US Army Corps
of Engineers
Los Angeles District

LOS ANGELES COUNTY REGIONAL DREDGED MATERIAL MANAGEMENT PLAN PILOT STUDIES

LOS ANGELES COUNTY, CALIFORNIA

EVALUATION REPORT

U.S. Army Corps of Engineers
Los Angeles District
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The following acronyms are used throughout the document:

CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
CSTF	Los Angeles Contaminated Sediments Task Force
DGPS	Differential Global Positioning System
DMMP	Los Angeles County Regional Dredged Material Management Plan
DMMP Pilot Studies	Los Angeles County Regional Dredged Material Management Plan Pilot Studies
ECDC	A hazardous waste hauling and disposal company (see Waste by Rail)
EPA	U.S. Environmental Protection Agency
ERDC	U.S. Army Corps of Engineers' Engineering Research and Development Center, Waterways Experiment Station
ER-L	Effects Range-Low
FY	Fiscal Year
km	kilometer
LARE	Los Angeles River Estuary
LARWQCB	Los Angeles Regional Water Quality Control Board
m^3	cubic meter
mg/L	milligrams per liter
MLLW	mean lower low water
NEIBP	North Energy Island Borrow Pit
POLA	Port of Los Angeles
POLB	Port of Long Beach
SEIBP	South Energy Island Borrow Pit

SPI	sediment profile imaging
TDS	total dissolved solids
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers, Los Angeles District
WBR	Waste by Rail *(formerly ECDC)*

1 INTRODUCTION AND PURPOSE

In 2001, the U.S. Army Corps of Engineers (USACE), Los Angeles District, initiated the Los Angeles County Regional Dredged Material Management Plan Pilot Studies (DMMP Pilot Studies) to evaluate the feasibility of managing contaminated sediments in the Los Angeles County region through disposal or treatment. In support of the Los Angeles County Dredge Material Management Plan Study, four disposal management alternatives were selected for immediate evaluation under the USACE Operations and Maintenance program:

- **Aquatic Capping** – Dredging contaminated sediments and placing them in an inner harbor subaqueous man made pit located directly offshore of the City of Long Beach.
- **Cement Stabilization** – Dredging contaminated sediments and rehandling them to an upland staging area where the dredged sediments are mixed with a cement-based product to bind the contaminants and to create structurally stable soil material.
- **Sediment Washing** – Dredging contaminated sediments and rehandling them to an upland staging area where the dredged sediments are washed to remove chloride, allowing for the potential of Class 3 landfill disposal or beneficial use.
- **Sediment Blending** – Dredging fine grained contaminated sediments and rehandling them to an upland staging area where the dredged sediments are blended with coarser grained sediments to create structurally stable material for use in a nearshore fill.

The four DMMP Pilot Studies were performed from mid-2001 through early 2002. Post-construction monitoring for the Aquatic Capping alternative was completed in February 2002. The purposes of this Evaluation Report are (1) to summarize the results of the pilot studies; (2) to provide an evaluation — using the five evaluation criteria discussed in Section 4 — of each alternative relative to a Baseline Case; and (3) to assess the advantages and disadvantages of each alternative. This report does not select a preferred alternative for the management of contaminated sediments.

The technical information in this Evaluation Report will be used to support both the USACE DMMP Feasibility Study and the Los Angeles Contaminated Sediments Task Force (CSTF) Strategy Report, both of which are discussed in more detail below.

1.1 Background

Los Angeles County's coastline includes two of the nation's largest commercial ports and several major marina complexes and small-vessel harbors. Periodically, sediment dredging is required to maintain authorized depths in existing channels and berths and to support expansion and modernization of ports, harbors, and marinas. Some of the dredged sediments from these sources contain elevated levels of heavy metals, pesticides, and other contaminants. Although the concentrations of these contaminants do not approach unacceptable levels as determined by regulatory requirements in most cases, the dredged sediments may contain contaminant concentrations sufficient to make them unsuitable for unconfined ocean disposal. Additionally, California State’s Bay Protection and Toxic Cleanup Program has identified bays and estuaries containing areas with contaminated sediments. Disposing of contaminated sediments in the Los Angeles region requires specialized management techniques, such as placement in a contained aquatic disposal site, confined disposal facility, or disposal at Class 1 or 2 landfill sites. Some ports and harbors have also considered other management techniques, such as treatment and beneficial use or geotextile containment.

Presently, regulatory agencies evaluate disposal options for dredging projects on a case-by-case basis without the benefit of a regional perspective on management alternatives, cumulative impacts, and long-term solutions to prevent recontamination. This approach has led to public concern over the cumulative ecological and human health implications of current practices for disposing of contaminated dredged sediments. To resolve these issues, the Federal and State Regulatory and resource agencies, Los Angeles area ports and harbors, environmental groups, and other interested parties in the Los Angeles region agreed to establish the CSTF. The CSTF was formed in 1998 and chartered with developing a long-term management strategy for contaminated sediments. This strategy will be presented in January 2005 in the CSTF’s Strategy Report. Active participants in the

CSTF include the USACE; local, state, and federal resource and regulatory agencies; and local environmental groups.

The USACE is an active participant in the CSTF, and is working together with the CSTF to prepare a long-term management strategy (i.e., DMMP) for dredged material disposal of contaminated marine sediments and disposal of clean sediments. The project study area for the DMMP Feasibility Study is located along the coastal waters of Los Angeles County and includes Marina del Rey, the Ports of Long Beach and Los Angeles, and the Los Angeles River Estuary. Non-federal sponsors for the DMMP Feasibility Study are the County of Los Angeles, City of Long Beach, and Port of Los Angeles. Although the USACE DMMP Feasibility Study and the CSTF Strategy Report have overlapping objectives, key differences in approach or conclusions may occur under the two programs. The USACE and the CSTF both intend to coordinate the two study efforts as much as possible to minimize duplication of effort and to develop a unified approach for the long-term management of contaminated dredged sediments.

1.1.1 905(b) Reconnaissance Report

The USACE 905(b) Reconnaissance Report (USACE 2000) was prepared in September 2000. Its purpose was to determine whether there was a federal interest in participating in a detailed DMMP Feasibility Study to develop a regional DMMP and alternatives for multi-user disposal sites and evaluate other disposal and reuse alternatives for the isolation and containment of contaminated dredged sediments originating from the coastal/harbor waters of Los Angeles County. The reconnaissance phase led to the conclusion that there is a federal interest in continuing the study into the feasibility phase and identified study objectives for the DMMP Feasibility Study. The four DMMP Pilot Studies evaluated in this report were developed to support Objective 4 of the 905(b) Reconnaissance Report:

> *Implement pilot projects to assess the viability of various treatment alternatives for contaminated dredged sediments through the Corps' Operations and Maintenance program.*

1.1.2 DMMP Feasibility Study

The USACE will conduct the DMMP Feasibility Study to address long-term management of clean and contaminated sediments. Objectives of the DMMP Feasibility Study as defined in the 905(b) Reconnaissance Report include:

1. Establishing preliminary sediment threshold levels for the disposal of dredged sediments by defining trigger points and hierarchal approaches for the disposal of dredged sediments.
2. Establishing local best management practices for the dredging and disposal of contaminated and non-contaminated marine sediments.
3. Identifying regional disposal alternatives for contaminated and non-contaminated dredged sediments.
4. Implementing bench-scale and pilot-scale projects to assess the viability of various treatment alternatives for contaminated dredged sediments through the Corps' Operations and Maintenance program.
5. Identifying environmental restoration and/or enhancement opportunities that are directly related to the dredging and disposal of contaminated marine sediments.
6. Preparing detailed cost estimates for identified disposal alternatives.
7. Recommending a regional disposal management strategy, to include: i) the recommended regional disposal sites and/or treatment alternatives; ii) best management practices for the dredging and disposal operations; iii) a consolidated and consistent plan for regulatory review; iv) chemical trigger levels for sediment testing and the selection of disposal sites; and v) a tiered approach to the selection of sites for the disposal of dredged sediments.
8. Preparing a programmatic environmental impact statement/environmental impact review to implement regional disposal management alternatives.
9. Recommending a regional dredged material management plan that is consistent with the CSTF implementation strategy.

The DMMP Feasibility Study will evaluate to an equivalent degree the alternatives listed below, which variously involve both soft and hard structures, sediment treatments, capping sites, and beneficial uses to manage the disposal of dredged sediments:

- No Action
- Ocean Disposal
- Upland Disposal
- Aquatic Capping
- Nearshore Confined Disposal Facility (CDF) Disposal
- Shallow Water Habitat Creation
- Treatment
  - Stabilization
  - Washing
  - Blending
  - Separation
  - Thermal Desorption
- Beneficial Use
  - Construction Fill
  - Landfill Cover
  - Reclamation Fill
  - Oil Well Injections
  - Geotextile Encapsulation

1.1.3 CSTF Strategy Report

The CSTF was established through a Memorandum of Understanding among the state and federal agencies with regulatory jurisdiction over dredging and disposal activities and other agencies representing ports, harbors, and marinas. The following agencies are signatories to the Memorandum of Understanding: U.S. Army Corps of Engineers; U.S. Environmental Protection Agency (EPA) Region 9; California Coastal Commission; Los Angeles Regional Water Quality Control Board (LARWQCB); County of Los Angeles Department of Beaches and Harbors; City of Long Beach; Port of Long Beach (POLB); and Port of Los Angeles (POLA). The CSTF's primary goal is to develop a long-term management plan for the dredging and disposal of contaminated sediments from coastal waters adjacent to Los Angeles County. The CSTF's primary objectives are to:

1. Develop unified multi-agency policies related to the management of sediments not suitable for unconfined aquatic disposal.
2. Promote multi-user disposal facilities.
3. Promote beneficial uses.
4. Support efforts for watershed management to control contaminants at their sources.

The CSTF's secondary goal is to identify alternatives for contaminated sediment management and disposal. These alternatives must be both environmentally sound (i.e., not pose unacceptable or poorly defined risks to human health, marine organisms, or the environment) and feasible (i.e., without environmental, technical, economic, or political constraints that prevent full implementation). The CSTF will identify potential beneficial uses, treatment, and disposal alternatives for managing the region's contaminated sediments in the Strategy Report.

