5 in. diameter). Fragments and pebble seem to be from same source of quartzite. This sandstone outcrops on the canyon walls 15 ft from the drill site and is the dominant component of the 2-ft to 6-ft diameter boulders in the creek bottom in this immediate area and extending for 150 ft u/s and 300 ft d/s of the drill site. **Pre-reservoir bedrock surface is at or near -19.9 ft.**	Core run -20.9 to -25.3 ft; recovery 63 inches No sample for lab tests	no test	top 6" mid 6" last 6"	

ADDITIONAL REMARKS:

Water, CON DET, and *EZ Mud* added at 0-feet.
A tri-cone bit was used with casing-advancer-rotary wash drilling system; coring below -20.9 ft.
SPT tests done while samplers were being driven (140 lb hammer, cathead).
Brass sleeves were used on the 3" split-spoon sampler.

o

GRAPHIC LOG LEGEND: SEE PLATE A-3

Depth (feet)	Sample Blows	USCS	Materials Description
0		GW	**SANDY GRAVEL** – well graded from silty sand matrix to gravel, gravel ave. 0.5-inch diameter, clasts of sandstone, volcanic rock and microcrystalline quartz fragments, approx. 45% gravel
10			– water
		SP	**GRAVELLY SAND** – medium sand and fine gravel, gap- graded, approx. 10% gravel, sand grains are approx. 50% quartz and feldspar, approx. 50% volcanics, olive-gray
20			– approx. 40% fine sand and silt with 20% rounded gravel, gap-graded, dark gray
		SW	**GRAVELLY SAND** – coarse, well-sorted, approx. 20% gravel and 5% silt
30		GP	**SANDY GRAVEL** – fine sand, gap-graded, subrounded gravel ave. 0.75 to 1 inch diameter, approx. 50% gravel, 50% fine sand
		SM	**SILTY SAND** – fine sand, poorly graded, micaceous, slightly cohesive, soft, organic odor, black
	10	ML	**CLAYEY SILT** – with approx. 35% fine sand
40		SM	**SILTY SAND** – well-sorted, approx. 85% sand, abundant organic material (leaves, twigs), non-cohesive, brownish-black
		SW	**GRAVELLY SAND** – coarse, approx. 15% subrounded gravel, olive-gray
50	9		–increasing silt, decreasing gravel, brownish gray
	8	SM	**SILTY SAND** – fine, approx. 35% micaceous silt, sand composed of approx. 65% quartz and feldspar, brownish black (wet), light gray (dry)
60	8	OL CL	**SILTY CLAY** – with organics, slightly plastic, with medium to high dry strength, brownish black (wet)
70		ML	

OWNER: State of California
LOCATION: Malibu Canyon
DRILLED BY: Valley Well Drilling
METHOD: Hollow-stem auger

BOREHOLE DEPTH: 87 feet
BOREHOLE DIAMETER: 6.5 inches
DATE DRILLED: 8/30 – 8/31/93
LOGGED BY: DJA

DEPARTMENT OF FISH AND GAME
MALIBU CREEK DAM
PROJECT NO. 2661.40181.0002

BORING 1

PLATE A-1.1a

LAW/CRANDALL, INC.

PROJECT No. 2661.40181.0002 DATE 04/22/1994 PROJ. MGR. DFTR.

GRAPHIC LOG LEGEND: SEE PLATE A-3

SAMPLE Blows	Interval	DEPTH feet	USCS	GRAPHIC LOG	MATERIALS DESCRIPTION
12		70	ML		**SANDY SILT** – 35% fine to medium sand, slightly plastic, organic matter, grayish black (wet)
16					
		80			
50			SP		**GRAVELLY SAND** – coarse, poorly graded, subrounded sand grains are mainly (65%) volcanic and quartz/feldspar, with approx. 5–10% silt
					Ts: SESPE FORMATION – well-indurated, calcite- cemented sandstone, with randomly oriented, siliceous veinlets. End boring at 87 feet.
		90			
					NOTE: B1 was drilled from 0 to 49 feet with air advance tubex system. The boring was continued approx. 15 feet west the following day using hollow-stem auger.
		100			
		110			
		120			
		130			
		140			

OWNER: State of California
LOCATION: Malibu Canyon
DRILLED BY: Valley Well Drilling
METHOD: Hollow-stem auger

BOREHOLE DEPTH: 87 feet
BOREHOLE DIAMETER: 6.5 inches
DATE DRILLED: 8/30 – 8/31/93
LOGGED BY: DJA

DEPARTMENT OF FISH AND GAME
MALIBU CREEK DAM
PROJECT NO. 2661.40181.0002

BORING 1

PLATE A-1.1b

LAW/CRANDALL, INC.

PROJECT No. 2661.40181.0002 DATE 04/22/1994 PROJ. MGR. ______ DFTR. ______

GRAPHIC LOG LEGEND: SEE PLATE A-3

SAMPLE Blows	DEPTH feet	USCS	MATERIALS DESCRIPTION
	0	ML	**SANDY SILT** – well graded with approx. 35% sand and 25% gravel, moderate olive brown
	10	SP	**GRAVELLY SAND** – gap-graded fine and coarse sand with approx. 15% silt and 10% rounded gravel up to 1.5 inches in diameter – water at 7 feet – increasing gravel, decreasing silt
		SW	**GRAVELLY SAND** – coarse, well-graded
		SM	**SILTY SAND** – abundant organic matter (leaves, bark), dark gray
3	20	CL OL	**SILTY CLAY** – micaceous, slight to low plasticity, soft to medium stiff, grayish black
5	30	SP	**GRAVELLY SAND** – medium-grained, gap-graded, with approx. 20% subrounded gravel and 15% silt
6, 7	40	ML	**SANDY SILT** – approx. 70% silt with fine sand, micaceous, with organic material (roots)
5		OL	**CLAYEY SILT** – abundant organic material (leaves, twigs, roots), micaceous, with approx. 5% fine sand, slight plasticity, soft, brownish black
	50	CL	**SILTY CLAY** – micaceous, slight plasticity, soft, organic odor, little organic material, no sand – increasing sand
12, 4	60	SM	**SILTY SAND** – fine to medium, well graded, approx. 60% sand composed of angular to subrounded quartz grains, with 40% silt
5		CL	**SILTY CLAY** – micaceous, slight plasticity, soft, organic odor, little organic material, no sand
	70	ML	**SANDY SILT** – fine, sand is mostly quartz and feldspar grains, approx. 35% silt, soft, non-plastic to slightly plastic, organic matter (twigs), brownish black

OWNER: State of California
LOCATION: Malibu Canyon
DRILLED BY: Valley Well Drilling
METHOD: Hollow-stem auger

BOREHOLE DEPTH: 103.5 feet
BOREHOLE DIAMETER: 6.5 inches
DATE DRILLED: 9/1/93
LOGGED BY: DJA

DEPARTMENT OF FISH AND GAME
MALIBU CREEK DAM
PROJECT NO. 2661.40181.0002

BORING 2

PLATE A-1.2a

LAW/CRANDALL, INC.

PROJECT No. 2661.40181.0002 DATE 04/22/1994 PROJ. MGR. ______ DFTR. ______

GRAPHIC LOG LEGEND: SEE PLATE A-3

SAMPLE: Blows	SAMPLE: Interval	DEPTH feet	USCS	GRAPHIC LOG	MATERIALS DESCRIPTION
13		70	ML		
6			CL		**SILTY CLAY** – micaceous, slight plasticity, soft, organic odor, little organic material, no sand, olive black
		80			
6					– color change: black, soft, moderate plasticity
		90			
8			CH		**CLAY** – moderate to high plasticity, medium stiff, organic odor, olive black
		100	GP		**SANDY GRAVEL** – subangular to subrounded, sandstone clasts up to 1 inch in diameter
					Ts: SESPE FORMATION – feldspathic arenite, moderately– indurated angular clasts of sandstone. Grains are equigranular and approx. 35% subangular quartz and approx. 60% feldspar with approx. 5% mica and microcrystalline dark minerals. Trace calcite cement, probably siliceous cement. End boring at 103.5 feet.
		110			
		120			
		130			
		140			

OWNER: State of California
LOCATION: Malibu Canyon
DRILLED BY: Valley Well Drilling
METHOD: Hollow-stem auger

BOREHOLE DEPTH: 103.5 feet
BOREHOLE DIAMETER: 6.5 inches
DATE DRILLED: 9/1/93
LOGGED BY: DJA

DEPARTMENT OF FISH AND GAME
MALIBU CREEK DAM
PROJECT NO. 2661.40181.0002

BORING 2

PLATE A-1.2b

LAW/CRANDALL, INC.

PROJECT No. 2661.40181.0002 DATE 04/22/1994 PROJ. MGR. ______ DFTR. ______

GRAPHIC LOG LEGEND: SEE PLATE A-3

SAMPLE Blows	DEPTH feet	USCS	MATERIALS DESCRIPTION
	0	ML	**SILTY SAND** – fine to coarse, gap-graded, with approx. 35% silt, and 5% gravel, grains are subangular to subrounded quartz, feldspar and volcanics – water at 6 feet
	10	GW	**SILTY SANDY GRAVEL** – well graded, with approx. 55% subangular gravel 0.5 to 0.75 inches in diameter, approx. 30% coarse sand, moderate olive brown – decreasing grain size – gravel lens – increasing silt – approx. 30%
5	20	SM	**SILTY SAND** – poorly graded, approx. 60% quartz, feldspar, and volcanic subrounded sand grains with 40% silt, non-plastic, greenish-black
9	30	ML	**SANDY SILT** – poorly graded, micaceous, plastic, very soft, organic odor, olive black
		GW	**GRAVEL** – gravel lens
6		SM	**SILTY SAND** – poorly graded, angular to subangular grains with approx. 35% silt, organic odor, dark gray
11	40	SW	**SILTY SAND** – well graded, with approx. 15% silt and 5% gravel
		GW	**SILTY SANDY GRAVEL** – well graded, approx. 60% subrounded gravel clasts up to 1 inch diameter
15	50	GC	**GRAVELLY SILTY SAND** – poorly graded subrounded gravel clasts
220	60		– approximate boundary of Sespe Formation, irregular basement, auger slipping down dip. **Ts: SESPE FORMATION** – feldspathic arenite, poorly- indurated, angular clasts of equigranular sandstone. Grains are approx. 35% quartz, 65% feldspar and approx. 10% microcrystalline dark minerals and mica. Locally calcite cemented. End boring at 60 feet. **NOTE:** Boring B3 initially hit bedrock at 50 feet. The boring was continued approx. 15 feet north to a depth of 60 feet.
	70		

OWNER: State of California
LOCATION: Malibu Canyon
DRILLED BY: Valley Well Drilling
METHOD: Hollow-stem auger

BOREHOLE DEPTH: 60 feet
BOREHOLE DIAMETER: 8.5 inches
DATE DRILLED: 9/2/93
LOGGED BY: DJA

DEPARTMENT OF FISH AND GAME
MALIBU CREEK DAM
PROJECT NO. 2661.4018L0002

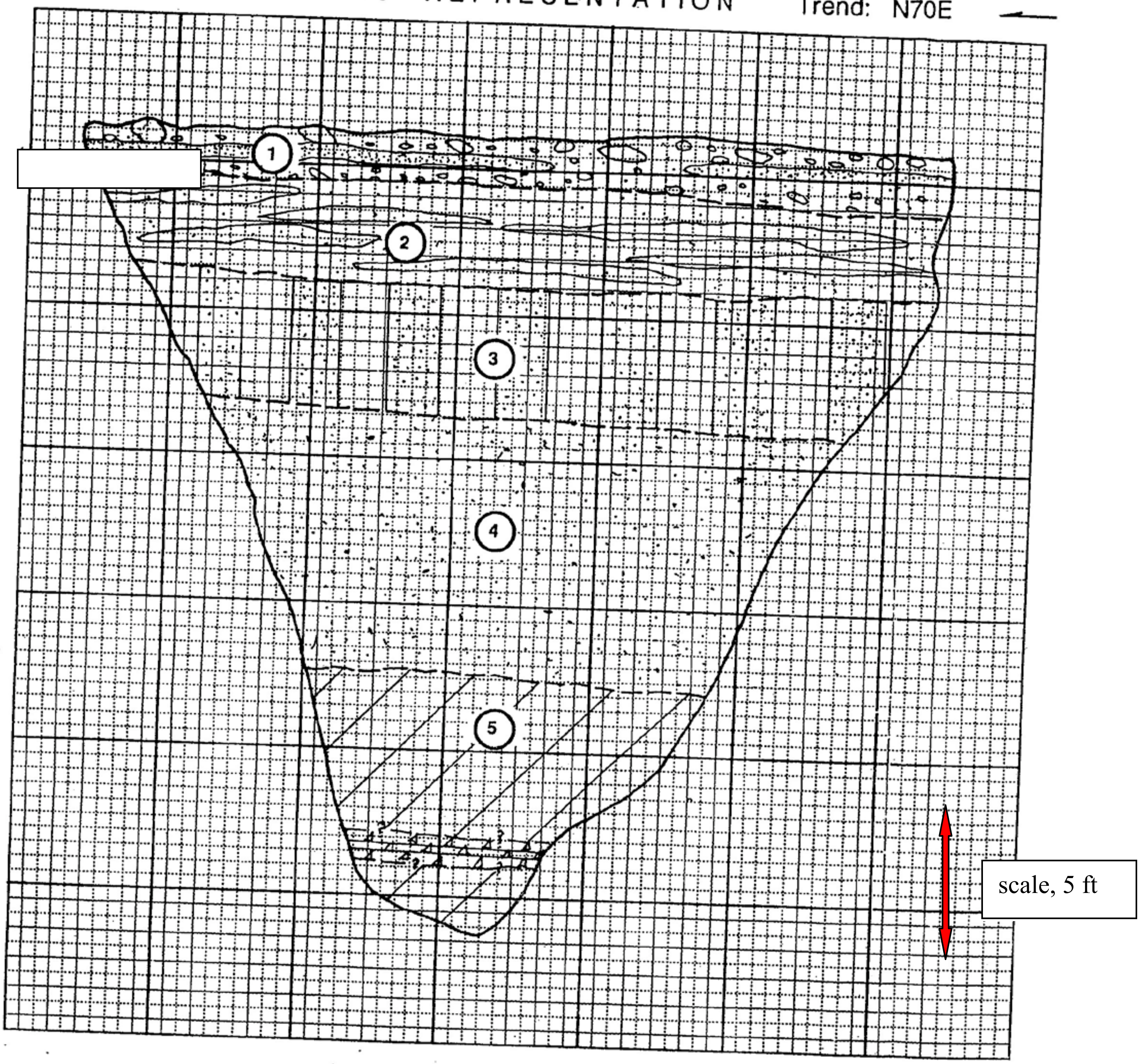
BORING 3

PLATE A-1.3

LAW/CRANDALL INC.

PROJECT No. 26614018L0002 DATE 04/22/1994 PROJ. MGR ______ DFTR ______

Scale: 1" = 5' GRAPHIC REPRESENTATION Trend: N70E



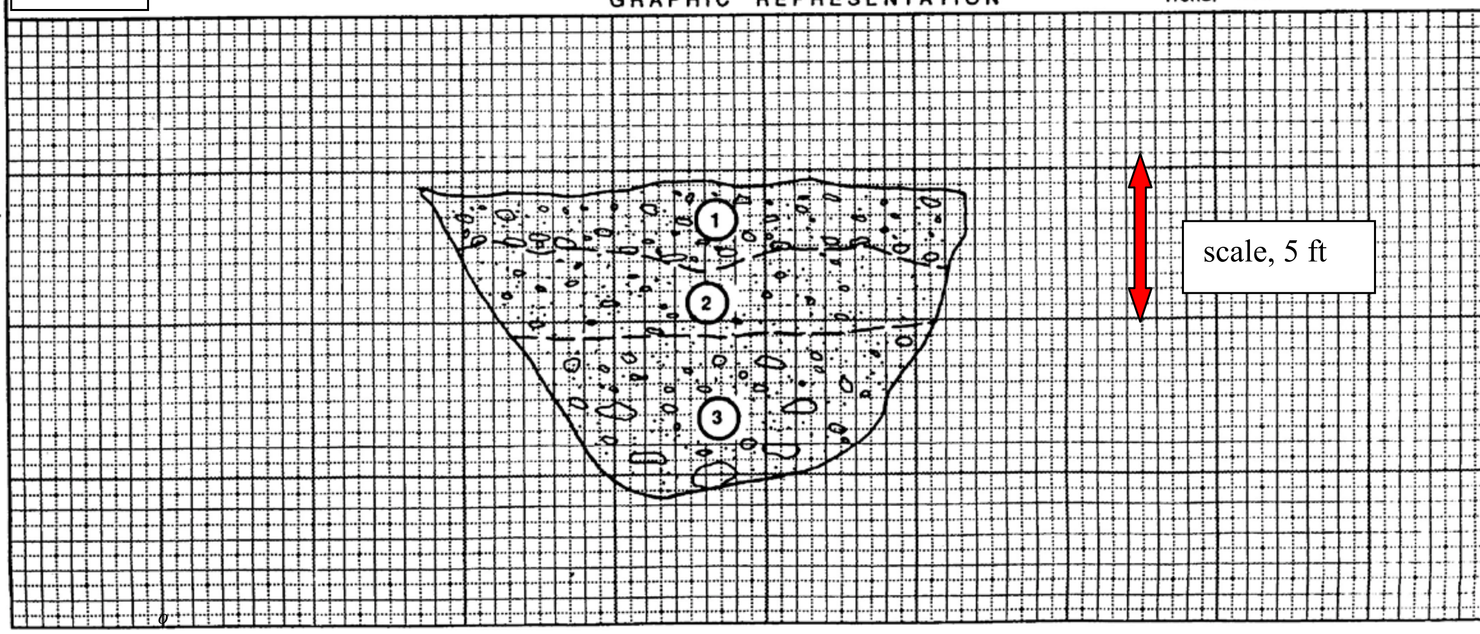
JOB 2661.40181.0001 DATE 3/17/94 DR. lk CHKD GK

LOG OF TEST PIT NO. 2

Project:	STATE OF CALIFORNIA
Job No: 2661.40181.0001	Geologist GK

Description	Attitudes
(1) SAND (SW) - well graded, some Gravel and Cobbles, poorly sorted, crudely stratified, subangular to subrounded, light grey (2) SAND (SP) - fine to coarse, some Gravel, few Cobbles, brown (3) GRAVEL (GW) - well graded, some Sand and Cobbles, few Boulders, poorly sorted, well rounded, reddish brown	

GRAPHIC REPRESENTATION Trend: N47E



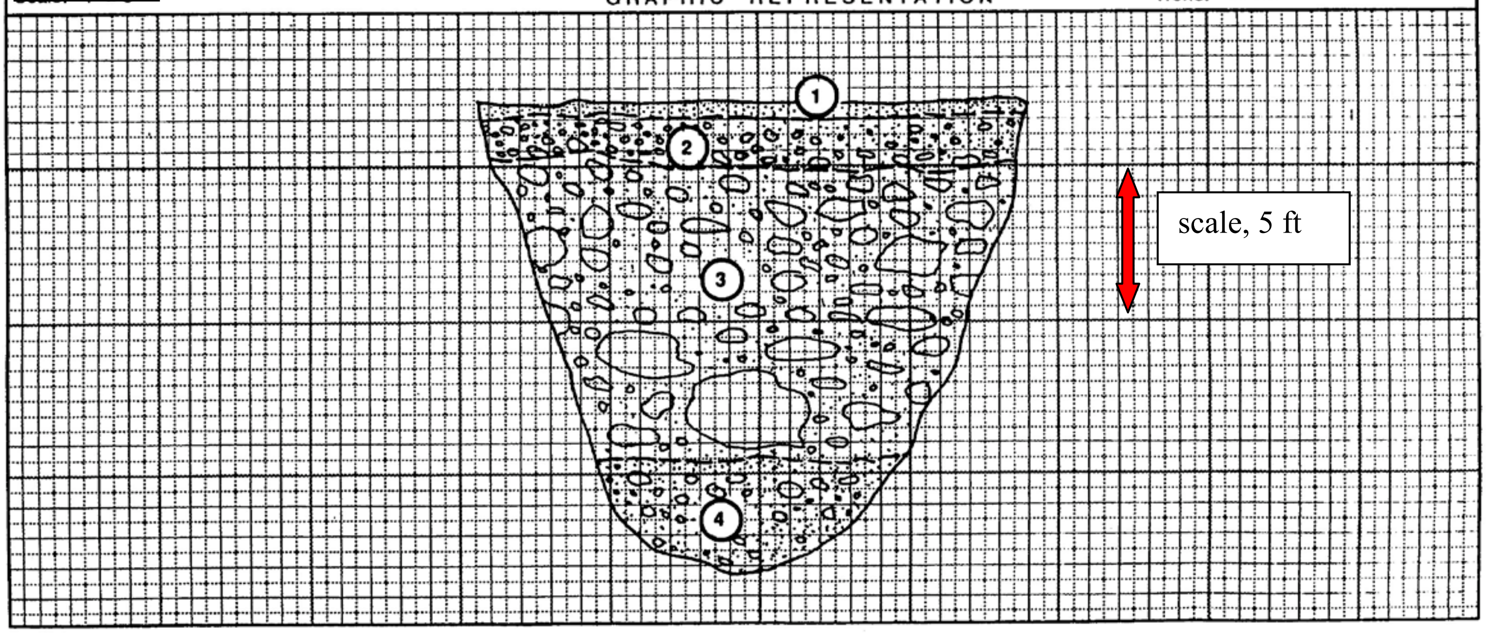
LAW / CRANDALL, INC. PLATE A-2.2

JOB 2661.40181.0001 DATE 3/17/94 DR. lk CHKD GK

LOG OF TEST PIT NO. 3	Project: STATE OF CALIFORNIA	
	Job No: 2661.40181.0001	Geologist GK

Description	Attitudes
(1) SAND (SP) - fine to medium, well sorted, light greyish brown	
(2) GRAVEL (GW) - abundant Cobbles, some Sand, subrounded, reddish brown	
(3) COBBLES and BOULDERS (to 24" in diameter) - poorly sorted, subangular to rounded, brown	
(4) COBBLES - some Sand and Gravel, few Boulders, poorly sorted, well rounded, dark reddish brown	

GRAPHIC REPRESENTATION Trend: N26W



LAW / CRANDALL, INC. PLATE A-2.3

JOB 2661.40181.0001 DATE 3/17/94 DR. lk CHKD GK

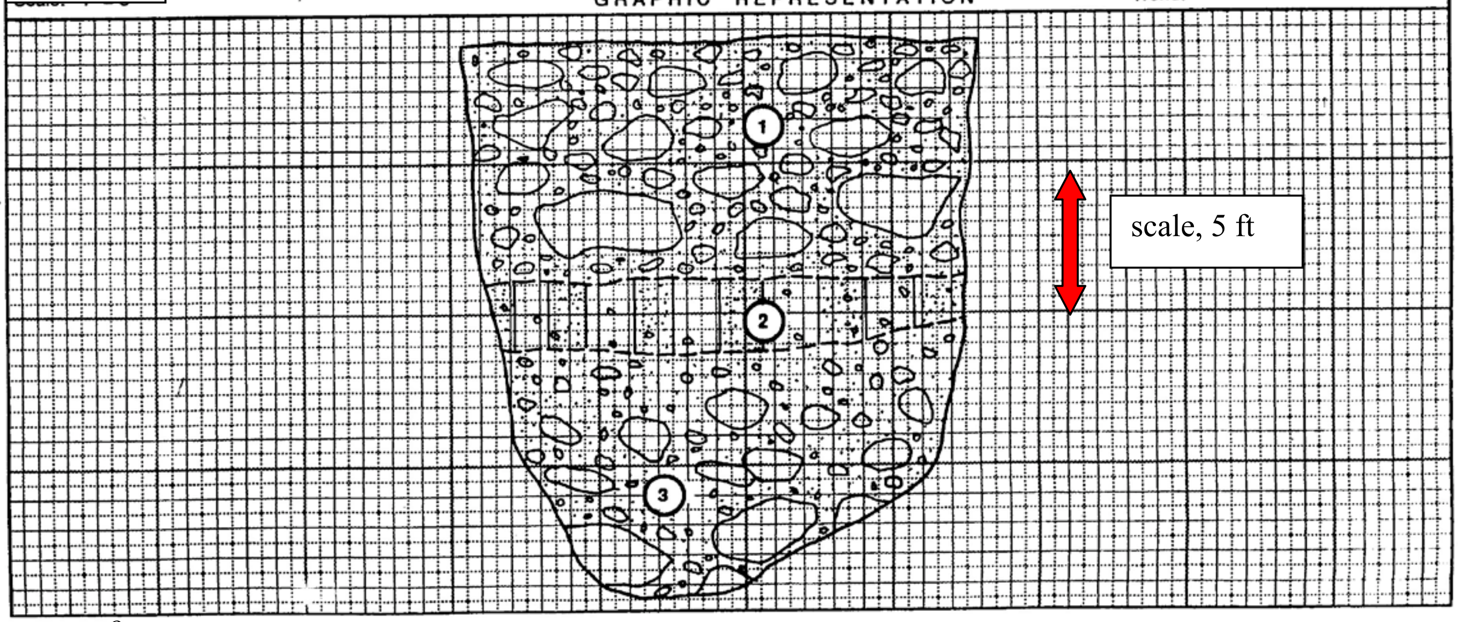
LOG OF TEST PIT NO. 4

Project: STATE OF CALIFORNIA

Job No: 2661.40181.0001 Geologist: GK

Description	Attitudes
(1) GRAVEL (GW) - well graded, some Sand, Cobbles, and Boulders (to 4' in diameter), angular to subrounded, brown	
(2) SANDY SILT (ML) - few Gravel, brown and dark grey	
(3) SAND (SW) - medium to coarse, abundant Gravel, some Cobbles and Boulders, poorly sorted, subrounded to rounded, brown	

GRAPHIC REPRESENTATION Trend: N40W



LAW / CRANDALL, INC. PLATE A-2.4

This page was intentionally left blank for duplex printing.

Appendix D2
Lab and Environmental Testing Logs

This page was intentionally left blank for duplex printing.

Laboratory test results from Rindge Dam reservoir boring samples.

Gradation analyses, moisture content, Atterberg limits, USC classifications and symbols.
Classifications in all capital letters are from lab determinations; if in lower case letters, indicates classification from field examination only.