The CSTF identified five basic goals that it must accomplish in preparing the Strategy Report. These goals are to:

1. Identify the locations, sources, approximate quantities, and nature of contaminated sediments that may be dredged in the five-year period following completion of the Strategy Report. The CSTF will update these estimates annually.
2. Identify environmentally preferable and feasible management and disposal alternatives for the Los Angeles County region, including multi-user disposal sites and beneficial uses.
3. Develop the unified set of policies that the various resource and regulatory agencies will need to evaluate the dredging of contaminated sediments.
4. Promote and implement region-wide efforts at source reduction through watershed management.
5. Seek funding for additional studies and implementation of the strategy.

1.2 Development and Description of Pilot Study Alternatives

The reconnaissance study recommended pilot and bench scale studies to be performed under the USACE Operations and Maintenance program to assess the viability of several disposal options: Aquatic Capping, Cement Stabilization, Sediment Washing and Sediment Blending. The planning and implementation of each pilot study was a cooperative effort between the USACE and CSTF. Specific components (such as monitoring requirements) were discussed at the CSTF Aquatic Subcommittee meetings to gain consensus. Certain constraints also helped to bound the scope of the pilot studies, including USACE budget (and timing to spend the allocated budget), availability of existing information, and contractor availability. The technologies associated with each of the four alternatives are briefly described in the following sections.

1.2.1 Aquatic Capping

Aquatic capping technology involves placing a cover or cap over contaminated sediments within a subaqueous environment to isolate them from the surrounding marine environment. Many processes influence the fate of contaminants in bottom sediments. Contaminants can be transported into the overlying water column by advective and diffusive chemical and biological mechanisms. Mixing and reworking of the upper layer of contaminated sediments by benthic organisms continually exposes contaminated sediments to the sediment-water interface, where contaminants can be released to the water column (Reible et al. 1993). Bioaccumulation of contaminants by benthic organisms in direct contact with contaminated sediments may result in the movement of contaminants into the food chain. Sediment resuspension, caused by natural and man-made erosive forces, can greatly increase the exposure of contaminants to the water column and result in the transportation of large quantities of sediment contaminants downstream (Brannon et al. 1985).

Aquatic capping can remedy these adverse impacts through three primary functions:

1. Physical isolation of the contaminated sediments from the benthic environment.

2. Stabilization of contaminated sediments, preventing resuspension and transport to other sites.
3. Reduction of the flux of dissolved contaminants into the water column.

To achieve these results, an Aquatic Capping project must be treated as an engineered project with carefully considered design, construction, and monitoring. The basic criterion for a capping project is to design a cap that can be successfully placed and maintained.

The Aquatic Capping Pilot Study (which consisted of a pilot- or field-scale study) specific to the DMMP Pilot Studies is the subject of this Evaluation Report and is summarized in Section 5.1.

1.2.2 Cement Stabilization

Stabilizing contaminated sediments with cement-based additive mixes is a treatment technology that converts contaminants in the sediments into less soluble, mobile, or toxic forms. The process also enhances the physical properties of the sediments. The technology, commonly known as cement-based stabilization or Cement Stabilization, has been widely used in upland soil remediation projects.

The Cement Stabilization Pilot Study (which consisted of both bench-scale and pilot- or field-scale studies) specific to the DMMP Pilot Studies is the subject of this Evaluation Report and is summarized in Section 5.3.

1.2.3 Sediment Washing

Sediment washing technology typically is described as a process that involves slurrying contaminated dredged sediments and subjecting the slurry to physical collision, shearing and abrasive actions and aeration, cavitation, and oxidation processes while reacting with chemical additives such as chelating agents, surfactants, and peroxides. Using this process, the contaminants are transferred from the sediments to the water phase, leaving less contaminated sediments that can be dewatered and used for beneficial purposes.

For the DMMP Pilot Studies, however, the objective of the Sediment Washing Pilot Study was revised on the basis of input from the CSTF to focus on evaluating the effectiveness of Sediment Washing at removing chlorides from the dredged sediments to support potential beneficial uses of the treated sediments. Chloride removal is necessary if contaminated sediments are to be disposed of at an upland landfill (e.g., for daily cover) under current guidance from the LARWQCB.

The Sediment Washing Pilot Study (which consisted of a bench-scale study) specific to the DMMP Pilot Studies is the subject of this Evaluation Report and is summarized in Section 5.5.

1.2.4 Sediment Blending

Sediment blending has traditionally been defined for dredged sediments as the process of blending dredged sediments with borrowed coarse material to create a more suitable material for use in near shore fills. Sediment blending is not intended to bind or reduce contaminants nor is it intended to chemically dilute the sediment, however, Sediment Blending may have an effect on contaminant concentrations through dilution.

Following a detailed literature review and regional users survey, the study team determined that Sediment Blending would not be field-tested because of its high costs and limited value. This decision is discussed in Section 5.7.

1.3 Report Organization

This Evaluation Report summarizes results from the four DMMP Pilot Studies and evaluates them to a Baseline Case scenario. The background and history of the project are discussed in Section 1; program planning activities, including the permitting and approval process, are discussed in Section 2; the Baseline Case scenario is defined in Section 3; the evaluation criteria are defined in Section 4; and the evaluation of alternatives appears in Section 5, which summarizes Appendices A through D, where detailed reports on the alternatives appear. Section 6 provides analysis of the alternatives to evaluate the relative performance of each against the five evaluation criteria. Section 7 presents conclusions supported by the Evaluation Report, and Section 8 lists the references cited in this report.

2 PILOT STUDY PLANNING

Planning and design for the DMMP Pilot Studies began soon after the USACE 905(b) Reconnaissance Report was completed in September 2000.

2.1 Responsibilities and Coordination

The USACE took responsibility for developing the DMMP Pilot Studies and funding the studies through its Operations and Maintenance program. Funds to complete the DMMP Pilot Studies were obtained for federal Fiscal Year 2001 (FY 2001), with the restriction that all the funds had to be expended by the end of FY 2001. Planning, permitting, and design activities were implemented concurrently to meet the fast-track schedule. The U.S. Army Corps of Engineers' Engineering Research and Development Center (ERDC) at the Waterways Experiment Station was contacted to provide support with modeling and laboratory testing (Sediment Washing Pilot Study) and to review planning and design documents.

The USACE recognized the critical importance of having the CSTF's support and technical review throughout the planning, environmental review, and design phases to support the objective of achieving both DMMP Feasibility Study and CSTF Strategy Report goals when performing the DMMP Pilot Studies. For that reason, the USACE coordinated closely with the CSTF at key decision points. The forum for this coordination was the Aquatic Subcommittee meetings. Because reaching consensus within the CSTF was sometimes challenging, multiple iterations of the pilot study objectives and design were necessary.

2.2 Permits and Approvals

Because the Aquatic Capping and Cement Stabilization alternatives involved dredging and disposal, permits and approvals were required from regulatory agencies. The permitting and approval process was expedited by the respective reviewing agencies because the projects were pilot studies and because continuous coordination was maintained during the environmental review and design phases.

USACE permits (under Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act of 1899) were not required because the USACE was the project proponent. However, all regulatory laws and policies were adhered prior to and during project implementation. The LARWQCB was responsible for coordinating the water quality certification. An Environmental Assessment was required to address potential environmental impacts in compliance with the National Environmental Policy Act for the Aquatic Capping and Cement Stabilization field-scale studies; that assessment was completed in July 2001. The USACE submitted its Consistency Determination in March 2001 to the California Coastal Commission for concurrence. At the California Coastal Commission Public Hearing held in Monterey, California, on May 9, 2001, the Board unanimously concurred with the Consistency Determination. The USACE completed an informal consultation with the U.S. Fish and Wildlife Service in accordance with Section 7 of the Endangered Species Act. The result was a determination that the project would not adversely impact any threatened or endangered species.

3 BASELINE CASE DEFINITION

To facilitate evaluation of the Pilot Study alternatives relative to one another, a Baseline Case project scenario that identified a consistent set of site conditions and operational practices was defined. The Baseline Case does not represent an actual project. Rather, it is a conceptual project that can be used as a standard for making equivalent assessments of the four alternatives. In general, the Aquatic Capping alternative was identified as the model for the Baseline Case. The following sections describe the Baseline Case.

3.1 Contaminated Sediment Source Material

The source of contaminated dredged sediments in the Baseline Case is the mouth of the Los Angeles River Estuary (LARE), upstream of the Queensway Bridge (i.e., immediately upstream of the Queensway Marina). This location was selected because it represents an on-going depositional contaminated sediment source from the Los Angeles River and because it is periodically dredged to maintain navigational depths for vessels using the Queensway Marina. This location was dredged as part of the Aquatic Capping Pilot Study.

Chemical characterization of LARE sediments indicated that the typical sediment was not acceptable for ocean disposal, but contained contaminant concentrations below hazardous waste concentrations. Detailed chemistry results from the most recent LARE testing are presented in Appendix A.

The physical characteristics of LARE sediments were evaluated by collecting four cores in the LARE dredge area at depths of 4.6 to 4.9 meters below mud line. For use in the Baseline Case, the general description of LARE sediments is "silty sand with trace clay and occasional organics." The volume-weighted grain size distribution of the four cores was:

- Gravel content of 1 percent
- Sand content of 77 percent
- Silt content of 17 percent
- Clay content of 5 percent

3.2 Volumes

The Baseline Case assumes an in-situ dredged volume of 100,000 cubic meters (m^3). For alternatives involving upland operations, the Baseline Case assumes insignificant dredged sediment bulking due to the high percentage of sand.

Each of the Pilot Study alternatives has additional alternative-specific material volumes not discussed here. For example, the Aquatic Capping alternative also includes capping material volume, while the Cement Stabilization alternative includes cement additive volume. These secondary volumes were determined based on disposal/treatment of the primary 100,000 m^3 volume.