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
Boring no.	Sam-ple no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200	PL	LL	PI			
TH02-01	1	51	0-3 / Unit 1	100	100	90	69	48	38	29	20	9	4	1	NT	NT	NT		GP	POORLY GRADED GRAVEL WITH SAND
TH02-01	2	52	3-8 / Unit 1	no gradation tests run											--	--	--	23.4		Sand with gravel
TH02-01	3	53	8-13 / Unit 2	100	100	100	100	97	88	69	32	13	8	4	NT	NT	NT	27.1	SP	POORLY GRADED SAND
TH02-01	4	54	13-19 / Unit 2	100	100	100	100	92	86	78	59	32	14	8	NT	NT	NT	14.2	SW-SM	WELL GRADED SAND WITH SILT
TH02-01	5	55	19-22 / Unit 2	100	100	100	98	94	88	75	57	36	22	12	NT	NT	NT	23.2	SW-SM	WELL GRADED SAND WITH SILT
TH02-01	6	56	22-29 / Unit 2	100	100	100	100	100	97	94	91	88	70	41	NT	NT	NT	84.4	SM	SILTY SAND
TH02-01	7	57	29-34 / Unit 2	100	100	100	100	100	100	100	99	91	58	27	NP t	NP v	--	40.3	SM	SILTY SAND
TH02-01	8	58	34-39 / Unit 2	100	100	100	100	100	99	98	93	71	40	17	NP t	NP v	--	39.3	SM	SILTY SAND
TH02-01	9	59	39-44 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	39.2		Silty sand
TH02-01	10	60	44-49 / Unit 3	100	100	100	100	100	98	97	96	95	91	79	NP t	NP v	--	55.1	ML	SILT WITH SAND
TH02-01	11	61	49-53 / Unit 3	100	100	100	100	100	98	97	96	95	91	79				NT	ML	SILT WITH SAND

Mechanical analysis, moisture, other lab tests				**GRAVEL (in.), % passing**				**SAND (sieve no.), % passing**						**Fines**	Atterberg			**M.C. (%)**	Class. symbol	**Classification**
															PL	**LL**	**PI**			
Boring no.	Sam-ple no.	Lab no.	Depth, top, bottom (ft) / Unit #.	**3.0**	**1.5**	**3/4**	**3/8**	**4**	**8**	**16**	**30**	**50**	**100**	**200**						
--	--	--	--	**note: lab sample nos. 60-61 combined for gradation, LL, PL tests due to small samples**											--	--	--	--	--	--
TH02-01	12	62	53-59 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Sand with silt
TH02-01	13	63	59-61 / Unit 3	100	100	100	100	100	100	99	98	96	95	87	NP t	NP v	--	44.7	ML	SILT
TH02-01	14	64	61-68 / Unit 3	100	100	100	100	100	100	100	100	100	100	100	33	69	36	47.5	OH	ORGANIC CLAY
TH02-01	15	65	68-72 / Unit 3	100	100	100	100	100	100	100	99	91	61	27	NT	NT	NT	28.8	SM	SILTY SAND
TH02-01	16	66	72-76.4 / Unit 3	100	100	100	100	100	100	100	100	100	100	98	38	59	21	48.7	MH	ELASTIC SILT
TH02-01	17	67	81.5-84 / Unit 3	100	100	100	100	100	100	100	100	100	100	98	34	61	27	49.3	OL	ORGANIC SILT
TH02-01	18	68	84-91.5 / Unit 3	100	100	100	100	100	100	100	100	99	97	84	25	45	20	31.1	CL	LEAN CLAY WITH SAND
TH02-01	19	69	91.5-93.5 / Unit 3	100	100	100	100	100	99	98	95	90	88	84	35	68	33	40.5	OL	ORGANIC SILT WITH SAND
TH02-02	1	70	0-4.9 / Unit 1	100	79	68	54	41	33	26	18	9	3	1	NT	NT	NT	0.3	GP	POORLY GRADED GRAVEL WITH SAND
TH02-02	2	71	6.4-14.5 / Unit 1	100	100	85	80	75	66	51	32	16	8	5	NT	NT	NT	NT	SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL
TH02-02	3	72	14.5-16.4 / Unit 2	100	100	100	97	91	89	85	75	43	19	11	NT	NT	NT	NT	SW-SM	WELL GRADED SAND WITH SILT
TH02-02	4	73	16.4-23 / Unit 2	100	100	100	97	91	89	85	75	43	19	11	NT	NT	NT	20.6	SW-SM	WELL GRADED SAND WITH SILT
TH02-02	5	74	23-30.8 / Unit 2	100	100	99	98	92	84	70	41	20	14	9	NT	NT	NT	22.6	SW-SM	WELL GRADED SAND WITH SILT
TH02-02	6	75	30.8-34.9 / Unit 2	100	100	100	100	100	100	100	99	78	37	18	NT	NT	NT	28.2	SM	SILTY SAND
TH02-02	7	76	34.9-36 / Unit 2	100	100	100	99	98	98	97	94	79	49	25	NT	NT	NT	27.1	SM	SILTY SAND

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
Boring no.	Sample no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200	PL	LL	PI			
TH02-02	8	77	36-38 / Unit 2	100	100	100	100	100	100	100	99	96	94	80	NP t	NP v	--	73.0	ML	SILT WITH SAND
TH02-02	9	78	38-44.9 / Unit 2	100	100	100	100	100	100	100	98	87	58	24	NT	NT	NT	31.2	SM	SILTY SAND
TH02-02	10	79	45.5-46 / Unit 2	100	100	100	100	100	100	100	99	96	83	61	NP t	NP v	--	41.6	ML	SANDY SILT
TH02-02	11	80	46.4-51 / Unit 2	100	100	100	95	91	83	68	46	21	10	5	NT	NT	NT	24.1	SW-SM	WELL GRADED SAND WITH SILT
TH02-02	12	81	51-52 / Unit 2	100	100	100	100	93	91	90	87	76	50	26	NT	NT	NT	27.4	SM	SILTY SAND
TH02-02	13	82	52-55 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Organic silt
TH02-02	14	83	55-56.4 / Unit 3	100	100	100	100	100	100	100	100	99	97	88	33	50	17	34.4	MH	ELASTIC SILT
TH02-02	15	84	56.4-58.4 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Lean clay
TH02-02	16	85	58.4-64 / Unit 3	100	100	100	100	100	99	98	94	86	67	31	NT	NT	NT	34.4	SM	SILTY SAND
TH02-02	17	86	64-67 / Unit 3	100	100	100	100	100	100	99	97	92	68	38	NT	NT	NT	39.6	SM	SILTY SAND
TH02-02	18	87	67-71.4 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Silt
TH02-02	19	88	71.4-74 / Unit 3	100	100	100	100	98	91	78	59	40	30	19	NT	NT	NT	22.7	SM	SILTY SAND
TH02-02	20	89	74-79 / Unit 3	100	100	100	100	100	100	100	100	99	97	71	NP t	NP v	--	34.4	ML	SILT WITH SAND
TH02-02	21	90	79-80.5 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Clay
TH02-02	22	91	80.5-81.4 / Unit 4	100	95	78	61	46	31	22	15	10	7	5	NT	NT	NT	14.0	GW-GM	WELL GRADED GRAVEL WITH SILT AND SAND
TH02-02	23	92	81.5-83.5 / Unit 4	100	100	48	14	8	8	8	7	7	7	7	NT	NT	NT	NT	GP-GM	POORLY GRADED GRAVEL WITH SILT
TH02-03	1	93	0-6.6 / Unit 1	100	100	85	78	72	47	30	19	11	7	5	NT	NT	NT	17.5	SW-SM	WELL GRADED SAND WITH SILT AND GRAVEL

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
															PL	LL	PI			
Boring no.	Sample no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200						
TH02-03	2	94	6.6-11.6 / Unit 1	100	100	86	50	36	23	14	8	5	3	2	NT	NT	NT	NT	GW	WELL GRADED GRAVEL WITH SAND
TH02-03	3	95	11.6-16.6 / Unit 1	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Sand with gravel
TH02-03	4	96	16.6-23.1 / Unit 2	100	100	100	100	94	91	85	68	36	26	9	NT	NT	NT	22.0	SW-SM	WELL GRADED SAND WITH SILT
TH02-03	5	97	23.1-26.6 / Unit 2	100	100	100	100	99	94	87	66	43	33	21	NT	NT	NT	NT	SM	SILTY SAND
TH02-03	6	98	26.6-31.6 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	27.0		Silty sand
TH02-03	7	99	31.6-36.1 / Unit 2	100	100	95	91	85	79	69	53	30	16	9	NT	NT	NT	24.7	SW-SM	WELL GRADED SAND WITH SILT AND GRAVEL
TH02-03	8	100	36.6-41.6 / Unit 2	100	100	100	100	100	95	78	51	25	15	7	NT	NT	NT	30.6	SW-SM	WELL GRADED SAND WITH SILT
TH02-03	9	101	41.6-46.6 / Unit 2	100	100	100	100	100	100	100	99	89	52	20	NT	NT	NT	NT	SM	SILTY SAND
TH02-03	10	102	46.6-51.6 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Silty sand
TH02-03	11	103	51.6-56.6 / Unit 2	100	100	100	100	100	99	97	88	61	31	10	NT	NT	NT	29.0	SP-SM	POORLY GRADED SAND WITH SILT
TH02-03	12	104	56.6-61.6 / Unit 2	100	100	100	100	100	100	100	94	63	26	12	NT	NT	NT	30.1	SP-SM	POORLY GRADED SAND WITH SILT
TH02-03	13	105	61.6-66.6 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Silty sand
TH02-03	14	106	66.6-73.3 / Unit 3	100	100	100	100	100	100	100	99	99	95	75	NT	NT	NT	NT	ML	SILT WITH SAND

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
Boring no.	Sam-ple no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200	PL	LL	PI			
TH02-04	1	107	0-5 / Unit 1	100	77	71	56	38	29	22	15	7	2	1	NT	NT	NT	7.8	GW	WELL GRADED GRAVEL WITH SAND
TH02-04	2	108	5-8 / Unit 1	100	100	78	54	36	28	21	13	7	5	3	NT	NT	NT	NT	GW	WELL GRADED GRAVEL WITH SAND
TH02-04	2a	--	8-16.25 / Unit 1	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Sand with gravel
TH02-04	3	109	16.25-18 / Unit 2	100	100	100	96	92	89	84	67	35	23	18	NT	NT	NT	26.8	SM	SILTY SAND
TH02-04	4	110	18-23 / Unit 2	100	100	100	100	100	100	100	99	97	93	86	32	58	26	47.4	MH-OL	ELASTIC SILT-ORGANIC SILT
TH02-04	5	111	23-30.2 / Unit 2	100	100	100	100	100	100	100	97	63	26	13	NT	NT	NT	25.1	SM	SILTY SAND
TH02-04	6	112	30.2-31.2 / Unit 2	100	100	100	100	100	100	100	100	100	99	98	32	62	31	57.4	CH	FAT CLAY
TH02-04	7	113	31.2-39.7 / Unit 2	100	100	100	100	100	99	97	94	81	56	27	NT	NT	NT	41.3	SM	SILTY SAND
TH02-04	8	114	39.7-42 / Unit 2	100	100	100	100	100	100	99	98	97	95	91	41	64	23	61.7	OL	ORGANIC SILT
TH02-04	9	115	42-51.1 / Unit 2	100	100	100	100	100	99	99	96	81	50	20	NT	NT	NT	29.2	SM	SILTY SAND
TH02-04	10	116	51.1-53 / Unit 2	no gradation tests run											NT	NT	NT	36.8		Silt
TH02-04	11	117	53-56.5 / Unit 3	100	100	100	100	100	100	100	100	99	99	96	30	49	19	47.9	ML	SILT
TH02-04	12	118	56.5-63 / Unit 3	100	100	100	100	100	100	100	99	98	97	91	28	52	24	51.8	CH	FAT CLAY
TH02-04	13	119	63-69 / Unit 3	100	100	100	100	100	100	99	98	94	77	64	NP t	NP v	--	37.9	ML	SANDY SILT
TH02-04	14	120	69-73 / Unit 3	100	100	100	100	100	100	100	100	100	100	99	46	77	31	50.6	OL	ORGANIC SILT
TH02-04	15	121	73-75 / Unit 3	100	100	100	100	100	100	100	100	100	100	99	42	71	29	51.3	MH-OL	ELASTIC SILT-ORGANIC SILT
TH02-04	16	122	75-84 / Unit 3	100	100	100	100	100	100	100	99	97	90	69	NP t	NP v	--	37.6	ML	SANDY SILT

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
															PL	LL	PI			
Boring no.	Sam-ple no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200						
TH02-04	17	123	84-88.9 / Unit 3	100	100	100	100	100	100	100	100	99	99	99	42	85	43	56.1	OL	ORGANIC SILT
TH02-04	18	124	88.9-91.5 / Unit 4	100	73	21	3	1	1	1	1	1	1	1	NT	NT	NT	NT	GP	POORLY GRADED GRAVEL
TH02-05	1	125	0-4 / Unit 1	100	86	71	57	43	32	23	15	6	3	1	NT	NT	NT	0. 7	GP	POORLY GRADED GRAVEL WITH SAND
TH02-05	2	126	4-8 / Unit 1	100	100	82	68	55	46	36	23	13	8	5	NT	NT	NT	6.0	SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL
TH02-05	3	127	8-11.2 / Unit 1	100	100	77	71	60	49	33	20	11	8	4	NT	NT	NT	19.2	SP	POORLY GRADED SAND WITH GRAVEL
TH02-05	4	128	11.2-16.2 / Unit 1	environmental tests only on this sample-no laboratory classification											NT	NT	NT	20.6		Sand with gravel
TH02-05	5	129	16.2-23 / Unit 1	100	100	98	83	74	71	69	61	38	25	10	NT	NT	NT	28.2	SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL
TH02-05	6	130	23-26.2 / Unit 2	100	100	100	100	95	90	81	57	24	14	9	NT	NT	NT	NT	SW-SM	WELL GRADED SAND WITH SILT
TH02-05	7	131	26.2-33.7 / Unit 2	100	100	69	64	56	46	35	20	11	10	5	NT	NT	NT	23.2	SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL
TH02-05	8	132	33.7-38 / Unit 2	100	100	100	100	100	99	97	93	84	71	37	NT	NT	NT	NT	SM	SILTY SAND
TH02-05	9	133	38-41.2 / Unit 2	100	100	100	100	100	100	100	99	97	96	90	NT	NT	NT	NT	ML	SILT
TH02-05	10	134	41.2-48 / Unit 2	100	100	100	100	100	100	99	97	96	96	93	NT	NT	NT	34.2	ML	SILT
TH02-05	11	135	48-51.2 / Unit 2	100	100	100	96	94	90	83	67	37	24	8	NT	NT	NT	25.7	SW-SM	WELL GRADED SAND WITH SILT
TH02-05	12	136	51.2-56.2 / Unit 2	100	100	100	97	94	89	75	58	32	22	5	NT	NT	NT	27.4	SW-SM	WELL GRADED SAND WITH SILT
TH02-05	13	137	63-70 / Unit 3	small sample; all material used on Atterberg limits tests											31	56	25	NT		Fat clay