3.3 Equipment

The Baseline Case assumes that all sediments are mechanically dredged with a clamshell dredge and placed into barges (e.g., split-hull barges for open water disposal alternatives and haul barges for transport to an upland offloading site). One derrick, two scows, one tugboat, and one workboat are assumed to be standard equipment for dredging operations.

Additional equipment specific to each alternative is included in the cost estimates and discussed in the descriptions of alternatives.

3.4 Operational Considerations

Dredged sediment disposal or treatment can be a limiting factor for the overall project production rate. To provide a comparable assessment between alternatives, a constant project production rate for dredging operations needs to be assumed; this constant production rate was set at 2,000 m^3 per day.

The Baseline Case assumes that no special best management practices, such as silt curtains, will be applied. The overall project production rate is assumed to incorporate similar operational controls in all alternatives for minimizing potential water quality impacts.

4 EVALUATION CRITERIA

Evaluation criteria were selected early in the planning process for the DMMP Pilot Studies to help focus field sampling and testing efforts during the design and construction of both bench-scale and pilot-scale (field-scale) projects. The evaluation criteria were generally based on the balancing criteria found in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which include short-term effectiveness; long-term effectiveness and permanence; reduction of mobility, toxicity, and volume through treatment; implementability; and cost. The CERCLA evaluation criteria were slightly modified to better match the objectives for the DMMP Pilot Studies. The selected evaluation criteria, which were discussed and approved by both the USACE and CSTF, are defined in more detail below.

4.1 Short-Term Effectiveness

This evaluation criterion addresses the effectiveness of an alternative during the construction and implementation phases until the sediment management objectives are met. Sediment management objectives vary depending on the alternative. For Aquatic Capping, short-term effectiveness refers to the alternative's ability to control the loss of contaminated sediments during dredging, placement, and capping operations and to result in isolated sediments immediately after construction. For the Cement Stabilization, Sediment Washing, and Sediment Blending alternatives (i.e., the treatment alternatives), short-term effectiveness refers to an alternative's ability to control the loss of contaminated sediments during dredging, transport, handling, and treatment, as well as to an alternative's ability to reduce the mobility, toxicity, or volume of contaminants immediately after the treatment process is complete. For the treatment alternatives, short-term effectiveness also refers to an alternative's ability to meet secondary objectives, such as improving the sediment's physical characteristics for beneficial use, immediately after treatment.

4.2 Long-Term Effectiveness

This evaluation criterion addresses the effectiveness of an alternative at maintaining sediment management objectives over the long-term (i.e., for years) following the construction and implementation phases. For Aquatic Capping, long-term effectiveness refers to the ability of the constructed facility to continually isolate contaminants from the marine environment. For the treatment alternatives, long-term effectiveness refers to an alternative's ability to maintain the reduction in contaminant mobility, toxicity, or volume initially achieved by the treatment process. For the treatment alternatives, long-term effectiveness also refers to an alternative's ability to maintain secondary objectives, such as improving the sediment's physical characteristics for beneficial use.

4.3 Implementability

The implementability criterion addresses the technical feasibility of implementing an alternative and the availability of various services and materials required during implementation. For the purpose of this Evaluation Report, this criterion focuses on technical issues related to the construction of an alternative (e.g., the availability of equipment, experienced personnel, and sites) and does not include evaluation of the administrative issues (e.g., regulatory approval and permitting).

4.4 Environmental Impacts

This evaluation criterion addresses whether a specific alternative poses unacceptable short-term impacts (i.e., during or immediately after construction). For Aquatic Capping, short-term impacts are primarily related to water and sediment quality. For the treatment alternatives, short-term impacts are primarily related to the upland, although some treatment alternatives may also embrace water quality issues.

4.5 Cost

This evaluation criterion addresses the associated construction costs (both direct and indirect) and annual operations and maintenance costs for each alternative. The costs of short-term and long-term monitoring are not considered in this evaluation criterion because such costs can vary significantly by project.

5 EVALUATION OF ALTERNATIVES

In the evaluation of alternatives that follows, each alternative is assessed against the evaluation criteria described in Section 4. In Section 6, the results of this assessment are arrayed to identify the key tradeoffs among them.

This evaluation relies on conclusions presented in each of the Alternative Evaluation Appendices (Appendices A through D). Those conclusions, in turn, are based on compilation, review, and interpretation of the monitoring and/or laboratory data collected during the implementation of each alternative.

5.1 Summary of Aquatic Capping Pilot Study Results

The Aquatic Capping Pilot Study — which was conducted at only the pilot, or field scale, not at the bench scale — yielded a large amount of water quality monitoring data, construction observations (including photo logs and daily records), and sediment quality data. These data can be compiled, evaluated, and interpreted in numerous ways. In order to succinctly summarize the results, our methodology was to assess large-scale trends, rather than to differentiate results on a daily basis. Additional data interpretation can be performed, but for the purposes of this evaluation, examining general trends was sufficient to assess the relative differences among alternatives. Complete results of the Aquatic Capping Pilot Study are presented in Appendix A.

5.1.1 Pilot Study Description

The Aquatic Capping Pilot Study involved dredging approximately 105,000 m^3 of sediment characterized as unsuitable for open ocean disposal. Dredging was performed using a mechanical clamshell dredge. The contaminated sediments were dredged from the LARE, at the mouth of the Los Angeles River, just upstream from the Queensway Bridge. The LARE is located in the City of Long Beach, California, approximately 32 kilometers (km) south of downtown Los Angeles and connects the Los Angeles River channel with Long Beach Harbor. Figure 1 shows the location of the estuary and the features surrounding it.

The contaminated sediments were transported by barge to the disposal location in the North Energy Island Borrow Pit (NEIBP) and placed there by bottom-dump barges. The NEIBP is a relatively steep-walled depression. The top of the pit wall is approximately –8 meters mean lower low water (MLLW), and the deepest point in the pit is approximately –20 meters MLLW. The capping site represents a small portion of the entire NEIBP area (Figure 1). Bathymetry within the capping site ranges from –8 to –18.5 meters MLLW. Placement of the LARE dredged sediments raised the bottom elevation to approximately –15 meters MLLW.

After sufficient time had passed[1] to allow the contaminated sediments to settle and gain bearing strength following placement, the contaminated sediments were capped with clean sandy material. Approximately 66,000 m^3 of clean cap material were mechanically dredged from the South Energy Island Borrow Pit (SEIBP), transported by barges, and placed using two placement techniques: cap placement by rehandling and by bottom-dump barge. The cap thickness was designed to be approximately 1.5 meters, resulting in a final surface elevation of approximately –13.5 meters MLLW.

Monitoring of water quality, construction activities, and sediment quality was performed during and after the construction operations. These data were used to compare the project as constructed to the design specifications and predicted results.

5.1.2 Short-Term Effectiveness

The short-term effectiveness criterion addresses the effectiveness of the alternative during the construction and implementation phases until the sediment management objectives are met (e.g., after capping has discretely isolated contaminated sediments). For the Aquatic Capping alternative, this refers to the ability of the contractor to control the loss of contaminated sediments during dredging, placement, and capping. (Contaminant loss during dredging operations is essentially the same for all alternatives.) A comparison of

[1] Minimum duration determined to be 45 days. Actual duration of LARE consolidation was 117 days.

actual contaminant loss — as represented by total suspended solids (TSS) concentrations, water quality contaminant concentrations, and post-placement surface sampling results — to the predicted results and to results for other, similar projects in the Los Angeles region (see review in Anchor 2002) indicates that the contractor successfully controlled sediment loss during placement. Surface sediment chemistry results around the NEIBP were not substantially elevated and were below sediment chemistry guidelines commonly used in the region to screen for sediment toxicity (i.e., Effects Range-Low [ER-L]; Long et al. 1995) for both the post-disposal and post-capping conditions.

LARE Contaminated Sediment Dredging

TSS concentrations in the water column are a good general measure of how much sediment (along with associated particulate-bound chemicals) is likely lost during dredging and placement operations. Results for water quality monitoring downstream of the dredging indicated that TSS concentrations were generally greater than background concentrations and that light transmission was generally lower than background, as were predicted. Dredging operations typically result in elevated TSS concentrations and reduced light transmission (Anchor 2002). The degree of sediment resuspension is a function of the equipment, the site conditions, and the skill of the dredge operator. Observed TSS concentrations were within the overall range predicted by pre-project modeling, with observed concentrations often being lower than was predicted close to the dredge and sometimes higher than was predicted at 200 meters from the dredge (Appendix A). Overall, the observed TSS concentrations fell within the normal range of standard dredging operations in the Los Angeles County region (see review in Anchor 2002).

Contaminant loss during dredging was judged to be minimal and was within the standard ability of mechanical dredge equipment to control. Although the data do not allow a direct determination of the percentage of sediment loss during the dredging process, TSS concentration data indicate that the amount of TSS around the dredge was within the ranges expected by predictive computer models. These models are based on observed dredging resuspension rates in the 0.1 to 9 percent range, with an average of about 2 percent for mechanical dredges

(Anchor 2002). The TSS concentration data observed for this project would be considered consistent with the approximate 2 percent resuspension of sediment typical for mechanical dredging operations.

NEIBP Contaminated Sediment Placement

TSS results during placement of the contaminated sediments into the NEIBP indicated slightly higher average TSS concentrations downstream of placement operations than were observed during dredging operations, particularly at distances of about 50 meters from the respective operations. The higher TSS concentrations were more frequent in deeper water samples from near the disposal barge, which indicates that the elevated TSS may at least be partially caused by bottom sediment that is resuspended as the contaminated sediment load impacts the bottom (Appendix A).

This hypothesis is supported by an evaluation of material found outside of the NEIBP during placement operations. Sampling and testing of sediments found outside the NEIBP showed relatively clean silt/clay sediments, similar to the pre-existing NEIBP bottom sediments (i.e., NEIBP foundation sediments) and dissimilar to the relatively contaminated and sandy sediments from the LARE.

Sediment resuspension during placement operations was estimated to be between approximately 0.15 and 3.3 percent for one relatively typical barge load. Estimates of sediment loss could not be made through visual observations (i.e., sediment profile imaging [SPI]) of sediment deposition around the NEIBP because of the confounding factor of NEIBP foundation sediment resuspension and deposition. TSS concentrations observed for disposal operations were generally at or below those predicted by modeling. Therefore, it appears likely that the amount of sediment loss was less than that experienced for most confined aquatic disposal projects.

5.1.3 Long-Term Effectiveness

The long-term effectiveness criterion addresses the effectiveness of the alternative at maintaining sediment management objectives following the construction and implementation phases; for instance, maintaining isolation of contaminants after capping has been completed. Based on long-term monitoring of aquatic caps for other projects (Sumeri 1995), as well as on successful placement of the cap to the required thickness and horizontal coverage without excessive mixing, the NEIBP site is expected to be effective at isolating contaminants in the long-term.

The three main components of a successful cap are physical isolation, erosion protection, and chemical isolation. The primary mechanisms that could impact the long-term effectiveness of the cap by impacting those components are:

- Bioturbation (i.e., sediment mixing by organisms living in sediments)
- Erosive forces, including waves, currents, and propeller wash
- Contaminant mobility, including advective and diffusive transport

The cap thickness required to address all the design components was determined to be 95 centimeters (cm) (Appendix A). For construction, a targeted average cap thickness of 1.5 meters was specified, with a minimum cap thickness of 1 meter.

Design criteria were developed to account for bioturbation and were incorporated into the design as discussed in Appendix A. Long-term monitoring of the cap is required to demonstrate that bioturbation does not exceed the design criteria established for the pilot project and does not cause unacceptable mixing of underlying sediment with the cap material.

Predictive modeling was used to assess long-term effectiveness of the cap against erosive forces. The LTFATE model predicted potential erosion at the NEIBP site under the January 1988 storm event, which was considered a major storm event. Using conservative assumptions, the model predicted average erosion depths of less than 6 cm for both cohesive and non-cohesive sediments (Appendix A – Attachment C). The maximum erosion depths (representing the deepest points predicted) were 33.5 cm for non-cohesive sediments and 8.2 cm for cohesive sediments (Appendix A – Attachment C). Because the Aquatic Capping site is located within a depression, erosion, if it occurred, would likely represent surficial mixing rather than loss of cap material. In addition, the NEIBP has been shown to be a depositional area (Appendix A), so that effective cap thickness would likely increase over the long-term. Long-term monitoring of the cap is required to demonstrate that significant erosion does not occur over the long-term.

Contaminant mobility modeling for this alternative included the RECOVERY model and empirical equations to estimate the time it would take for the cap to reach chemical saturation (Appendix A). Results of the RECOVERY modeling indicate that the cap is highly effective at isolating contaminants from the water column and aquatic organisms. Burial of the cap through the new deposition of suspended solids is predicted to occur at a faster rate than is diffusion of contaminants up into the cap. The NEIBP experiences sedimentation because the bottom of the NEIBP is at a much lower elevation than the surrounding area, which causes the NEIBP to act as a sediment trap. The sources of sedimentation are the Los Angeles River and Long Beach Harbor. The ongoing process of off-site sedimentation means that potential contaminant mobility through the cap is further mitigated by the addition of new cap material.

Simple diffusive flux calculations (presented in Appendix A) also indicate that any migration of contaminants through the cap would occur at an extremely slow pace (hundreds to thousands of years). Even if it is assumed that equilibrium conditions are not eventually reached (which is evaluated by more complex models such as RECOVERY), simple flux calculations indicate that the rate of flux would be outpaced by the sedimentation rate observed in the NEIBP.

Actual long-term results depend on how well the cap was placed to avoid excessive mixing or insufficient cap thickness. The post-construction monitoring data, which include post-capping bathymetric surveys, core logs, and chemical concentrations through the cap, indicate that the contractor was able to place a discrete cap that had limited mixing and was able to meet the design criteria for cap thickness and horizontal coverage. Chemistry results show a distinct difference between chemical concentrations in contaminated sediments versus in the clean cap material. Further, the contaminated sediment-clean cap interface is distinct, indicating little if any mixing of sediments during cap placement at most locations sampled.

5.1.4 Implementability

The implementability criterion addresses the technical feasibility of implementing an alternative and the availability of various services and materials required during its implementation. For Aquatic Capping, implementability generally refers to the contractor's ability to construct the project to the specified design criteria. Aquatic Capping is considered readily implementable. Mechanical dredging and accessory equipment are available locally, and the process uses reliable, proven technologies. Results from the monitoring performed during dredging and placement operations, as well as review of the post-placement and post-capping bathymetry, demonstrate that the contractor was able to meet the required design criteria.

LARE Contaminated Sediment Dredging

Implementability issues at the LARE dredge site would be the same for all alternatives, because the contaminated sediments must be removed for all alternatives. Therefore, no additional discussion is provided because implementability at the LARE dredge site is not relevant to a comparison of alternatives.

NEIBP Contaminated Sediment Placement

The design criteria specified that all contaminated sediments placed into the NEIBP were to be placed within the pit boundaries to an elevation of –15 meters MLLW, with an allowance for equipment tolerance of ±0.5 meter vertically (Figure 2). MDFATE modeling predicted that material could be placed within the specified 1 meter total vertical tolerance (Appendix A) using bottom-dump barges. During construction, the contractor did use bottom-dump barges to place the contaminated sediments, and post-placement bathymetric surveys indicated that the contractor met the specified elevation range.

The contractor employed a real-time positioning system using the Differential Global Positioning System (DGPS) to ensure that bottom-dump barge loads were not discharged outside of the specified NEIBP boundaries. All placement events were recorded by the contractor, and the records showed that the contractor was within the specified boundaries during all discharges.

SEIBP Clean Cap Dredging

The contractor had no difficulties during dredging of the SEIBP clean cap material and was able to meet the grades and elevations specified in the plans and specifications.

The cap material from SEIBP is clean navigational dredged sediment. The ideal grain size for cap material is slightly fine to medium sand.

NEIBP Clean Cap Placement

The design criteria for the cap specified placing clean cap sediment within the pit boundaries to elevation –13.5 meters MLLW with an allowance for equipment tolerance of ±0.5 meter vertically (Figure 2). MDFATE modeling predicted that material could be placed within the specified 1 meter total vertical tolerance (Appendix A) using bottom-dump barges. The design required the contractor to place the clean cap material using two techniques: via bottom-dump barge and through rehandling cap sediment from the haul barge using mechanical equipment. Both cap placement techniques produced a discrete cap layer without excessive mixing as indicated from diver cores and chemical testing. The post-capping bathymetric survey indicated that the contractor was able to meet the specified elevation range using either placement technique.

Because the NEIBP is relatively deep and somewhat protected from wind, wave, and propeller wash action, the sandy cap material used for this project is sufficient to resist what are predicted to be minimal erosive forces, and no site restrictions are needed for the NEIBP disposal area or any future similar projects.

Production rates for cap placement were much higher for the bottom-dump barge technique than for the rehandling bucket placement. Because there was no measurable difference between the techniques in terms of meeting cap design criteria and minimizing the mixing of contaminated sediments with cap material, the bottom-dump barge technique, with its higher production rate, appears preferable.

5.1.5 Environmental Impacts

The environmental impacts criterion addresses whether a specific alternative poses unacceptable short-term environmental impacts. For Aquatic Capping, this generally refers to whether significant short-term adverse water quality impacts occur during construction operations. Potential water quality impacts include changes in physical parameters (e.g., changes in dissolved oxygen or pH or reduced light transmission), elevated dissolved or particulate chemical concentrations in the water column, contaminated sediment loss, and/or significant changes to other standard water quality parameters (e.g., TSS, temperature, salinity). It is important to remember that the short-term water quality impacts observed during dredging would apply equally to each alternative. The observed short-term water quality impacts are discussed below.

LARE Contaminated Sediment Dredging

Water quality monitoring results during dredging indicated that TSS concentrations downstream of dredging were generally greater than background levels and that light transmission was generally lower than background, as were predicted. Observed TSS concentrations were within the overall range predicted by pre-project modeling with concentrations often being lower than was predicted close to the dredge and sometimes higher than was predicted at 200 meters from the dredge (Appendix A). However, the observed TSS concentrations fell within the normal range of standard dredging operations in the Los Angeles County region (see review in Anchor 2002).

Chemistry results for samples collected from the water column downstream of dredging showed no detected organic compounds. Occasionally, some metals, including chromium, mercury, and nickel, were detected at concentrations greater than the California Ocean Plan (COP 2001) objectives and above background concentrations. In typical dredging projects, a mixing zone distance of 100 meters is allowed for dredging dilution. Metals were periodically detected above background concentrations and California Ocean Plan objectives at distances greater than 100 meters from the dredging. However, these exceedances were sporadic. The total number of exceedances (at any downstream distance) represented only between 8 and 29 percent (depending on the metal in question) of all the samples collected throughout the dredge area, indicating that exceedances were not chronic (Appendix A).

Dissolved oxygen concentrations were generally depressed downstream of LARE dredging. However, a similar (although less frequent) trend was observed during the dredging of clean cap material. Light transmission was also depressed to some extent downstream of both operations, regardless of whether LARE or cap sediments were being dredged. This indicates that some of the observed water quality effects are not caused by sediment contaminants alone and would be applicable in any dredging operation.

NEIBP Contaminated Sediment Placement

The results of water quality monitoring during placement of the contaminated sediments into the NEIBP indicated slightly higher average TSS concentrations than were found during dredging operations, particularly at distances of about 50 meters from the respective operations. The higher TSS concentrations were more frequent in deeper water samples from near the disposal barge, which indicates that the elevated TSS may at least be partially caused by bottom sediments that are resuspended as the contaminated sediment load impacts the bottom (Appendix A).