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
Boring no.	Sample no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200	PL	LL	PI			
TH02-05	14	138	72-78 / Unit 3	100	100	100	100	100	100	100	100	99	99	96	28	46	18	43.1	ML	SILT
TH02-05	15	139	78-83 / Unit 3	environmental tests only on this sample-no laboratory classification											NT	NT	NT	39.3		Sandy silt
TH02-05	16	140	83-85.7 / Unit 3	100	100	100	95	95	95	94	94	93	93	91	30	64	34	56.5	CH	FAT CLAY
TH02-06	1	141	0-6.8 / Unit 1	100	89	82	68	58	45	29	18	11	10	5	NT	NT	NT	21.9	SW-SM	WELL GRADED SAND WITH SILT AND GRAVEL
TH02-06	2	142	6.8-12 / Unit 2	100	100	92	83	73	58	38	22	13	11	6	NT	NT	NT	15.0	SW-SM	WELL GRADED SAND WITH SILT AND GRAVEL
TH02-06	3	143	12-16.8 / Unit 2	100	100	100	98	95	90	78	45	21	17	8	NT	NT	NT	19.5	SW-SM	WELL GRADED SAND WITH SILT
TH02-06	4	144	16.8-23.9 / Unit 2	100	100	100	94	87	78	60	33	16	14	7	NT	NT	NT	25.1	SW-SM	WELL GRADED SAND WITH SILT
TH02-06	5	145	23.9-28 / Unit 2	100	100	100	100	98	97	95	93	76	50	23	NT	NT	NT	NT	SM	SILTY SAND
TH02-06	6	146	28-33 / Unit 2	100	100	100	100	100	100	99	98	93	80	42	28	53	25	36.2	SC	CLAYEY SAND
TH02-06	7	147	33-37 / Unit 2	100	100	100	100	100	100	99	87	43	25	9	NT	NT	NT	31.5	SP-SM	POORLY GRADED SAND WITH SILT
TH02-06	8	148	37-41.8 / Unit 4	100	100	71	57	51	49	48	47	45	42	28	NT	NT	NT	29.9	GM	SILTY GRAVEL WITH SAND
TH02-06	9	149	46.8-50.3 / Unit 5	100	100	100	100	82	76	70	66	62	60	48	NT	NT	NT	NT	SM	SILTY SAND WITH GRAVEL
TH02-07	1	150	0-3 / Unit 1	86	72	49	36	28	21	13	5	1	1	1	NT	NT	NT	1.5	GW	WELL GRADED GRAVEL WITH SAND
TH02-07	2	151	4-6.25 / Unit 1	100	100	72	53	35	23	16	12	9	8	4	NT	NT	NT	20.1	GW	WELL GRADED GRAVEL WITH SAND
TH02-07	3	152	6.25-13.8 / Unit 1	100	84	64	48	29	19	13	10	7	6	3	NT	NT	NT	10.0	GW	WELL GRADED GRAVEL WITH SAND

Mechanical analysis, moisture, other lab tests				GRAVEL (in.), % passing				SAND (sieve no.), % passing						Fines	Atterberg			M.C. (%)	Class. symbol	Classification
Boring no.	Sample no.	Lab no.	Depth, top, bottom (ft) / Unit #.	3.0	1.5	3/4	3/8	4	8	16	30	50	100	200	PL	LL	PI			
TH02-07	4	153	13.8-16.5 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Silty sand
TH02-07	5	154	16.5-21.5 / Unit 2	environmental tests only on this sample-no laboratory classification											NT	NT	NT	NT		Silty sand
TH02-07	6	155	21.5-28 / Unit 2	100	100	100	98	94	90	85	79	66	55	28	NT	NT	NT	29.1	SM	SILTY SAND
TH02-07	7	156	28-33 / Unit 2	100	100	100	100	99	98	96	90	71	48	19	NT	NT	NT	44.9	SM	SILTY SAND
TH02-07	8	157	33-36 / Unit 2	100	100	100	95	85	75	65	55	38	32	14	NT	NT	NT	20.8	SM	SILTY SAND WITH GRAVEL
TH02-07	9	158	36-44 / Unit 2	100	100	100	100	99	98	97	91	59	39	13	NT	NT	NT	22.1	SM	SILTY SAND
TH02-07	10	159	44-48.5 / Unit 2	100	100	100	93	83	68	49	27	10	9	3	NT	NT	NT	21.8	SP	POORLY GRADED SAND WITH GRAVEL
TH02-07	11	160	48.5-53 / Unit 2	100	100	100	89	86	85	83	77	60	51	21	NT	NT	NT	32.3	SM	SILTY SAND
TH02-07	12	161	53-53.9 / Unit 2	100	100	100	99	99	98	95	92	78	63	26	NT	NT	NT	72.2	SM	SILTY SAND
TH02-08	1	162	0-7 / Unit 1	100	87	58	45	38	32	28	24	20	18	12	NT	NT	NT	15.4	GP-GM	POORLY GRADED GRAVEL WITH SILT AND SAND
TH02-08	2	163	7-14.9 / Unit 1	100	100	75	46	34	27	22	17	11	9	5	NT	NT	NT	10.6	GP-GM	POORLY GRADED GRAVEL WITH SILT AND SAND
TH02-08	3	164	14.9-19.9 / Unit 2	100	100	100	100	100	100	100	97	70	44	14	30	51	21	NT	SM	SILTY SAND

abbreviations used:
LL = liquid limit
PL = plastic limit
PI = plasticity index
NT = not tested
NP_v = non plastic, based on visual examination only, no test run
NP_t = non plastic, based on results of actual test run

Environmental laboratory test results from Rindge Dam reservoir boring samples.

The ocean disposal test suite, and (separately, at end) the upland disposal test suite.

Ocean disposal test suite, first five samples:

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
				ERL	ERM	SL	ML	fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
				(Long et al., 1999)		(PSDDA, 2000)						
PHYSICAL/CONVENTIONALS								**Unit 1**	**Unit 1**	**Unit 1**	**Unit 2**	**Unit 2**
Total Solids (wet weight)	EPA 160.3M	0.01	%					84.2	78.2	67.9	70.4	67.3
Total Volatile Solids (wet weight)	SM 2540G	0.01	%					1.09	1.07	1.09	5.98	4.20
pH (wet basis)	EPA 9045B	0.1	pH units					7.6 ***(P)***	7.6 ***(P)***	7.9 ***(P)***	7.1 ***(P)***	7.1 ***(P)***
Ammonia (as nitrogen)	EPA 350.1M	varies see test columns	mg/kg					1.9 w/ MRL 0.2 / MDL 0.2	9.6 w/ MRL 0.2 / MDL 0.2	115 w/ MRL 0.4 / MDL 0.2	146 w/ MRL 0.2 / MDL 0.2	86.0 w/ MRL 0.2 / MDL 0.2
Total Organic Carbon	ASTM D4129-82M	0.05/ 0.02	%					0.11	0.13	2.78	2.93	1.59
Soluble Sulfides (acid soluble)	EPA9030B	varies see test columns	mg/kg					ND ***(P)*** w/ MRL 12	ND ***(P)*** w/ MRL 13	ND ***(P)*** w/ MRL 12	51 ***(P)*** w/ MRL 15	67 ***(P)*** w/ MRL 15
Total Sulfides	EPA CE-81-19030B	varies see test columns	mg/kg					ND ***(P)*** w/ MRL 1	ND ***(P)*** w/ MRL 1	ND ***(P)*** w/ MRL 1	85 ***(P)*** w/ MRL 2	140 ***(P)*** w/ MRL 2
Calcium carbonate	ASTM D-4373	0.1	%					0.20	0.20	0.28	0.28	0.28
Oil and Grease	EPA 9071A	varies see test columns	mg/kg					ND w/ MRL 367	487 w/ MRL 387	ND w/ MRL 348	484 w/ MRL 437	ND w/ MRL 446
Total Recoverable Petroleum Hydrocarbons	EPA 418.1	varies see test columns	mg/kg					16 w/ MRL 12	88 w/ MRL 13	89 w/ MRL 12	70 w/ MRL 15	161 w/ MRL 15
METALS												
Antimony (Sb)	EPA 6010B	varies see test	mg/kg			15	200	ND w/ MRL 12	ND w/ MRL 13	ND w/ MRL 12	ND w/ MRL 15	ND w/ MRL 15

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM (Long et al., 1999)	SL (PSDDA, 2000)	ML (PSDDA, 2000)	Sample Testing Results [3] fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
		columns										
Arsenic (As)	EPA 6020	varies see test columns	mg/kg	8.2	70	57	700	ND w/ MRL 12	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 7	ND w/ MRL 7
Cadmium (Cd)	EPA 6010B	varies see test columns	mg/kg	1.2	9.6	5.1	14	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 7	ND w/ MRL 7
Chromium (Cr)	EPA 6010B	varies see test columns	mg/kg	81	370			39 w/ MRL 6	35 w/ MRL 6	41 w/ MRL 6	38 w/ MRL 7	36 w/ MRL 7
Copper (Cu)	EPA 6010B	varies see test columns	mg/kg	34	270	390	1,300	17 w/ MRL 12	13 w/ MRL 13	35 w/ MRL 12	25 w/ MRL 15	15 w/ MRL 15
Lead (Pb)	EPA 6010B	varies see test columns	mg/kg	46.7	218	450	1,200	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 7	ND w/ MRL 7
Mercury (Hg)	EPA 7471A	varies see test columns	mg/kg	0.15	0.71	0.41	2.3	ND w/ MRL 0.1	ND w/ MRL 0.1	ND w/ MRL 0.1	ND w/ MRL 0.1	ND w/ MRL 0.1
Nickel (Ni)	EPA 6010B	varies see test columns	mg/kg	20.9	51.6	140	370	**39** w/ MRL 6	**37** w/ MRL 6	**38** w/ MRL 6	**42** w/ MRL 7	**40** w/ MRL 7
Selenium (Se)	EPA 6020	varies see test columns	mg/kg					ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 7	ND w/ MRL 7
Silver (Ag)	EPA 6010B	varies see test columns	mg/kg	1	3.7	6.1	8.4	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 6	ND w/ MRL 7	ND w/ MRL 7
Zinc (Zn)	EPA 6010B	varies see test columns	mg/kg	150	410	410	3,800	37 w/ MRL 12	30 w/ MRL 13	32 w/ MRL 12	57 w/ MRL 15	42 w/ MRL 15
ORGANICS												
PESTICIDES												
Total Chlorinated Pesticides [4]	EPA 3540C	varies see test columns	ug/kg	6.8	108.1	56.9	69.0	**NR**	**NR**	ND	ND	ND

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM (Long et al., 1999)	SL (PSDDA, 2000)	ML (PSDDA, 2000)	Sample Testing Results [3]: fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
Aldrin	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.2 / MDL 0.28	ND w/ MRL 1.3 / MDL 0.30	ND w/ MRL 1.2 / MDL 0.27	ND w/ MRL 1.5 / MDL 0.34	ND w/ MRL 1.5 / MDL 0.34
alpha BHC	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.13	ND w/ MRL 1.3 / MDL 0.14	ND w/ MRL 1.2 / MDL 0.12	ND w/ MRL 1.5 / MDL 0.15	ND w/ MRL 1.5 / MDL 0.15
beta-BHC	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.18	ND w/ MRL 1.3 / MDL 0.19	ND w/ MRL 1.2 / MDL 0.17	ND w/ MRL 1.5 / MDL 0.21	ND w/ MRL 1.5 / MDL 0.21
delta-BHC	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.44	ND w/ MRL 1.3 / MDL 0.48	ND w/ MRL 1.2 / MDL 0.43	ND w/ MRL 1.5 / MDL 0.53	ND w/ MRL 1.5 / MDL 0.53
gamma-BHC Lindane	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.2 / MDL 0.29	ND w/ MRL 1.3 / MDL 0.32	ND w/ MRL 1.2 / MDL 0.28	ND w/ MRL 1.5 / MDL 0.35	ND w/ MRL 1.5 / MDL 0.35
alpha-Chlordane	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.2 / MDL 0.13	ND w/ MRL 1.3 / MDL 0.14	ND w/ MRL 1.2 / MDL 0.13	ND w/ MRL 1.5 / MDL 0.16	ND w/ MRL 1.5 / MDL 0.16
gamma-Chlordane	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.18	ND w/ MRL 1.3 / MDL 0.19	ND w/ MRL 1.2 / MDL 0.17	ND w/ MRL 1.5 / MDL 0.21	ND w/ MRL 1.5 / MDL 0.21
Dieldrin	EPA 3540C	varies see test columns	ug/kg	0.02	8.0	10		ND w/ MRL 1.2 / MDL 0.37	ND w/ MRL 1.3 / MDL 0.40	ND w/ MRL 1.2 / MDL 0.36	ND w/ MRL 1.5 / MDL 0.44	ND w/ MRL 1.5 / MDL 0.44
Total DDT [5]	EPA 3540C	varies see test columns	ug/kg	1.58	46.1	6.9	69.0	NR	NR	ND	ND	ND
4,4'-DDD	EPA 3540C	varies see test columns)	ug/kg	1.0	7.0			0.18 w/ MRL 1.2 / MDL 0.18	ND w/ MRL 1.3 / MDL 0.20	ND w/ MRL 1.2 / MDL 0.18	ND w/ MRL 1.5 / MDL 0.22	ND w/ MRL 1.5 / MDL 0.22
4,4'-DDE	EPA 3540C	varies see test columns	ug/kg	2.2	27			ND w/ MRL 1.2 / MDL 0.30	ND w/ MRL 1.3 / MDL 0.32	ND w/ MRL 1.2 / MDL 0.29	ND w/ MRL 1.5 / MDL 0.35	ND w/ MRL 1.5 / MDL 0.35
4,4'-DDT	EPA 3540C	varies see test columns	ug/kg	2.0	20			ND w/ MRL 1.2 / MDL 0.21	0.26 w/ MRL 1.3 / MDL 0.22	ND w/ MRL 1.2 / MDL 0.20	ND w/ MRL 1.5 / MDL 0.25	ND w/ MRL 1.5 / MDL 0.24