As with dredging operations, no organic compounds were detected in any water samples taken near the disposal operation. In addition, there were no metals exceedances of background concentrations or California Ocean Plan objectives downstream of disposal operations. As with dredging operations, dissolved oxygen and light transmission were commonly depressed near disposal operations. However, a similar trend (although to a lesser degree) was observed for cap material disposal as well. Therefore, contaminated sediments may not strictly cause these effects. The range of TSS concentrations was generally lower than the concentrations predicted by computer modeling prior to construction, and TSS concentrations were generally in the range of background by 200 meters from the operation.

In addition, all surface sediment chemistry results for samples collected in areas around the NEIBP after placement of the LARE sediments and after all operations were complete were below the ER-L (a commonly used sediment quality guidance), indicating that no significant chemical impacts occurred to the surrounding sediment as a result of disposal operations.

SEIBP Clean Cap Dredging

As noted, dissolved oxygen and light transmission were fairly commonly depressed during dredging of the cap material. The range of TSS concentrations was generally comparable to the concentrations predicted by computer modeling, and TSS concentrations were in the range of background by 200 meters from the operation.

NEIBP Clean Cap Placement

Dissolved oxygen and light transmission were again observed to be depressed downstream of cap placement operations. No organic compounds were detected in any samples. With the exception of chromium in 17 percent of the samples, no metals were detected at concentrations above background and California Ocean Plan objectives. TSS concentrations were generally within the range predicted by computer modeling, with slightly higher concentrations observed at 100 meters from the placement operation. However, TSS concentrations were within the range of background at 200 meters from the operation.

5.1.6 Cost

The cost criterion addresses the associated capital costs (both direct and indirect) and annual operations and maintenance costs. There are no operations costs associated with the Aquatic Capping alternative, and there are no anticipated costs for cap maintenance over time, because the NEIBP is a depositional area. There are annual costs associated with monitoring the site, but monitoring costs have not been included in this evaluation because monitoring requirements, and therefore costs, will vary from project to project. The capital costs developed for this evaluation are based on dredging and isolating 105,000 m^3 of contaminated sediments under 66,000 m^3 of clean cap. The unit cost for dredging and disposing of contaminated sediments in the Aquatic Capping Pilot Study was approximately $26 per m^3. Capital costs for the Aquatic Capping Pilot Study are summarized in Table 1.

Table 1
Aquatic Capping Pilot Study Costs

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	105,000	m^3	$ 8.24	$ 865,200
Placement of Contaminated Sediment				
Placement	105,000	m^3	$ 2.00	$ 210,000
Hydrographic Surveys	1	LS	$ 46,631	$ 46,631
Capping				
Mobilization/Demobilization	1	LS	$ 141,749	$ 141,749
Dredging and Capping	66,000	m^3	$ 11.90	$ 785,400
Hydrographic Surveys	5	each	$ 4,513	$ 22,565
Cost Subtotal				$ 2,362,261
OVERHEAD @ 8.0%				$ 188,981
PROFIT @ 6.5%				$ 165,831
BOND @ 1.23%				$ 33,420
TOTAL				$ 2,750,493

5.2 Extrapolated Results: Aquatic Capping to Baseline Case

This section discusses the results extrapolated from adjusting the Aquatic Capping Pilot Study data to the Baseline Case condition.

5.2.1 Baseline Case Adjustments

Minimal adjustment is required to extrapolate to the Baseline Case, because the Baseline Case was initially based on project components of the Aquatic Capping alternative. The actual volume dredged for the pilot study was 105,000 m^3, which needs to be adjusted to the Baseline Case volume of 100,000 m^3.

5.2.2 Short-Term Effectiveness

The same short-term effectiveness issues relevant to the Aquatic Capping Pilot Study apply to the Baseline Case. It is anticipated that the contractor would be able to control significant contaminant loss for the Baseline Case.

5.2.3 Long-Term Effectiveness

The same long-term effectiveness issues relevant to the Aquatic Capping Pilot Study apply to the Baseline Case. It is anticipated that the NEIBP would prove effective at isolating contaminated sediments over the long-term for the Baseline Case.

5.2.4 Implementability

The same implementability issues relevant to the Aquatic Capping Pilot Study apply to the Baseline Case. It is anticipated that the contractor would be able to construct the Baseline Case to the required design criteria.

5.2.5 Environmental Impacts

The same environmental impact issues relevant to the Aquatic Capping Pilot Study apply to the Baseline Case. It is anticipated that the contractor would be able to control potential environmental impacts to acceptable levels.

5.2.6 Cost

Capital costs for the Baseline Case were developed using the same cost estimate format as for the Aquatic Capping alternative, adjusted to account for the reduced volume to be dredged and isolated. The Baseline Case unit cost is approximately \$27 per m^3. The capital costs for the Aquatic Capping Baseline Case are summarized in Table 2.

Table 2
Aquatic Capping Baseline Case Costs

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	100,000	m^3	$ 8.24	$ 824,000
Placement of Contaminated Sediment				
Placement	100,000	m^3	$ 2.00	$ 200,000
Hydrographic Surveys	1	LS	$ 46,631	$ 46,631
Capping				
Mobilization/Demobilization	1	LS	$ 141,749	$ 141,749
Dredging and Capping	66,000	m^3	$ 11.90	$ 785,400
Hydrographic Surveys	5	each	$ 4,513	$ 22,565
Cost Subtotal				$ 2,311,061
OVERHEAD @ 8.0%				$ 184,885
PROFIT @ 6.5%				$ 162,236
BOND @ 1.23%				$ 32,696
TOTAL				$ 2,690,878

5.3 Summary of Cement Stabilization Bench-Scale and Pilot-Scale Results

The Cement Stabilization studies consisted of a laboratory bench-scale study (here called the Bench Study) and a pilot, or field, scale study (here called the Pilot Study) for applying cement-based stabilization technology to contaminated dredged sediments. (Collectively, the two studies are referred to as the Cement Stabilization Pilot Study to create consistency in terminology among all four alternatives.) The Bench Study was initiated by the USACE as a precursor to the Pilot Study to develop laboratory data on the effectiveness of Cement Stabilization at treating contaminated sediments. The primary objective for the Bench Study was to provide guidance for developing design criteria for the Pilot Study. However, funding and scheduling constraints made it necessary to initiate the Pilot Study before completing the Bench Study. Members of the CSTF recommended proceeding with the Pilot Study while funding was available in the current fiscal year. The Pilot Study team subsequently was actively involved in reviewing preliminary results of the Bench Study, which helped to enable development and field implementation of the Pilot Study, thereby mitigating the circumstance that forced the studies to be initiated in reverse order.

5.3.1 Bench Study Description

Moffatt & Nichol Engineers, MEC Analytical Systems, and Waste by Rail (WBR) conducted the Bench Study under separate contract with the USACE. Sediment samples were taken from four marine sites in Los Angeles County: Marina del Rey, the LARE, POLB Channel 2, and POLA Consolidated Slip. The Bench Study implemented a relatively wide range of binder mixes, including Portland cement, fly ash, and fluid bed ash, and provided substantial data for evaluating the effectiveness of the Cement Stabilization process at treating dredged sediments from the Los Angeles County region. Bench Study details are documented in Appendix B1.

5.3.2 Pilot Study Description

The Pilot Study was constructed at the POLA's Anchorage Road site. The location of the project site is indicated on Figure 3. Construction activities at the project site included:

- Site preparation
- Treatment
- Residual management

The project site was prepared by laying out and constructing four treatment cells, four compaction pads, and stockpile areas. Each treatment cell was created by excavating a pit approximately 1.5 meters in depth, with an approximate side slope of 1 horizontal to 1.5 vertical (1H:1.5V). The treatment cells were surrounded by berms approximately 1.2 meters in height.

The dredged sediments used in the Pilot Study were obtained from a dredged material holding basin near the project site. The source sediments had been previously dredged from various POLA harbor channels and stockpiled in the pond for a period of days to weeks. The source sediments were excavated from the holding basin, hauled to the nearby project site in dump trucks, and placed in the treatment cells by the POLA's dredging contractor.

To create an "as-dredged" condition for the relatively dry material from the holding basin, the contractor added water from the nearby POLA Consolidated

Slip to the filled cells and blended the sediment and water with a rake-headed excavator. The same equipment was then used to rake the material to remove debris. A long-stick excavator equipped with a rotary mixer was then used to blend in binder mixes at mix ratios listed in Table 3.

Table 3
Binder Mix Ratios

Cell	Binder Mix Ratio	
	Portland Cement (Type II) (% wet weight)	Fly Ash (Class F) (% wet weight)
1	1.5	0.0
2	2.0	2.0
3	6.0	0.0
4	2.0	4.0

Following thorough mixing over a specified time, the mixed sediments went through an initial in-cell curing period of approximately 12 to 24 hours.

After initial in-cell curing, the treated sediments were transferred from the treatment cells to on-site stockpiling using an excavator and loader. The treated sediments were then relocated to on-site compaction pads, placed in lifts, compacted, and allowed to complete the 28-day curing period. Coring samples were taken during the 28-day curing period for use in geotechnical, chemical, and leachate tests.

Following the 28-day curing period, the treated sediments were spread on site. Debris and operations wastes were collected in roller-off containers, hauled to, and disposed of at an ECDC-owned landfill in Utah in compliance with applicable regulatory requirements.

After treatment was complete, the project site was restored to pre-project conditions as required by the POLA. Monitoring of construction activities was performed during construction, and post-treatment sediment quality testing was also completed. The resulting data were used in evaluating the constructed project results. See Appendix B2 for a description and discussion of the Pilot Study.

5.3.3 Short-Term Effectiveness

The short-term effectiveness criterion addresses the effectiveness of the alternative during the construction and implementation phases until the sediment management objectives are met. Cement stabilization is considered effective in the short-term (i.e., during and immediately after construction). This alternative reduces potential contaminant sources by removing contaminated sediments from the marine environment. The Pilot Study demonstrated measurable reduction in the leachability of targeted metals in the period immediately after cement additives were mixed in.

5.3.4 Long-Term Effectiveness

The long-term effectiveness criterion addresses the effectiveness of the alternative in maintaining sediment management objectives in the long-term (i.e., over years) after the construction and implementation phases. The Pilot Study results indicated that Cement Stabilization has long-term effectiveness for treating contaminated sediments from Los Angeles County. The results also demonstrated that Cement Stabilization is effective in producing an engineering fill material with substantially enhanced strength characteristics. The material's improved geotechnical properties afford a wide range of opportunities for beneficial use of the treated sediment. Cement stabilization was also effective at binding targeted metals contaminants, with the result that metals leachability of the contaminated sediments was substantially reduced following treatment.

The Pilot Study further demonstrated that Cement Stabilization is effective at encapsulating and containing a highly soluble and mobile contaminant such as sodium chloride within the treated sediments in a monolithic form. The potential for sodium chloride to leach was consistently and substantially reduced with increasing binder content within the relatively moderate range of mix ratios tested.

Cement stabilization was also shown to be contaminant-specific in its effectiveness. Certain metals in the raw sediments were mobilized upon treatment, indicating that a detailed bench-scale treatability study needs to be conducted as part of any Cement Stabilization project. For large-scale field application, target contaminants should first be identified and a bench-scale treatability test conducted to determine proper binder types, mix ratios, and pH controls to ensure immobilization of the target contaminants.

Uncertainty remains in regard to the lack of correlation between pH and metal solubility for a number of non-target metals contaminants that mobilized upon treatment. Another uncertainty is the ability of Cement Stabilization to treat organic contaminants, because the Bench Study did not assess how organic contaminants react during stabilization.

5.3.5 Implementability

The implementability criterion addresses the technical feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The Pilot Study results indicated that Cement Stabilization of dredged sediments could be implemented using a land-based system. The study demonstrated that in-ground treatment cells are convenient and economical vessels in which to treat the dredged sediments and complete initial curing. Operational controls were executed satisfactorily and without difficulty over in-cell material handling, debris removal, binder introduction, blending, excavation of cured material, and sample collection. The equipment configuration and operating scheme, which were designed to simulate a full-scale project, were shown to be implementable and efficient both logistically and operationally. However, the equipment used is specialized and may not be readily available.

The land-based system designed for and implemented in the Pilot Study could be adapted to a barge-based system, where treatment takes place in a series of docked barges instead of upland constructed cells, without significant modification. Most of the findings and conclusions from the Pilot Study with regard to treatment operations apply to a barge-based system as well. The efficient implementation of a land-based treatment system, as demonstrated in the Pilot Study, suggests that a similar level of implementability can be expected from a barge-based treatment system.

Cement stabilization can have significant limitations with respect to identifying locations for siting the treatment cells and for final disposal of the treated sediments. The small volume of sediments treated in the Pilot Study made identifying and selecting the treatment location easier than would be the case for a full-scale project.

5.3.6 Environmental Impacts

The environmental impacts criterion addresses whether a specific alternative poses unacceptable short-term environmental impacts. The Pilot Study's operations and results of on-site monitoring indicate no observable occurrences with potential to result in significant environmental impacts to the project area. The Pilot Study site was located near the POLA dredged material holding basin, which is currently used to hold untreated dredged sediments. Because of the similar use, no significant change to the water available to migrate into the groundwater is expected.

Pilot Study operations were executed in compliance with the Spill Prevention Plan. Dredged sediment handling and transport from the holding basin to the treatment cells were conducted using trucks, under detailed operational controls, and with monitoring by designated personnel. No significant in-transit spills of the raw sediments occurred.

The project generated no residual process water. Other residual wastes, including debris and operations wastes, were managed without spillage through proper on-site handling, storage, off-site transfer, and landfill disposal. The project site was backfilled and restored after the project was completed using indigenous site soil or treated sediments having contaminant levels equivalent to or less than the pre-project conditions.

Potential air quality impacts were avoided through an on-site decision to employ a slurry-based binder introduction method after the planned dry-cement injection method was observed to generate excess dust.

Increased emissions of volatile constituents could occur during the treatment process as a result of the blending and heat generation that accompany the hydration process. Although the levels of volatile constituents in the pre-treated sediments are unknown, on-site observations indicate there were no releases of significantly elevated levels of volatile constituents during the treatment process (Appendix B2).

5.3.7 Cost

The cost criterion addresses the associated capital costs (both direct and indirect) and annual operations and maintenance costs for each alternative. The Pilot Study treated approximately 1,850 m^3 of contaminated sediments at a cost of approximately $521,000, or $282 per m^3. Table 4 identifies cost components for the Pilot Study.

For a full-scale project, a disposal site (or use location) would be needed for the stabilized sediments. There may be costs associated with a permanent disposal site, such as tipping fees and annual costs associated with monitoring or operations and maintenance. However, monitoring costs have not been included in this evaluation because monitoring requirements, and therefore costs, will vary from project to project.

Table 4
Cement Stabilization Pilot Study Costs

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	NA	LS	NA	NA
Dredging and Hauling	NA	m^3	NA	NA
Treatment Activities				
Site Preparation	4	Cell	$ 12,000	$ 48,000
Binders	1	LS	$ 23,446	$ 23,446
Handling and Treatment	1	LS	$ 95,840	$ 95,840
Residuals Disposal and Site Restoration	1	LS	$ 9,994	$ 9,994
Field Consulting	1	LS	$ 52,097	$ 52,097
Compaction Tests	1	LS	$ 49,520	$ 49,520
Sampling and Testing	1	LS	$ 168,187	$ 168,187
Cost Subtotal				$ 447,084
OVERHEAD @ 8.0%				$ 35,767
PROFIT @ 6.5%				$ 31,385
BOND @ 1.23%				$ 6,325
TOTAL				$ 520,561

The cost of the Pilot Study provides a basis for estimating the cost of a full-scale project of similar nature. It should be noted that the cost of the Pilot Study cannot be directly translated to a full-scale project on a unit-cost basis, because the goal of the Pilot Study was to acquire technical and operational information. The benefit of the Pilot Study is measured by the information acquired and data collected, not the amount of dredged sediments treated. The itemized costs, however, can be scaled up to provide a cost estimate for a full-scale project.

5.4 Extrapolated Results: Cement Stabilization to Baseline Case

This section discusses the results extrapolated from adjusting the Pilot Study data to the Baseline Case condition.

5.4.1 Baseline Case Adjustments

The primary adjustments required to scale up the Pilot Study results to the full-scale Baseline Case are an increase in the treatment volume to the Baseline Case of 100,000 m^3 and a corresponding increase in project duration and the space required for treatment. Since treatment design and field operations for the Pilot Study were specified and executed to simulate a full-scale project, the findings on effectiveness, implementability, environmental impacts, and major cost components are transferable to the Baseline Case without need for significant re-evaluation.

5.4.2 Short-Term Effectiveness

Cement stabilization is expected to be effective in the short-term (i.e., during construction) for the Baseline Case. This alternative will reduce the potential contaminant sources by removing contaminated sediments from the marine environment. The Pilot Study demonstrated that contaminant mobility was reduced in the treated sediments in the period immediately after cement additives were mixed in.

5.4.3 Long-Term Effectiveness

Cement stabilization is expected to be effective at immobilizing contaminants for the Baseline Case. The level of effectiveness may be substantially improved if a detailed pre-project bench-scale treatability study is conducted. This treatability study would need to identify target contaminants, then formulate treatments specific to the target contaminants in terms of binder formula, mix ratio, and pH controls to ensure their immobilization.

Cement stabilization is also expected to be effective for the Baseline Case in enhancing the engineering properties of the dredged sediments. The level of effectiveness may be further improved with mix ratios higher than the range implemented in the Pilot Study. Enhancement of primary engineering properties, such as strength characteristics, will be achieved with relative certainty. A treatability study will be needed to meet specific property requirements.

Cement stabilization is further expected to be effective for the Baseline Case at reducing the leaching of chloride from treated sediments under the field-compacted geotechnical conditions the treated sediments are most likely to be subjected to when applied for beneficial uses. A treatability study will be needed to meet specific chloride levels.

5.4.4 Implementability

Field implementation is generally expected to be efficient both operationally and logistically for both land- and barge-based treatment scenarios at a port site. However, the specialized equipment required may not be readily available. The scaled-up equipment configuration and operating schemes should be capable of processing dredged sediments at a production rate of approximately 3,000 to 4,000 m^3 per day.

For the Baseline Case, it is assumed that a site at a port facility is available where treatment can be implemented. Finding such a site, however, is dependent on various factors, including period of use, existing port operations, space needs, and availability. Cement stabilization can have significant limitations with respect to identifying locations for the treatment cells and for final disposal of the treated sediments. Baseline Case siting would need to be conducted opportunistically. Available candidate sites include the POLA Anchorage Road site where the Pilot Study was conducted and periodically vacant piers at both POLA and POLB.

In addition, a full-scale project needs to be scheduled and coordinated with one or more receiver projects able to accept the treated sediments for beneficial use. Typical receiver projects include port development landfill projects, which take place on a regular basis. Other potential receiver projects include major construction and transportation projects within Los Angeles County (and neighboring counties within economical transport distances) that require large quantities of fill. Since a large stockpile area will potentially be required for the treated sediments if an adequate receiver project is not available, identifying and coordinating with a receiver project is crucial to the implementability of a full-scale Cement Stabilization project. Given the importance of a receiver project, adequate lead-time should be allowed to secure one.

5.4.5 Environmental Impacts

The Baseline Case Cement Stabilization project is not expected to result in significant adverse environmental impacts if it is designed and conducted consistent with considerations and requirements of the Pilot Study. Increased emissions of volatile constituents could occur during the treatment process as a result of the blending and heat generation that accompany the hydration process. The potential extent of any added volatilization, however, depends on the availability of volatile compounds in the raw dredged sediments. Although substantial releases of volatile constituents are not expected to occur during the treatment process, measures to control volatile emissions can be applied as preventative measures for full-scale projects.