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	Sample Testing Results [3] fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
	Endosulfan I	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.15	ND w/ MRL 1.3 / MDL 0.16	ND w/ MRL 1.2 / MDL 0.15	ND w/ MRL 1.5 / MDL 0.18	ND w/ MRL 1.5 / MDL 0.18
	Endosulfan II	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.26	ND w/ MRL 1.3 / MDL 0.28	ND w/ MRL 1.2 / MDL 0.25	ND w/ MRL 1.5 / MDL 0.31	ND w/ MRL 1.5 / MDL 0.31
	Endosulfan Sulfate	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.20	ND w/ MRL 1.3 / MDL 0.21	ND w/ MRL 1.3 / MDL 0.21	ND w/ MRL 1.5 / MDL 0.23	ND w/ MRL 1.5 / MDL 0.23
	Endrin	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.16	ND w/ MRL 1.3 / MDL 0.17	ND w/ MRL 1.2 / MDL 0.19	ND w/ MRL 1.5 / MDL 0.19	ND w/ MRL 1.5 / MDL 0.19
	Endrin Aldehyde	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.42	ND w/ MRL 1.3 / MDL 0.46	ND w/ MRL 1.2 / MDL 0.41	ND w/ MRL 1.5 / MDL 0.51	ND w/ MRL 1.5 / MDL 0.50
	Endrin Ketone	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.19	ND w/ MRL 1.3 / MDL 0.21	ND w/ MRL 1.2 / MDL 0.19	ND w/ MRL 1.5 / MDL 0.23	ND w/ MRL 1.5 / MDL 0.23
	Heptachlor	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.2 / MDL 0.17	ND w/ MRL 1.3 / MDL 0.18	ND w/ MRL 1.2 / MDL 0.16	ND w/ MRL 1.5 / MDL 0.20	ND w/ MRL 1.5 / MDL 0.20
	Heptachlor Epoxide	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.17	ND w/ MRL 1.3 / MDL 0.18	ND w/ MRL 1.2 / MDL 0.16	ND w/ MRL 1.5 / MDL 0.20	ND w/ MRL 1.5 / MDL 0.20
	Methoxychlor	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.2 / MDL 0.20	ND w/ MRL 1.3 / MDL 0.21	ND w/ MRL 1.2 / MDL 0.19	ND w/ MRL 1.5 / MDL 0.23	ND w/ MRL 1.5 / MDL 0.23
	Toxaphene	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 60 / MDL 11	ND w/ MRL 64 / MDL 12	ND w/ MRL 58 / MDL 11	ND w/ MRL 71 / MDL 14	ND w/ MRL 71 / MDL 14
	ORGANOTINS												
	Total Organotins [4]			ug/kg					ND	ND	ND	ND	ND
	Monobutyltin (n-Butyltin)	Krone	varies see tests column	ug/kg					ND w/ MRL 1.2 / MDL 0.56	ND w/ MRL 1.3 / MDL 0.61	ND w/ MRL 1.2 / MDL 0.54	ND w/ MRL 1.4 / MDL 0.67	ND w/ MRL 1.4 / MDL 0.67
	Di-n-butyltin	Krone	varies	ug/kg					ND w/	ND w/	ND w/	ND w/	ND w/

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
				ERL	ERM	SL	ML	fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
				(Long et al., 1999)		(PSDDA, 2000)						
		see tests column						MRL 1.2 / MDL 0.87	MRL 1.3 / MDL 0.94	MRL 1.2 / MDL 0.84	MRL 1.4 / MDL 1.1	MRL 1.4 / MDL 1.1
Tri-n-butyltin	Krone	varies see tests column	ug/kg					ND w/ MRL 1.2 / MDL 0.43	ND w/ MRL 1.3 / MDL 0.47	ND w/ MRL 1.2 / MDL 0.42	ND w/ MRL 1.4 / MDL 0.52	ND w/ MRL 1.4 / MDL 0.51
Tetra-n-butyltin	Krone	varies see tests column	ug/kg			0.15 [7]		ND w/ MRL 1.2 / MDL 0.97	ND w/ MRL 1.3 / MDL 1.1	ND w/ MRL 1.2 / MDL 0.93	ND w/ MRL 1.4 / MDL 1.2	ND w/ MRL 1.4 / MDL 1.2
PHTHALATES												
Total phthalates [4]			mg/kg			23,170		ND	**NR**	**NR**	ND	**NR**
Bis (2-ethylhexyl) phthalate	EPA 8270C	varies see tests column	mg/kg			8,300		ND w/ MRL 0.40 / MDL 0.023	0.079 w/ MRL 0.43 / MDL 0.024	0.053 w/ MRL 0.38 / MDL 0.022	ND w/ MRL 0.47 / MDL 0.027	0.027 w/ MRL 0.47 / MDL 0.027
Butyl benzyl phthalate	EPA 8270C	varies see tests column	mg/kg			970		ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.021	ND w/ MRL 0.38 / MDL 0.019	ND w/ MRL 0.47 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
Diethyl phthalate	EPA 8270C	varies see tests column	mg/kg			1,200		ND w/ MRL 0.40 / MDL 0.017	ND w/ MRL 0.43 / MDL 0.019	ND w/ MRL 0.38 / MDL 0.017	ND w/ MRL 0.47 / MDL 0.021	ND w/ MRL 0.47 / MDL 0.020
Dimethyl phthalate	EPA 8270C	varies see tests column	mg/kg			1,400		ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.021	ND w/ MRL 0.38 / MDL 0.019	ND w/ MRL 0.40 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
Di-n-butyl phthalate	EPA 8270C	varies see tests column	mg/kg			5,100		ND w/ MRL 0.40 / MDL 0.015	ND w/ MRL 0.40 / MDL 0.016	ND w/ MRL 0.38 / MDL 0.014	ND w/ MRL 0.47 / MDL 0.018	ND w/ MRL 0.47 / MDL 0.018
Di-n-octyl phthalate	EPA 8270C	varies see tests column	mg/kg			6,200		ND w/ MRL 0.40 / MDL 0.029	ND w/ MRL 0.40 / MDL 0.031	ND w/ MRL 0.38 / MDL 0.028	ND w/ MRL 0.47 / MDL 0.035	ND w/ MRL 0.47 / MDL 0.034
POLYCHLORINATED BIPHENYLS (PCB)												
Total PCBs [4]			ug/kg	22.7	180	130	3,100	**NR**	**NR**	ND	**NR**	**NR**
Aroclor 1016	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
Aroclor 1221	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 24 / MDL 0.98	1.1 w/ MRL 26 / MDL 1.1	ND w/ MRL 23 / MDL 0.94	1.2w/ MRL 29 / MDL 1.2	1.2w/ MRL 29 / MDL 1.2

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method (1)	Method Reporting Limit / Method Detection Limit(1a)	Units (2)	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	Sample Testing Results (3): fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
Aroclor 1232	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
Aroclor 1242	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
Aroclor 1248	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
Aroclor 1254	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
Aroclor 1260	EPA 8082	varies see tests column	ug/kg					0.98 w/ MRL 12 / MDL 0.98	1.1 w/ MRL 13 / MDL 1.1	ND w/ MRL 12 / MDL 0.94	1.2 w/ MRL 15 / MDL 1.2	1.2 w/ MRL 15 / MDL 1.2
POLYNUCLEAR AROMATICS HYDROCARBONS (PAH)												
Total PAHs (4)			ug/kg	4,022	44,792			**NR**	**NR**	**NR**	**NR**	12 **
2-Methylnaphthalene	EPA 8270C SIM	varies see tests column	ug/kg	70	670	670	1,900	0.26 w/ MRL 6 / MDL 0.25	0.49 w/ MRL 6.4 / MDL 0.27	0.31 w/ MRL 5.8 / MDL 0.25	3.0 w/ MRL 7.1 / MDL 0.30	4.5 w/ MRL 7.1 / MDL 0.30
Acenaphthene	EPA 8270C SIM	varies see tests column	ug/kg	16	500	500	2,000	ND w/ MRL 6 / MDL 0.25	ND w/ MRL 6.4 / MDL 0.27	ND w/ MRL 5.8 / MDL 0.25	0.35 w/ MRL 7.1 / MDL 0.30	0.38 w/ MRL 7.1 / MDL 0.30
Acenaphthylene	EPA 8270C SIM	varies see tests column	ug/kg	44	640	560	1,300	ND w/ MRL 6 / MDL 0.20	ND w/ MRL 6.4 / MDL 0.21	ND w/ MRL 5.8 / MDL 0.19	ND w/ MRL 7.1 / MDL 0.23	0.27 w/ MRL 7.1 / MDL 0.23
Anthracene	EPA 8270C SIM	varies see tests column	ug/kg	85.3	1,100	960	13,000	ND w/ MRL 6 / MDL 0.23	ND w/ MRL 6.4 / MDL 0.25	ND w/ MRL 5.8 / MDL 0.22	0.63 w/ MRL 7.1 / MDL 0.27	0.71 w/ MRL 7.1 / MDL 0.27
Benzo(a)anthracene	EPA 8270C SIM	varies see tests column	ug/kg	261	1,600	1,300	5,100	ND w/ MRL 6 / MDL 0.16	0.20 w/ MRL 6.4 / MDL 0.17	0.44 w/ MRL 5.8 / MDL 0.15	ND w/ MRL 7.1 / MDL 0.19	1.2 w/ MRL 7.1 / MDL 0.19
Benzo(a)pyrene	EPA 8270C SIM	varies see tests column	ug/kg	430	1,600	1,600	3,600	ND w/ MRL 6 / MDL 0.17	ND w/ MRL 6.4 / MDL 0.18	ND w/ MRL 5.8 / MDL 0.17	0.94 w/ MRL 7.1 / MDL 0.20	0.76 w/ MRL 7.1 / MDL 0.20
Benzo(b)fluoranthene	EPA 8270C SIM	varies	ug/kg			1,600	4,950	0.23 w/	0.26 w/	0.18 w/	1.2 w/	0.78 w/

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method (1)	Method Reporting Limit / Method Detection Limit(1a)	Units (2)	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM (Long et al., 1999)	SL (PSDDA, 2000)	ML (PSDDA, 2000)	Sample Testing Results (3) fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
			see tests column						MRL 6 / MDL 0.17	MRL 6.4 / MDL 0.18	MRL 5.8 / MDL 0.17	MRL 7.1 / MDL 0.20	MRL 7.1 / MDL 0.20
	Benzo(k)fluoranthene	EPA 8270C SIM	varies see tests column	ug/kg			1,600	4,950	ND w/ MRL 6 / MDL 0.18	ND w/ MRL 6.4 / MDL 0.20	ND w/ MRL 5.8 / MDL 0.18	0.71 w/ MRL 7.1 / MDL 0.22	0.66 w/ MRL 7.1 / MDL 0.22
	Benzo(g,h,i)perylene	EPA 8270C SIM	varies see tests column	ug/kg			670	3,200	0.29 w/ MRL 6 / MDL 0.12	0.27 w/ MRL 6.4 / MDL 0.13	0.25 w/ MRL 5.8 / MDL 0.12	1.4 w/ MRL 7.1 / MDL 0.15	1.1 w/ MRL 7.1 / MDL 0.15
	Chrysene	EPA 8270C SIM	varies see tests column	ug/kg	384	2,800	1,400	21,000	0.44 w/ MRL 6 / MDL 0.18	0.39 w/ MRL 6.4 / MDL 0.20	0.43 w/ MRL 5.8 / MDL 0.18	1.6 w/ MRL 7.1 / MDL 0.22	1.8 w/ MRL 7.1 / MDL 0.22
	Dibenzo(a,h)anthracene	EPA 8270C SIM	varies see tests column	ug/kg	63.4	260	230	1,900	ND w/ MRL 6 / MDL 0.22	ND w/ MRL 6.4 / MDL 0.24	ND w/ MRL 5.8 / MDL 0.21	ND w/ MRL 7.1 / MDL 0.26	ND w/ MRL 7.1 / MDL 0.26
	Fluoranthene	EPA 8270C SIM	varies see tests column	ug/kg	600	5,100	1,700	30,000	0.46 w/ MRL 6 / MDL 0.21	0.49 w/ MRL 6.4 / MDL 0.22	0.37 w/ MRL 5.8 / MDL 0.20	2.9 w/ MRL 7.1 / MDL 0.25	2.8 w/ MRL 7.1 / MDL 0.21
	Fluorene	EPA 8270C SIM	varies see tests column	ug/kg	19	540	540	3,600	ND w/ MRL 6 / MDL 0.21	ND w/ MRL 6.4 / MDL 0.22	ND w/ MRL 5.8 / MDL 0.20	4.4 w/ MRL 7.1 / MDL 0.25	3.4 w/ MRL 7.1 / MDL 0.25
	Indeno(1,2,3-cd)pyrene	EPA 8270C SIM	varies see tests column	ug/kg			600	4,400	ND w/ MRL 6 / MDL 0.18	ND w/ MRL 6.4 / MDL 0.20	ND w/ MRL 5.8 / MDL 0.18	1.2 w/ MRL 7.1 / MDL 0.22	1.1 w/ MRL 7.1 / MDL 0.22
	Naphthalene	EPA 8270C SIM	varies see tests column	ug/kg	160	2,100	2,100	2,400	0.39 w/ MRL 6 / MDL 0.21	0.45 w/ MRL 6.4 / MDL 0.27	0.83 w/ MRL 5.8 / MDL 0.25	7.0 w/ MRL 7.1 / MDL 0.30	12 w/ MRL 7.1 / MDL 0.30
	Phenanthrene	EPA 8270C SIM	varies see tests column	ug/kg	240	1,500	1,500	21,000	0.69 w/ MRL 6 / MDL 0.18	0.48 w/ MRL 6.4 / MDL 0.20	0.49 w/ MRL 5.8 / MDL 0.18	4.6 w/ MRL 7.1 / MDL 0.22	5.6 w/ MRL 7.1 / MDL 0.22
	Pyrene	EPA 8270C SIM	varies see tests column	ug/kg	665	2,600	2,600	16,000	0.68 w/ MRL 6 / MDL 0.14	0.51 w/ MRL 6.4 / MDL 0.15	0.43 w/ MRL 5.8 / MDL 0.13	2.6 w/ MRL 7.1 / MDL 0.16	2.6 w/ MRL 7.1 / MDL 0.16
	PHENOLS												
	Total Phenols (4)			mg/kg			1582	5777	ND	ND	ND	ND	ND
	2,4-Dimethylphenol	EPA 8270C	varies see tests	mg/kg			29	210	ND w/ MRL 0.40 /	ND w/ MRL 0.43 /	ND w/ MRL 0.38 /	ND w/ MRL 0.47 /	ND w/ MRL 0.47 /