Primary considerations for minimizing potential environmental impacts during a Cement Stabilization project include:

- Locating land-based treatment at a site where the temporary storage of dredged sediments is currently, or can be, permitted, as well as lining the treatment cells if (1) additional protection from seepage is required or (2) the treatment site is located away from a permitted storage area for dredged sediments.
- Designing and implementing a comprehensive Spill Prevention Plan to protect the environment of the treatment site as well as areas along the material handling and transfer routes (between barges, treatment site, and placement destination) that are susceptible to spill during project operations.
- Managing project residuals, including residual process water, debris, and operations wastes, using proper handling, storage, transfer, and disposal procedures, as well as recycling excess barge water as process water to the greatest extent possible and disposing of residuals in compliance with applicable laws and regulations.

5.4.6 Cost

The cost of a full-scale, land-based Cement Stabilization project in the Los Angeles County region is expected to be approximately \$46 per m^3, as shown in Table 5. That cost covers treatment activities from the point when the dredged sediments are delivered dockside by barge to a port facility, to the point when the treated sediments are delivered by truck for placement at the receiver site. It does not include stockpiling or placement at the receiver site.

The cost of a full-scale, barge-based Cement Stabilization project is expected to be in the same range as its land-based counterpart, given their similarity in operations and equipment.

Table 5
Cement Stabilization Baseline Case Costs

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	100,000	m^3	$ 8.24	$ 824,000
Treatment Activities				
Mobilization/Demobilization	1	LS	$ 58,800	$ 58,800
Equipment	1	LS	$ 635,000	$ 635,000
Site Preparation	5	Cell	$ 35,000	$ 175,000
Transportation to Treatment Site	1	LS	$ 441,000	$ 441,000
Cement Treatment	1	LS	$ 956,100	$ 956,100
Residuals Disposal and Site Restoration	1	LS	$ 100,000	$ 100,000
Disposal of Treated Sediments	1	LS	$ 441,000	$ 441,000
Cost Subtotal				$ 3,921,616
OVERHEAD @ 8.0%				$ 313,729
PROFIT @ 6.5%				$ 275,297
BOND @ 1.23%				$ 55,481
Total				$ 4,566,123

5.5 Summary of Sediment Washing Bench-Scale Results

This section summarizes results of the Sediment Washing bench-scale laboratory study (here called the Bench Study) conducted by staff at the ERDC Environmental Laboratory. (Sediment washing was studied only at the bench scale; however, the study is sometimes referred to as the Sediment Washing Pilot Study to create consistency in terminology among all four alternatives.) Complete results of this evaluation are presented in Appendix C.

5.5.1 Bench Study Description

ERDC conducted the Sediment Washing Bench Study to evaluate the effectiveness of Sediment Washing for removing chlorides and sodium from marine sediments. Sediments having high chloride concentrations currently cannot be used at upland disposal sites because of a concern that chloride leaching from the sediments could impact groundwater. The purpose of the Sediment Washing Bench Study was to develop information to support potential upland beneficial use of contaminated sediments as daily landfill cover.

Two test methodologies were evaluated to simulate potential field applications for regional dredging projects: active and passive washing techniques. Active (mechanical) washing was simulated in the laboratory by using a pressure filter to dewater the sediments and deionized water to wash salts from the dewatered sediment cake. Passive (gravity drainage) washing was simulated in the laboratory using a column leaching apparatus that diluted and removed the salts from the sediment cake.

The two principal feasibility issues addressed in the Bench Study were:

- Determining the volume of water required to reduce chloride and total dissolved solids (TDS) levels to below State of California conservative groundwater quality criteria of 30 milligrams per liter (mg/L) for chloride and 500 mg/L for TDS in filtrate.
- Assessing the efficiency of chemical removal from the treated sediment and the potential for subsequent contaminant release following treatment.

Results of the Bench Study showed that Sediment Washing was effective at removing chloride and sodium from the dredged sediments using both laboratory approaches. Chemical constituents (e.g., metals) were not significantly reduced. The greatest variability was demonstrated for the unconsolidated column tests, with wash water requirements ranging from 1.5 to 60 void volumes. The least variability was observed for the pressure filter tests, with void volumes ranging from 7.6 to 21.

5.5.2 Short-Term Effectiveness

The short-term effectiveness criterion addresses the effectiveness of the alternative during the construction and implementation phases until the sediment management objectives are met. Sediment washing is considered effective in the short-term (i.e., during and immediately after construction). This alternative will reduce potential contaminant sources by removing contaminated sediments from the marine environment. The Bench Study demonstrated a reduction in chloride concentrations to acceptable levels during successive washing events. However, Sediment Washing did not affect metals leachability.

5.5.3 Long-Term Effectiveness

The long-term effectiveness criterion addresses the effectiveness of the alternative in maintaining sediment management objectives after the construction and implementation phases over the long-term (i.e., for years). The Bench Study results demonstrated that Sediment Washing is effective at reducing chloride and TDS concentrations, thereby producing a usable product for potential upland applications within the Los Angeles County region. However, metals leachability of the treated sediments was not substantially altered, suggesting that future contaminant mobility may be an issue if the treated sediments are used in an upland application where groundwater resources could be exposed.

5.5.4 Implementability

The implementability criterion addresses the technical feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The Bench Study results indicated that the washing of dredged sediments could be implemented with a land-based system, provided that further laboratory bench-scale studies were first conducted to determine optimal operational procedures.

5.5.5 Environmental Impacts

The environmental impacts criterion addresses whether a specific alternative poses unacceptable short-term environmental impacts. The Bench Study results indicated no observable occurrences with potential to result in significant environmental impacts to the project area from the treatment process.

There is, however, a potential impact related to the treatment of wash water if dissolved chemical concentrations result during Sediment Washing. The Bench Study indicated that there are no elevated concentrations of dissolved chemicals. For example, metals leaching did not occur. However, it is uncertain whether highly contaminated sediments would demonstrate unacceptable leachate concentrations. If unacceptable leachate concentrations occurred, there could be a need to treat wash water prior to discharging it into the receiving water.

There is also potential for environmental impacts if there is a loss of contaminated sediments during transport from the dredge site, to and from the washing facility, or from the resulting waste stream.

5.5.6 Cost

The cost criterion addresses the associated capital costs (both direct and indirect) and annual operations and maintenance costs for each alternative. The Sediment Washing Bench Study was a small laboratory study. As such, there are no pilot study costs to report.

5.6 Extrapolated Results: Sediment Washing to Baseline Case

This section discusses the results extrapolated from adjusting the Bench Study data to the Baseline Case condition.

5.6.1 Baseline Case Adjustments

Adjusting the Bench Study to a field-scale project, as described in the Baseline Case scenario, involves increasing the sediment volume to 100,000 m^3 and accounting for the construction and operation of an on-land processing facility and the transport of material to and from that processing facility. Because the Bench Study used sediment from the LARE, which has also been identified for the Baseline Case, no adjustments for sediment type are required.

5.6.2 Short-Term Effectiveness

The Sediment Washing procedure involves transporting the dredged sediments to an on-shore processing facility, effectively removing them from the aquatic environment. Offloading 100,000 m^3 of contaminated sediments will require the use of heavy equipment to rehandle the material into trucks for transport to the processing facility. There is the potential that some of the material could be lost during offloading, allowing it to reenter the aquatic environment. However, these risks can be minimized through operational controls, such as using the proper rehandling bucket or providing an over-water catch plate to collect spilled sediments during offloading.

5.6.3 Long-Term Effectiveness

From the standpoints of sediment management and aquatic risk, Sediment Washing for the Baseline Case will provide long-term effectiveness because the contaminated sediments will be removed from the aquatic environment, thus eliminating the potential aquatic risk pathway. However, because neither of the Sediment Washing procedures outlined in the Bench Study were effective at removing chemical contaminants, Sediment Washing is not considered effective in the long-term as a treatment alternative for beneficial use. Whether this becomes an issue depends on future upland beneficial use for the material and residual chemical concentrations in the material.

5.6.4 Implementability

The Sediment Washing Baseline Case is considered implementable using standard construction equipment and techniques. The passive washing method identified in the Bench Study requires construction of a passive dewatering facility (e.g., containment lagoon) that can be flooded with fresh water to wash the chloride from the dredged sediments. To accommodate the targeted 100,000 m^3, such a facility would need to be quite large, which makes land acquisition somewhat problematic.

The active washing method requires an industrial-sized filter press or some other method of mechanical dewatering. While this type of equipment is available, its use may significantly reduce production rates and may therefore necessitate construction of a temporary sediment holding facility to avoid downtime for the dredging operations.

One potentially significant limitation on implementing the Sediment Washing alternative in the Los Angeles County region will be locating sufficient space near the dredge sites where the washing can occur. Hauling the untreated dredged sediments to an inland washing facility is an option, but may require additional operational controls such as dump trucks to prevent water leakage during hauling. Other implementability issues include the large volume of fresh water required to wash the sediments and the unknown water treatment required before the wash water can be returned to its original source or discharged to the ocean.

5.6.5 Environmental Impacts

The same short-term environmental impacts that arise from the Bench Study apply to the Baseline Case. It is anticipated that the contractor would be able to control potential environmental impacts to acceptable levels through the application of best management practices during transport and the treatment of wash water prior to its discharge, if necessary.

5.6.6 Cost

The estimated costs for implementing the Sediment Washing Baseline Case are presented in Table 6a (passive washing) and 6b (active washing). These costs do not include land acquisition, but assume that containment facilities will be needed. For the passive washing procedure, the costs assume that an engineered bermed facility would need to be constructed to contain the entire dredge volume. Only the costs for importing fill, constructing the bermed facility, and restoring the site to its original condition are included. For the active washing procedure, a temporary holding cell would need to be constructed to act as a staging area for the mechanical dewatering step, because it is expected that the dredging production rate will exceed the rate at which sediments undergo the washing process. Both options assume that the treatment facility would be located within 4 miles of the dredge location and that the final disposal location would be within 4 miles of the processing location.

For both the passive and active procedures, these costs do not include the need to treat the resulting wastewater stream other than to control suspended solids, and it is assumed that all wastewater would be returned to the point of dredging following use. Routine monitoring would be conducted to ensure that water quality is not degraded. Lastly, the cost of wash water used in the process has not been included, because it is assumed that reclaimed wastewater would be available for use as wash water.