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [(1)]	Method Reporting Limit / Method Detection Limit[(1a)]	Units [(2)]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [(3)]				
					ERL	ERM	SL	ML	fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
					(Long et al., 1999)		(PSDDA, 2000)						
			column						MDL 0.018	MDL 0.020	MDL 0.018	MDL 0.022	MDL 0.022
	2-Methylphenol	EPA 8270C	varies see tests column	mg/kg			63	77	ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.022	ND w/ MRL 0.38 / MDL 0.020	ND w/ MRL 0.47 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
	4-Methylphenol **(see note at end of this part of table)**	EPA 8270C	varies see tests column	mg/kg			670	3,600	ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.022	ND w/ MRL 0.38 / MDL 0.020	ND w/ MRL 0.47 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
	Pentachlorophenol	EPA 8270C	varies see tests column	mg/kg			400	690	ND w/ MRL 2.4 / MDL 0.15	ND w/ MRL 2.6 / MDL 0.16	ND w/ MRL 2.3 / MDL 0.15	ND w/ MRL 2.9 / MDL 0.18	ND w/ MRL 2.9 / MDL 0.18
	2-Chlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.012	ND w/ MRL 0.43 / MDL 0.013	ND w/ MRL 0.38 / MDL 0.012	ND w/ MRL 0.47 / MDL 0.015	ND w/ MRL 0.47 / MDL 0.015
	4-Chloro-3-methylphenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.022	ND w/ MRL 0.38 / MDL 0.019	ND w/ MRL 0.47 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
	2,4-Dichlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.020	ND w/ MRL 0.43 / MDL 0.021	ND w/ MRL 0.38 / MDL 0.019	ND w/ MRL 0.47 / MDL 0.024	ND w/ MRL 0.47 / MDL 0.024
	2-Nitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.017	ND w/ MRL 0.43 / MDL 0.018	ND w/ MRL 0.38 / MDL 0.016	ND w/ MRL 0.47 / MDL 0.020	ND w/ MRL 0.47 / MDL 0.020
	4-Nitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.4 / MDL 0.18	ND w/ MRL 2.6 / MDL 0.19	ND w/ MRL 2.3 / MDL 0.17	ND w/ MRL 2.9 / MDL 0.21	ND w/ MRL 2.9 / MDL 0.21
	2,4-Dinitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.4 / MDL 0.14	ND w/ MRL 2.6 / MDL 0.15	ND w/ MRL 2.3 / MDL 0.13	ND w/ MRL 2.9 / MDL 0.16	ND w/ MRL 2.9 / MDL 0.16
	2-Methyl-4,6-dinitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.4 / MDL 0.18	ND w/ MRL 2.6 / MDL 0.19	ND w/ MRL 2.3 / MDL 0.17	ND w/ MRL 2.9 / MDL 0.21	ND w/ MRL 2.9 / MDL 0.21
	2,4,5-Trichlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.021	ND w/ MRL 0.43 / MDL 0.022	ND w/ MRL 0.38 / MDL 0.020	ND w/ MRL 0.47 / MDL 0.025	ND w/ MRL 0.47 / MDL 0.025
	2,4,6-Trichlorophenol	EPA 8270C	varies see tests	mg/kg					ND w/ MRL 0.40 /	ND w/ MRL 0.43 /	ND w/ MRL 0.38 /	ND w/ MRL 0.47 /	ND w/ MRL 0.47 /

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
					ERL	ERM	SL	ML	fluvial sand TH02-01-sample 5 & TH02-04 sample 2a	fluvial sand TH02-03-sample 3 & TH02-05 samples 4, 6	fluvial sand TH02-06-samples 2, 3, 4	reservoir sand TH02-01-samples 9, 12	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9
					(Long et al., 1999)		(PSDDA, 2000)						
			column						MDL 0.017	MDL 0.019	MDL 0.017	MDL 0.021	MDL 0.021
	Phenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.40 / MDL 0.024	ND w/ MRL 0.43 / MDL 0.025	ND w/ MRL 0.38 / MDL 0.023	ND w/ MRL 0.47 / MDL 0.028	ND w/ MRL 0.47 / MDL 0.028

(1) Analytical Method
EPA = United States Environmental Protection Agency
EPA Methods are EPA SW-846, 1994 3rd Edition or EPA 600/4-79-020, March 1983
SM = Standard Methods for wastewater analysis
ASTM = American Society for Testing and Materials
Plumb = Procedure for Handling and Chemical Analysis of Sediment and Water Samples. Tech Rep. USEPA/CE-81, Russell H. Plumb, Jr., 1981.
Krone =

(1a) If only one value is listed in the column, it is the MRL (method reporting limit); the second value listed in this column is the MDL (the method detection limit). In the individual test results columns, if a numerical value is listed, that analyte is present, but is *quantifiable* only if value listed also is above the MRL (method reporting limit); analyte values in numerical range *between* the MDL and MRL are estimates only; condition usually due to interference within the testing machinery from other substances within the sample.

(2) Units: all listed values based on dry weight unless otherwise noted; ug/kg = micrograms per kilogram, parts per billion; mg/kg = milligrams per kilogram, parts per million (dry weight unless otherwise noted)

(3) ND = not detected at or above lowest Method Detection Limit value for the particular compound(s) of interest
NT = not tested for a given analyte; NR = detectable quantities present but none exceed MRL so no viable total value can be reported here; " * " = some values over MRL, but others below MRL were detected, so this "total" is less than actual total, but no actual total can be calculated due to MRL limitations

(4) Total Chlorinated Pesticides, Total Organotins (Butyltins), Total Phthalates, Total PCBs, Total PAHs, and Total Phenols = sum of named compounds and their derivatives

(5) Total DDT = sum of 4,4'-DDE; 4,4'-DDD; and 4,4'-DDT

(P) = analyzed past holding time for this analyte.

Note concerning 4 Methylphenol analysis for all 5 samples on this part of the table (that is, composited samples TH02-01 sample 5 and TH02-04 sample 2a; composited samples TH02-03 sample 3 and TH02-05 samples 4 & 6; composited samples TH02-06 samples 2, 3, 4; composited samples TH02-01 samples 9, 12; TH02-03 samples 6, 9, 10 & TH02-05 samples 8, 9): Laboratory could not separate 4-Methylphenol from 3-Methylphenol

Ocean disposal test suite, sixth through ninth sample:

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	Sample Testing Results [3] reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
PHYSICAL/CONVENTIONALS								**Unit 2**	**Unit 3**	**Unit 3**	**Unit 3**	
Total Solids (wet weight)	EPA 160.3M	0.01	%					79.5	64.8	76.5	67.9	
Total Volatile Solids (wet weight)	SM 2540G	0.01	%					1.09	7.68	6.88	5.84	
pH (wet basis)	EPA 9045B	0.1	pH units					7.9 ***(P)***	7.2 ***(P)***	7.2 ***(P)***	7.6 ***(P)***	
Ammonia (as nitrogen)	EPA 350.1M	varies see test columns	mg/kg					35.7 w/ MRL 0.4 / MDL 0.2	326 w/ MRL 0.2 / MDL 0.2	88.3 w/ MRL 0.2 / MDL 0.2	115 w/ MRL 0.4 / MDL 0.2	
Total Organic Carbon	ASTM D4129-82M	0.05/ 0.02	%					1.08	2.28	1.93	2.78	
Soluble Sulfides (acid soluble)	EPA9030B	varies see test columns	mg/kg					41 ***(P)*** w/ MRL 15	116 ***(P)*** w/ MRL 16	92 ***(P)*** w/ MRL 15	128 ***(P)*** w/ MRL 16	
Total Sulfides	EPA CE-81-19030B	varies see test columns	mg/kg					80 ***(P)*** w/ MRL 2	393 ***(P)*** w/ MRL 2	136 ***(P)*** w/ MRL 2	306 ***(P)*** w/ MRL 2	
Calcium carbonate	ASTM D-4373	0.1	%					0.20	0.45	0.36	0.53	
Oil and Grease	EPA 9071A	varies see test columns	mg/kg					ND w/ MRL 450	ND w/ MRL 470	535 w/ MRL 450	ND w/ MRL 464	
Total Recoverable Petroleum Hydrocarbons	EPA 418.1	varies see test columns	mg/kg					103 w/ MRL 15	28 w/ MRL 16	77 w/ MRL 15	111 w/ MRL 16	
METALS												
Antimony (Sb)	EPA 6010B	varies see test columns	mg/kg			15	200	ND w/ MRL 15	ND w/ MRL 16	ND w/ MRL 15	ND w/ MRL 15	
Arsenic (As)	EPA 6020	varies see test columns	mg/kg	8.2	70	57	700	ND w/ MRL 7	ND w/ MRL 8	ND w/ MRL 7	ND w/ MRL 8	
Cadmium (Cd)	EPA 6010B	varies see test columns	mg/kg	1.2	9.6	5.1	14	ND w/ MRL 7	ND w/ MRL 8	ND w/ MRL 7	ND w/ MRL 8	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
				ERL	ERM	SL	ML	reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
				(Long et al., 1999)		(PSDDA, 2000)						
Chromium (Cr)	EPA 6010B	varies see test columns	mg/kg	81	370			57 w/ MRL 7	56 w/ MRL 8	63 w/ MRL 7	59 w/ MRL 8	
Copper (Cu)	EPA 6010B	varies see test columns	mg/kg	34	270	390	1,300	28 w/ MRL 15	**39** w/ MRL 16	33 w/ MRL 15	**42** w/ MRL 15	
Lead (Pb)	EPA 6010B	varies see test columns	mg/kg	46.7	218	450	1,200	ND w/ MRL 7	11 w/ MRL 8	9 w/ MRL 7	9 w/ MRL 8	
Mercury (Hg)	EPA 7471A	varies see test columns	mg/kg	0.15	0.71	0.41	2.3	ND w/ MRL 0.1	ND w/ MRL 0.2	ND w/ MRL 0.1	ND w/ MRL 0.2	
Nickel (Ni)	EPA 6010B	varies see test columns	mg/kg	20.9	51.6	140	370	**60** w/ MRL 7	**64** w/ MRL 8	**69** w/ MRL 7	**74** w/ MRL 8	
Selenium (Se)	EPA 6020	varies see test columns	mg/kg					ND w/ MRL 7	ND w/ MRL 8	ND w/ MRL 7	ND w/ MRL 8	
Silver (Ag)	EPA 6010B	varies see test columns	mg/kg	1	3.7	6.1	8.4	ND w/ MRL 7	ND w/ MRL 8	ND w/ MRL 7	ND w/ MRL 8	
Zinc (Zn)	EPA 6010B	varies see test columns	mg/kg	150	410	410	3,800	52 w/ MRL 15	99 w/ MRL 16	84 w/ MRL 15	77 w/ MRL 15	
ORGANICS												
PESTICIDES												
Total Chlorinated Pesticides [4]	EPA 3540C	varies see test columns	ug/kg	6.8	108.1	56.9	69.0	ND	ND	ND	ND	
Aldrin	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.3 / MDL 0.30	ND w/ MRL 1.6 / MDL 0.36	ND w/ MRL 1.4 / MDL 0.31	ND w/ MRL 1.5 / MDL 0.35	
alpha BHC	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.13	ND w/ MRL 1.6 / MDL 0.16	ND w/ MRL 1.4 / MDL 0.14	ND w/ MRL 1.5 / MDL 0.16	
beta-BHC	EPA 3540C	varies	ug/kg					ND w/	ND w/	ND w/	ND w/	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
				ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
		see test columns						MRL 1.3 / MDL 0.19	MRL 1.6 / MDL 0.23	MRL 1.4 / MDL 1.1	MRL 1.5 / MDL 0.22	
delta-BHC	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.47	ND w/ MRL 1.6 / MDL 0.57	ND w/ MRL 1.4 / MDL 0.49	ND w/ MRL 1.5 / MDL 0.55	
gamma-BHC Lindane	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.3 / MDL 0.31	ND w/ MRL 1.6 / MDL 0.38	ND w/ MRL 1.4 / MDL 1.4	ND w/ MRL 1.5 / MDL 0.36	
alpha-Chlordane	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.3 / MDL 0.14	ND w/ MRL 1.6 / MDL 0.17	ND w/ MRL 1.4 / MDL 0.50	ND w/ MRL 1.5 / MDL 0.16	
gamma-Chlordane	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.19	ND w/ MRL 1.6 / MDL 0.23	ND w/ MRL 1.4 / MDL 0.20	ND w/ MRL 1.5 / MDL 0.22	
Dieldrin	EPA 3540C	varies see test columns	ug/kg	0.02	8.0	10		ND w/ MRL 1.3 / MDL 0.39	ND w/ MRL 1.6 / MDL 0.48	ND w/ MRL 1.4 / MDL 0.40	ND w/ MRL 1.5 / MDL 0.46	
Total DDT [5]	EPA 3540C	varies see test columns	ug/kg	1.58	46.1	6.9	69.0	ND	ND	ND	ND	
4,4'-DDD	EPA 3540C	varies see test columns)	ug/kg	1.0	7.0			ND w/ MRL 1.3 / MDL 0.19	ND w/ MRL 1.6 / MDL 0.24	ND w/ MRL 1.4 / MDL 0.20	ND w/ MRL 1.5 / MDL 0.23	
4,4'-DDE	EPA 3540C	varies see test columns	ug/kg	2.2	27			ND w/ MRL 1.3 / MDL 0.31	ND w/ MRL 1.6 / MDL 0.38	ND w/ MRL 1.4 / MDL 0.33	ND w/ MRL 1.5 / MDL 0.37	
4,4'-DDT	EPA 3540C	varies see test columns	ug/kg	2.0	20			ND w/ MRL 1.3 / MDL 0.22	ND w/ MRL 1.6 / MDL 0.27	ND w/ MRL 1.4 / MDL 0.23	ND w/ MRL 1.5 / MDL 0.25	
Endosulfan I	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.16	ND w/ MRL 1.6 / MDL 0.19	ND w/ MRL 1.4 / MDL 0.25	ND w/ MRL 1.5 / MDL 0.19	
Endosulfan II	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.28	ND w/ MRL 1.6 / MDL 0.34	ND w/ MRL 1.4 / MDL 0.29	ND w/ MRL 1.5 / MDL 0.33	
Endosulfan Sulfate	EPA 3540C	varies	ug/kg					ND w/	ND w/	ND w/	ND w/	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	Sample Testing Results [3] reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
			see test columns						MRL 1.3 / MDL 0.21	MRL 1.6 / MDL 0.25	MRL 1.4 / MDL 0.84	MRL 1.5 / MDL 0.24	
	Endrin	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.17	ND w/ MRL 1.6 / MDL 0.21	ND w/ MRL 1.4 / MDL 0.18	ND w/ MRL 1.5 / MDL 0.20	
	Endrin Aldehyde	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.45	ND w/ MRL 1.6 / MDL 0.55	ND w/ MRL 1.4 / MDL 0.47	ND w/ MRL 1.5 / MDL 0.52	
	Endrin Ketone	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.20	ND w/ MRL 1.6 / MDL 0.25	ND w/ MRL 1.4 / MDL 0.21	ND w/ MRL 1.5 / MDL 0.24	
	Heptachlor	EPA 3540C	varies see test columns	ug/kg			10		ND w/ MRL 1.3 / MDL 0.17	ND w/ MRL 1.6 / MDL 0.21	ND w/ MRL 1.4 / MDL 0.18	ND w/ MRL 1.5 / MDL 0.20	
	Heptachlor Epoxide	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.18	ND w/ MRL 1.6 / MDL 0.21	ND w/ MRL 1.4 / MDL 0.18	ND w/ MRL 1.5 / MDL 0.21	
	Methoxychlor	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 1.3 / MDL 0.21	ND w/ MRL 1.6 / MDL 0.25	ND w/ MRL 1.4 / MDL 0.22	ND w/ MRL 1.5 / MDL 0.24	
	Toxaphene	EPA 3540C	varies see test columns	ug/kg					ND w/ MRL 63 / MDL 13	ND w/ MRL 77 / MDL 15	ND w/ MRL 66 / MDL 13	ND w/ MRL 74 / MDL 14	
	ORGANOTINS												
	Total Organotins [4]			ug/kg					ND	ND	ND	ND	
	Monobutyltin (n-Butyltin)	Krone	varies see tests column	ug/kg					ND w/ MRL 1.3 / MDL 0.60	ND w/ MRL 1.6 / MDL 0.73	ND w/ MRL 1.3 / MDL 0.62	ND w/ MRL 1.5 / MDL 0.70	
	Di-n-butyltin	Krone	varies see tests column	ug/kg					ND w/ MRL 1.3 / MDL 0.92	ND w/ MRL 1.6 / MDL 1.2	ND w/ MRL 1.3 / MDL 0.96	ND w/ MRL 1.5 / MDL 1.1	
	Tri-n-butyltin	Krone	varies see tests column	ug/kg					ND w/ MRL 1.3 / MDL 0.46	ND w/ MRL 1.6 / MDL 0.56	ND w/ MRL 1.3 / MDL 0.48	ND w/ MRL 1.5 / MDL 0.54	
	Tetra-n-butyltin	Krone	varies see tests	ug/kg			0.15 [7]		ND w/ MRL 1.3 /	ND w/ MRL 1.6 /	ND w/ MRL 1.3 /	ND w/ MRL 1.5 /	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM	SL (PSDDA, 2000)	ML	Sample Testing Results [3] reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
		column						MDL 1.1	MDL 1.3	MDL 1.1	MDL 1.2	
PHTHALATES												
Total phthalates [4]			mg/kg			23,170		ND	ND	ND	**NR**	
Bis (2-ethylhexyl) phthalate	EPA 8270C	varies see tests column	mg/kg			8,300		ND w/ MRL 0.42 / MDL 0.024	ND w/ MRL 0.51 / MDL 0.029	ND w/ MRL 0.44 / MDL 0.025	0.050 w/ MRL 0.49 / MDL 0.028	
Butyl benzyl phthalate	EPA 8270C	varies see tests column	mg/kg			970		ND w/ MRL 0.42 / MDL 0.021	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	
Diethyl phthalate	EPA 8270C	varies see tests column	mg/kg			1,200		ND w/ MRL 0.42 / MDL 0.018	ND w/ MRL 0.51 / MDL 0.022	ND w/ MRL 0.44 / MDL 0.019	ND w/ MRL 0.49 / MDL 0.021	
Dimethyl phthalate	EPA 8270C	varies see tests column	mg/kg			1,400		ND w/ MRL 0.42 / MDL 0.021	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	
Di-n-butyl phthalate	EPA 8270C	varies see tests column	mg/kg			5,100		ND w/ MRL 0.42 / MDL 0.016	ND w/ MRL 0.51 / MDL 0.019	ND w/ MRL 0.44 / MDL 0.016	ND w/ MRL 0.49 / MDL 0.018	
Di-n-octyl phthalate	EPA 8270C	varies see tests column	mg/kg			6,200		ND w/ MRL 0.42 / MDL 0.031	ND w/ MRL 0.51 / MDL 0.038	ND w/ MRL 0.44 / MDL 0.032	ND w/ MRL 0.49 / MDL 0.036	
POLYCHLORINATED BIPHENYLS (PCB)												
Total PCBs [4]			ug/kg	22.7	180	130	3,100	ND	**NR**	**NR**	ND	
Aroclor 1016	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 13 / MDL 1.1	1.3 w/ MRL 16 / MDL 1.3	1.1 w/ MRL 14 / MDL 1.1	ND w/ MRL 15 / MDL 1.3	
Aroclor 1221	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 26 / MDL 1.1	1.3 w/ MRL 31 / MDL 1.3	1.1 w/ MRL 27 / MDL 1.1	ND w/ MRL 30 / MDL 1.3	
Aroclor 1232	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 13 / MDL 1.1	1.3 w/ MRL 16 / MDL 1.3	1.1 w/ MRL 14 / MDL 1.1	ND w/ MRL 15 / MDL 1.3	
Aroclor 1242	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 13 / MDL 1.1	1.3 w/ MRL 16 / MDL 1.3	1.1 w/ MRL 14 / MDL 1.1	ND w/ MRL 15 / MDL 1.3	
Aroclor 1248	EPA 8082	varies	ug/kg					ND w/	1.3 w/	1.1 w/	ND w/	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
					ERL	ERM	SL	ML	reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
					(Long et al., 1999)		(PSDDA, 2000)						
			see tests column						MRL 13 / MDL 1.1	MRL 16 / MDL 1.3	MRL 14 / MDL 1.1	MRL 15 / MDL 1.3	
	Aroclor 1254	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 13 / MDL 1.1	1.3 w/ MRL 16 / MDL 1.3	1.1 w/ MRL 14 / MDL 1.1	ND w/ MRL 15 / MDL 1.3	
	Aroclor 1260	EPA 8082	varies see tests column	ug/kg					ND w/ MRL 13 / MDL 1.1	1.3 w/ MRL 16 / MDL 1.3	1.1 w/ MRL 14 / MDL 1.1	ND w/ MRL 15 / MDL 1.3	
	POLYNUCLEAR AROMATIC HYDROCARBONS (PAH)												
	Total PAHs [4]			ug/kg	4,022	44,792			**NR**	**NR**	11 *	**NR**	
	2-Methylnaphthalene	EPA 8270C SIM	varies see tests column	ug/kg	70	670	670	1,900	0.62 w/ MRL 6.3 / MDL 0.27	1.7 w/ MRL 7.7 / MDL 0.33	4.0 w/ MRL 6.6 / MDL 0.28	0.48 w/ MRL 7.4 / MDL 0.31	
	Acenaphthene	EPA 8270C SIM	varies see tests column	ug/kg	16	500	500	2,000	ND w/ MRL 6.3 / MDL 0.27	ND w/ MRL 7.7 / MDL 0.33	0.33 w/ MRL 6.6 / MDL 0.28	0.38 w/ MRL 7.4 / MDL 0.31	
	Acenaphthylene	EPA 8270C SIM	varies see tests column	ug/kg	44	640	560	1,300	ND w/ MRL 6.3 / MDL 0.21	ND w/ MRL 7.7 / MDL 0.25	ND w/ MRL 6.6 / MDL 0.21	ND w/ MRL 7.4 / MDL 0.24	
	Anthracene	EPA 8270C SIM	varies see tests column	ug/kg	85.3	1,100	960	13,000	0.28 w/ MRL 6.3 / MDL 0.24	0.33 w/ MRL 7.7 / MDL 0.30	0.88 w/ MRL 6.6 / MDL 0.25	ND w/ MRL 7.4 / MDL 0.28	
	Benzo(a)anthracene	EPA 8270C SIM	varies see tests column	ug/kg	261	1,600	1,300	5,100	0.78 w/ MRL 6.3 / MDL 0.17	1.1 w/ MRL 7.7 / MDL 0.21	1.1 w/ MRL 6.6 / MDL 0.17	1.5 w/ MRL 7.4 / MDL 0.20	
	Benzo(a)pyrene	EPA 8270C SIM	varies see tests column	ug/kg	430	1,600	1,600	3,600	ND w/ MRL 6.3 / MDL 0.18	0.68 w/ MRL 7.7 / MDL 0.22	0.91 w/ MRL 6.6 / MDL 0.19	ND w/ MRL 7.4 / MDL 0.21	
	Benzo(b)fluoranthene	EPA 8270C SIM	varies see tests column	ug/kg			1,600	4,950	0.51 w/ MRL 6.3 / MDL 0.18	1.2 w/ MRL 7.7 / MDL 0.22	1.0 w/ MRL 6.6 / MDL 0.19	2.0 w/ MRL 7.4 / MDL 0.21	
	Benzo(k)fluoranthene	EPA 8270C SIM	varies see tests column	ug/kg			1,600	4,950	0.37 w/ MRL 6.3 / MDL 0.19	0.96 w/ MRL 7.7 / MDL 0.24	0.65 w/ MRL 6.6 / MDL 0.20	1.2 w/ MRL 7.4 / MDL 0.23	
	Benzo(g,h,i)perylene	EPA 8270C SIM	varies see tests	ug/kg			670	3,200	ND w/ MRL 6.3 /	1.4 w/ MRL 7.7 /	1.2 w/ MRL 6.6 /	1.8 w/ MRL 7.4 /	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
					ERL	ERM	SL	ML	reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
					(Long et al., 1999)		(PSDDA, 2000)						
			column						MDL 0.13	MDL 0.16	MDL 0.14	MDL 0.15	
	Chrysene	EPA 8270C SIM	varies see tests column	ug/kg	384	2,800	1,400	21,000	1.3 w/ MRL 6.3 / MDL 0.19	2.0 w/ MRL 7.7 / MDL 0.24	1.5 w/ MRL 6.6 / MDL 0.20	2.4 w/ MRL 7.4 / MDL 0.23	
	Dibenzo(a,h)anthracene	EPA 8270C SIM	varies see tests column	ug/kg	63.4	260	230	1,900	0.29 w/ MRL 6.3 / MDL 0.23	ND w/ MRL 7.7 / MDL 0.28	ND w/ MRL 6.6 / MDL 0.24	ND w/ MRL 7.1 / MDL 0.27	
	Fluoranthene	EPA 8270C SIM	varies see tests column	ug/kg	600	5,100	1,700	30,000	1.1 w/ MRL 6.3 / MDL 0.22	2.6 w/ MRL 7.7 / MDL 0.27	2.8 w/ MRL 6.6 / MDL 0.23	3.3 w/ MRL 7.4 / MDL 0.26	
	Fluorene	EPA 8270C SIM	varies see tests column	ug/kg	19	540	540	3,600	0.91w/ MRL 6.3 / MDL 0.22	2.1 w/ MRL 7.7 / MDL 0.27	3.8 w/ MRL 6.6 / MDL 0.23	1.9 w/ MRL 7.4 / MDL 0.26	
	Indeno(1,2,3-cd)pyrene	EPA 8270C SIM	varies see tests column	ug/kg			600	4,400	0.66 w/ MRL 6.3 / MDL 0.19	1.3 w/ MRL 7.7 / MDL 0.24	1.1 w/ MRL 6.6 / MDL 0.20	1.4 w/ MRL 7.4 / MDL 0.23	
	Naphthalene	EPA 8270C SIM	varies see tests column	ug/kg	160	2,100	2,100	2,400	1.3 w/ MRL 6.3 / MDL 0.27	4.4 w/ MRL 7.7 / MDL 0.33	11 w/ MRL 6.6 / MDL 0.28	0.66 w/ MRL 7.4 / MDL 0.31	
	Phenanthrene	EPA 8270C SIM	varies see tests column	ug/kg	240	1,500	1,500	21,000	1.6 w/ MRL 6.3 / MDL 0.19	3.3 w/ MRL 7.7 / MDL 0.24	5.3 w/ MRL 6.6 / MDL 0.20	3.7 w/ MRL 7.4 / MDL 0.23	
	Pyrene	EPA 8270C SIM	varies see tests column	ug/kg	665	2,600	2,600	16,000	1.1 w/ MRL 6.3 / MDL 0.14	2.2 w/ MRL 7.7 / MDL 0.17	2.5 w/ MRL 6.6 / MDL 0.15	4.4 w/ MRL 7.4 / MDL 0.17	
	PHENOLS												
	Total Phenols [4]			mg/kg			1582	5777	ND	ND	ND	ND	
	2,4-Dimethylphenol	EPA 8270C	varies see tests column	mg/kg			29	210	ND w/ MRL 0.42 / MDL 0.019	ND w/ MRL 0.51 / MDL 0.024	ND w/ MRL 0.44 / MDL 0.020	ND w/ MRL 0.49 / MDL 0.023	
	2-Methylphenol	EPA 8270C	varies see tests column	mg/kg			63	77	ND w/ MRL 0.42 / MDL 0.022	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	
	4-Methylphenol **(see note at end of this part of table)**	EPA 8270C	varies see tests column	mg/kg			670	3,600	ND w/ MRL 0.42 / MDL 0.022	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"		Analytical Method (1)	Method Reporting Limit / Method Detection Limit(1a)	Units (2)	Sediment Quality Guidelines (SQGs) ERL (Long et al., 1999)	ERM (Long et al., 1999)	SL (PSDDA, 2000)	ML (PSDDA, 2000)	Sample Testing Results (3) reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
	Pentachlorophenol	EPA 8270C	varies see tests column	mg/kg			400	690	ND w/ MRL 2.6 / MDL 0.16	ND w/ MRL 3.1 / MDL 0.20	ND w/ MRL 2.7 / MDL 0.17	ND w/ MRL 3.0 / MDL 0.19	
	2-Chlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.013	ND w/ MRL 0.51 / MDL 0.016	ND w/ MRL 0.44 / MDL 0.013	ND w/ MRL 0.49 / MDL 0.015	
	4-Chloro-3-methylphenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.021	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	
	2,4-Dichlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.021	ND w/ MRL 0.51 / MDL 0.026	ND w/ MRL 0.44 / MDL 0.022	ND w/ MRL 0.49 / MDL 0.025	
	2-Nitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.018	ND w/ MRL 0.51 / MDL 0.022	ND w/ MRL 0.44 / MDL 0.019	ND w/ MRL 0.49 / MDL 0.021	
	4-Nitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.6 / MDL 0.19	ND w/ MRL 3.1 / MDL 0.23	ND w/ MRL 2.7 / MDL 0.20	ND w/ MRL 3.0 / MDL 0.22	
	2,4-Dinitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.6 / MDL 0.15	ND w/ MRL 3.1 / MDL 0.18	ND w/ MRL 2.7 / MDL 0.15	ND w/ MRL 3.0 / MDL 0.17	
	2-Methyl-4,6-dinitrophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 2.6 / MDL 0.19	ND w/ MRL 3.1 / MDL 0.23	ND w/ MRL 2.7 / MDL 0.19	ND w/ MRL 3.0 / MDL 0.22	
	2,4,5-Trichlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.022	ND w/ MRL 0.51 / MDL 0.027	ND w/ MRL 0.44 / MDL 0.023	ND w/ MRL 0.49/ MDL 0.026	
	2,4,6-Trichlorophenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.018	ND w/ MRL 0.51 / MDL 0.023	ND w/ MRL 0.44 / MDL 0.019	ND w/ MRL 0.49 / MDL 0.022	
	Phenol	EPA 8270C	varies see tests column	mg/kg					ND w/ MRL 0.42 / MDL 0.025	ND w/ MRL 0.51 / MDL 0.031	ND w/ MRL 0.44 / MDL 0.026	ND w/ MRL 0.49 / MDL 0.029	

Rindge Dam removal study--test results for potential contaminants in impounded sediments.

Abbreviations used for SQG's: ERL = "effects range -low"; ERM = "effects range - medium"; SL = "screening level" ML = "maximum level"	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Sediment Quality Guidelines (SQGs)				Sample Testing Results [3]				
				ERL	ERM	SL	ML	reservoir sand TH02-07-samples 4 & 5	reservoir silt TH02-02-sample 13, 15, 18, 21	reservoir silt TH02-03-samples 13, 14 & TH02-05 sample15	reservoir silt TH02-06-sample 8	
				(Long et al., 1999)		(PSDDA, 2000)						

(1) Analytical Method
EPA = United States Environmental Protection Agency
EPA Methods are EPA SW-846, 1994 3rd Edition or EPA 600/4-79-020, March 1983
SM = Standard Methods for wastewater analysis
ASTM = American Society for Testing and Materials
Plumb = Procedure for Handling and Chemical Analysis of Sediment and Water Samples. Tech Rep. USEPA/CE-81, Russell H. Plumb, Jr., 1981.
Krone =

(1a) If only one value is listed in the column, it is the MRL (method reporting limit); the second value listed in this column is the MDL (the method detection limit). In the individual test results columns, if a numerical value is listed, that analyte is present, but is *quantifiable* only if value listed also is above the MRL (method reporting limit); analyte values in numerical range *between* the MDL and MRL are estimates only; condition usually due to interference within the testing machinery from other substances within the sample.

(2) Units: all listed values based on dry weight unless otherwise noted; ug/kg = micrograms per kilogram, parts per billion; mg/kg = milligrams per kilogram, parts per million (dry weight unless otherwise noted)

(3) ND = not detected at or above lowest Method Detection Limit value for the particular compound(s) of interest
NT = not tested for a given analyte; NR = detectable quantities present but none exceed MRL so no viable total value can be reported here; " * " = some values over MRL, but others below MRL were detected, so this "total" is less than actual total, but no actual total can be calculated due to MRL limitations

(4) Total Chlorinated Pesticides, Total Organotins (Butyltins), Total Phthalates, Total PCBs, Total PAHs, and Total Phenols = sum of named compounds and their derivatives

(5) Total DDT = sum of 4,4'-DDE; 4,4'-DDD; and 4,4'-DDT

(P) = analyzed past holding time for this analyte.

Note concerning 4 Methylphenol analysis for 4 samples on this part of the table (that is, composited samples TH02-07 samples 4 & 5; composited sampleTH02-02 samples 13, 15, 18, 21; composited sample TH02-03 samples 13 and 14, and TH02-05 samples 8 and 9; non-composited sample TH02-06 sample 8): Laboratory could not separate 4-Methylphenol from 3-Methylphenol

Leachate test suite

Rindge dam removal study. Leachate (upland disposal) test suite

Substance	Analytical Method (1)	Method Reporting Limit / Method Detection Limit(1a)	Units (2)	Calif. Regulatory limit (mg/L)	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9	reservoir sand TH02-06-sample 5	reservoir silt TH02-01-sample 18 & TH02-04-sample14
Leachable metals					**Unit 2**	**Unit 2**	**Unit 3**
Arsenic	EPA 6020	0.01	mg/L	Test not required	0.01	ND	0.02
Barium	EPA 6020	0.01	mg/L	100.0	0.45	0.26	0.58
Cadmium	EPA 6020	0.01	mg/L	1.0	ND	ND	ND
Chromium	EPA 6020	0.05	mg/L	5.0	ND	ND	ND
Lead	EPA 6020	0.01	mg/L	5.0	ND	ND	ND
Mercury	EPA 7470A	0.0001	mg/L	0.2	0.0003	ND	ND
Selenium	EPA 6020	0.01	mg/L	1.0	ND	ND	ND
Silver	EPA 6020	0.01	mg/L	5.0	ND	ND	ND
Leachable semi-volatiles							
Cresols (total)	EPA 8270C	0.008	mg/L	200.0	ND	ND	ND
o-Cresol (2-Methylphenol)	EPA 8270C	0.008	mg/L	200.0	ND	ND	ND
m-Cresol (3-Methylphenol)	EPA 8270C	0.008	mg/L	200.0	ND	ND	ND
p-Cresol (4-Methylphenol)	EPA 8270C	0.008	mg/L	200.0	ND	ND	ND
1, 4-Dichlorobenzene	EPA 8270C	0.008	mg/L	7.5	ND	ND	ND
2, 4-Dinitrotoluene	EPA 8270C	0.008	mg/L	0.13	ND	ND	ND
Hexachlorobenzene	EPA 8270C	0.008	mg/L	0.13	ND	ND	ND
Hexachlorobutadiene	EPA 8270C	0.008	mg/L	0.5	ND	ND	ND
Hexachloroethane	EPA 8270C	0.008	mg/L	3.0	ND	ND	ND
Nitrobenzene	EPA 8270C	0.008	mg/L	2.0	ND	ND	ND
Pentachlorophenol	EPA 8270C	0.02	mg/L	100.0	ND	ND	ND
Pyridine	EPA 8270C	0.04	mg/L	5.0	ND	ND	ND
2, 4, 5-Trichlorophenol	EPA 8270C	0.008	mg/L	400.0	ND	ND	ND
2, 4, 6-Trichlorophenol	EPA 8270C	0.008	mg/L	2.0	**NT**	ND	ND
Leachable volatiles							
Benzene	EPA 8260B	0.005	mg/L	0.5	ND	ND	ND
Methyl ethyl ketone (or, 2-Butanone)	EPA 8260B	0.125	mg/L	200.0	ND	ND	ND
Carbon tetrachloride	EPA 8260B	0.01	mg/L	0.5	ND	ND	ND
Chlorobenzene	EPA 8260B	0.005	mg/L	100.0	ND	ND	ND
Chloroform	EPA 8260B	0.005	mg/L	6.0	ND	ND	ND
1, 2-Dichloroethane	EPA 8260B	0.005	mg/L	0.5	ND	ND	ND

Rindge dam removal study. Leachate (upland disposal) test suite

Substance	Analytical Method [1]	Method Reporting Limit / Method Detection Limit[1a]	Units [2]	Calif. Regulatory limit (mg/L)	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9	reservoir sand TH02-06-sample 5	reservoir silt TH02-01-sample 18 & TH02-04-sample14
1, 1-Dichloroethylene (or, 1, 1-Dichloroethene)	EPA 8260B	0.005	mg/L	0.7	ND	ND	ND
Tetrachloroethylene (or, ***PERC***, or tetrachloroethene)	EPA 8260B	0.005	mg/L	0.7	ND	ND	ND
Trichloroethylene (or, ***TCE***, or, trichloroethene)	EPA 8260B	0.005	mg/L	0.5	ND	ND	ND
Vinyl chloride	EPA 8260B	0.01	mg/L	0.2	ND	ND	ND
Pesticides							
Lindane (gamma-BHC)	EPA 8081	0.0008	mg/L	0.4	ND	ND	ND
Chlordane (total)	EPA 8081	0.0016	mg/L	0.03	ND	ND	ND
Endrin	EPA 8081	0.0016	mg/L	0.02	ND	ND	ND
Heptachlor	EPA 8081	0.0008	mg/L	0.008	ND	ND	ND
Heptachlor epoxide	EPA 8081	0.0008	mg/L	0.008	ND	ND	ND
Methoxychlor	EPA 8081	0.008	mg/L	10.0	ND	ND	ND
Toxaphene	EPA 8081	0.016	mg/L	0.5	ND	ND	ND
Leachable herbicides							
2, 4 D	EPA 8151	0.0048	mg/L	10.0	ND	ND	ND
2, 4, 5-TP (Silvex)	EPA 8151	0.00068	mg/L	1.0	ND	ND	ND

Rindge dam removal study. Leachate (upland disposal) test suite

Substance	Analytical Method [(1)]	Method Reporting Limit / Method Detection Limit[(1a)]	Units [(2)]	Calif. Regulatory limit (mg/L)	reservoir sand TH02-03-samples 6, 9, 10 & TH02-05 samples 8, 9	reservoir sand TH02-06-sample 5	reservoir silt TH02-01-sample 18 & TH02-04-sample14

(1) Analytical Method
EPA = United States Environmental Protection Agency
EPA Methods are EPA SW-846, 1994 3rd Edition or EPA 600/4-79-020, March 1983
SM = Standard Methods for wastewater analysis
ASTM = American Society for Testing and Materials
Plumb = Procedure for Handling and Chemical Analysis of Sediment and Water Samples. Tech Rep. USEPA/CE-81, Russell H. Plumb, Jr., 1981.
Krone =

(1a) If only one value is listed in the column, it is the MRL (method reporting limit); the second value listed in this column is the MDL (the method detection limit). In the individual test results columns, if a numerical value is listed, that analyte is present, but is ***quantifiable*** only if value listed also is above the MRL (method reporting limit); analyte values in numerical range ***between*** the MDL and MRL are estimates only; condition usually due to interference within the testing machinery from other substances within the sample.

(2) Units: all listed values based on dry weight unless otherwise noted; ug/kg = micrograms per kilogram, parts per billion; mg/kg = milligrams per kilogram, parts per million (dry weight unless otherwise noted)

(3) ND = not detected at or above lowest Method Detection Limit value for the particular compound(s) of interest
NT = not tested for a given analyte; NR = detectable quantities present but none exceed MRL so no viable total value can be reported here; " * " = some values over MRL, but others below MRL were detected, so this "total" is less than actual total, but no actual total can be calculated due to MRL limitations

Abbreviations used in this table: ND = "not detected"; NT = "not tested". Unit of mg/L = "milligrams per liter", which also is equivalent to mg/k (milligrams per kilogram), and is equivalent to ppm (parts per million). (P) = analyzed past holding time for this analyte.

This page was intentionally left blank for duplex printing.

Appendix D3
Site Photographs

This page was intentionally left blank for duplex printing.

Los Angeles District
Geotechnical Branch
Malibu Rindge Dam

Clockwise from left: View of the downstream face of the dam, left and right abutments, and spillway. View of the upstream face and crest of the dam. Sediment has deposited on the upstream face almost to the top. View of the upstream side of the spillway.

Los Angeles District
Geotechnical Branch
Malibu Rindge Dam



USACE subsurface exploration program.

Los Angeles District
Geotechnical Branch
Malibu Rindge Dam

Proposed storage Site F.

This page was intentionally left blank for duplex printing.