Table 6a
Sediment Washing Baseline Case Costs - Passive Washing

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	100,000	m^3	$ 8.24	$ 824,000
Treatment Activities				
Mobilization/Demobilization	1	LS	$ 58,800	$ 58,800
Site Preparation (containment facility)	1	LS	$ 821,000	$ 821,000
Transportation to Treatment Site	1	LS	$ 441,000	$ 441,000
Waste Stream Management/Monitoring	1	LS	$ 50,000	$ 50,000
Site Restoration	1	LS	$ 35,000	$ 35,000
Transport of Treated Sediments	1	LS	$ 441,000	$ 441,000
Cost Subtotal				$ 2,961,516
OVERHEAD @ 8.0%				$ 236,921
PROFIT @ 6.5%				$ 207,898
BOND @ 1.23%				$ 41,898
TOTAL				$ 3,448,233

Table 6b
Sediment Washing Baseline Case Costs - Active Washing

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	100,000	m^3	$ 8.24	$ 824,000
Treatment Activities				
Mobilization/Demobilization	1	LS	$ 58,800	$ 58,800
Site Preparation (temporary holding cell)	1	Cell	$ 35,000	$ 35,000
Transportation to Treatment Site	1	LS	$ 441,000	$ 441,000
Dewatering/Washing (including equipment)	100,000	m^3	$ 48.75	$ 4,875,000
Waste Stream Management/Monitoring	1	LS	$ 50,000	$ 50,000
Site Restoration	1	LS	$ 35,000	$ 35,000
Transport of Treated Sediments	1	LS	$ 441,000	$ 441,000
COST SUBTOTAL				$ 7,050,516
OVERHEAD @ 8.0%				$ 564,041
PROFIT @ 6.5%				$ 494,946
BOND @ 1.23%				$ 99,747
TOTAL				$ 8,209,250

5.7 Summary of Sediment Blending Study Results

To evaluate the Sediment Blending alternative, the original intent was to conduct a bench-scale study to develop performance curves showing the relationship between sediment additives to various geotechnical properties, which could then be used for planning future Sediment Blending projects. However, upon conducting a detailed literature review and regional users survey with the POLA, the POLB, and several local contractors, the study team determined that Sediment Blending is not actually performed in the field because of its high costs and limited value. Other procedures are instead applied that achieve virtually the same end result. In light of that information, the CSTF decided against conducting a laboratory study of Sediment Blending and instead opted for a detailed literature review of existing data, a users survey, and a qualitative evaluation of the available information about Sediment Blending against the evaluation criteria in order to assess current and potential uses of Sediment Blending in the Los Angeles County region. Complete results of this evaluation are presented in Appendix D.

5.7.1 Literature Review

The literature review showed that no other studies have been conducted for the purpose intended in the DMMP Pilot Studies; however, studies are available in which dredged sediments have been blended with other materials and reused in upland applications. The available information showed that, under the right conditions, the Sediment Blending methodology could be effective.

5.7.2 Users Survey

The regional users survey suggests that no contractors are currently blending fine-grained dredged sediments with additives to increase the structural properties of the sediments (for their use as fill), largely because of the costs associated with the process. Instead, the fine-grained sediments are either placed in layers or placed in less (structurally) critical locations within the landfills. The overwhelming response from all potential users surveyed was that they would not adopt a Sediment Blending approach as described in the 905(b) Reconnaissance Report.

5.8 Extrapolated Results: Sediment Blending to Baseline Case

This section discusses the results extrapolated from adjusting the literature review and users survey information to the Baseline Case condition. Because no bench-scale or field-scale pilot studies were conducted for this alternative, the evaluation presented here is of a qualitative nature.

5.8.1 Short-Term Effectiveness

The short-term effectiveness criterion addresses the effectiveness of the alternative during the construction and implementation phases until the sediment management objectives are met. Because all of the potential Sediment Blending options (Appendix D) include upland mixing of the dredged sediments within contained mixing cells, the alternative will be effective. There is potential that the short-term effectiveness criterion would not be met in cases where the dredged sediments were dewatered prior to offloading and mixing.

5.8.2 Long-Term Effectiveness

For the treatment alternatives, long-term effectiveness refers to an alternative's ability to maintain the reduction in contaminant mobility, toxicity, or volume initially achieved by the treatment process, as well as to maintain secondary objectives, such as improving the sediment's physical characteristics for beneficial use. From the standpoint of aquatic risk, the long-term effectiveness criterion will likely be met for the Sediment Blending Baseline Case, because the contaminated sediments will be removed from the aquatic environment, thus eliminating the potential risk pathway. The primary purpose of the Sediment Blending alternative is to structurally enhance the geotechnical properties of the dredged sediments. A secondary purpose is to improve environmental containment of the contaminants. Some additives (e.g., sand) do not have the binding capacity needed for contaminants to bind to the sediments, but their volume will act to dilute the chemical concentrations proportionately.

5.8.3 Implementability

The implementability criterion addresses the technical feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The Sediment Blending procedures (Appendix D) under evaluation have previously been implemented by the local ports on a case-by-case basis. Potential blending additives are readily available, as is standard construction mixing equipment. One potentially significant limitation in implementing the Sediment Blending alternative in the Los Angeles County region will be locating sufficient space near the dredge sites for the mixing to occur. Hauling the untreated dredged sediments to an inland mixing facility is an option, but will require additional operational controls, such as dump trucks, to prevent water leakage during transport.

5.8.4 Environmental Impacts

The environmental impacts criterion addresses whether a specific alternative poses unacceptable short-term environmental impacts. All of the Sediment Blending options (Appendix D) require rehandling and moving the dredged sediments to a blending or processing facility, which reduces the potential water quality impacts associated with in-water sediment management options. As such, most potential short-term impacts associated with Sediment Blending are the same as for any other upland sediment management option. These potential impacts include:

- Water quality impacts resulting from contaminated pore water draining from the dredged sediments during offloading.
- Loss of contaminated pore water during transport to and rehandling at the blending facility.

The targeted disposal option for blended dredged sediments is in a nearshore fill, where "nearshore" is defined as within the coastal zone for seawater intrusion. Thus, potential groundwater impacts would not be expected.

5.8.5 Cost

The cost criterion addresses the associated capital costs (both direct and indirect) and annual operations and maintenance costs for each alternative. Estimated costs, which were determined using information gathered during the literature review and in accordance with conditions of the Baseline Case, are presented in Table 7.

These costs do not include land acquisition, but do assume the construction of upland mixing cells for blending the dredged sediments. Also included are the costs for importing fill (clean sand), constructing unlined mixing cells, and restoring the site to its original condition. It is assumed that the processing facility will be located within 4 miles of the dredge location and that the disposal location for the blended sediments will be within 4 miles of the processing facility.

Table 7
Sediment Blending Baseline Case Costs

Description	Quantity	Unit	Unit Price	Amount
Dredging				
Mobilization/Demobilization	1	LS	$ 290,716	$ 290,716
Dredging and Hauling	100,000	m^3	$ 8.24	$ 824,000
Treatment Activities				
Mobilization/Demobilization	1	LS	$ 58,800	$ 58,800
Site Preparation (processing facility)	1	LS	$ 175,000	$ 175,000
Blending Costs	100,000	m^3	$ 19.50	$ 1,950,000
Transportation to Treatment Site	1	LS	$ 441,000	$ 441,000
Site Restoration	1	LS	$ 35,000	$ 35,000
Transport of Treated Sediments	1	LS	$ 441,000	$ 441,000
Cost Subtotal				$ 4,215,516
OVERHEAD @ 8.0%				$ 337,241
PROFIT @ 6.5%				$ 295,929
BOND @ 1.23%				$ 59,639
TOTAL				$ 4,908,325

6 ASSESSMENT OF ALTERNATIVES USING BASELINE CASE

In previous sections, the alternatives have been described and individually assessed against the five evaluation criteria. This section analyzes the relative performance of each alternative in relation to the evaluation criteria. The purpose of this analysis is to identify the advantages and disadvantages of each alternative and the key tradeoffs between them. The alternatives are assessed using the applicable adjusted Baseline Cases in order to make the assessment equivalent. Table 8 summarizes the analysis as well as the strengths and weaknesses of each alternative in each of the five evaluation criteria categories.

Table 8
Assessment of Alternatives (*Revised July 2003)

Pilot Study Alternative	Criteria Rating								Approximate Present Worth (2002 $)
	Short-Term Effectiveness		Long-Term Effectiveness		Implementability		Environmental Impacts		
	Strengths	Weaknesses	Strengths	Weaknesses	Strengths	Weaknesses	Strengths	Weaknesses	
Aquatic Capping (see Appendix A)	• Effectively isolates contaminated sediment after construction • Minimal risk to workers during construction	• Some loss of sediments in disposal phase • Some loss of cap sediments in capping phase	• Predicted to isolate chemicals from environment	• Monitoring is required to confirm long-term effectiveness • Large storm events could impact cap integrity • Potential for contaminant release	• Contractors experienced in capping • Standard equipment • Site used identified and feasible • Readily available materials (cap sediments) • Process appropriate for any type sediment	• Soft foundation sediments subject to displacement if not addressed	• Sediment losses unlikely to impact surrounding sediments • Raises bed elevation to more productive elevation range • Sediments isolated from aquatic environment	• Disposal and capping operations may cause minimal environmental impacts (primarily physical water impacts)	$2,691,000
Cement Stabilization (see Appendix B2)	• Sediment Removed from aquatic environment • Minimal loss of contaminated sediment • Reduced leachability for targeted metal contaminants • Improved geotechnical properties	• Uncertain ability to immobilize organic contaminants • Higher likelihood workers would come in contact with sediment	• Reduced leachability for targeted metal contaminants and chlorides • Improved geotechnical properties • Further reduction of leachability when applied as compacted fill	• Uncertain ability to immobilize organic contaminants	• Conventional construction operation	• Need open land and dock space as treatment site • Potential need for stockpile area • Potential need for specialized mixing equipment • Need placement site • Process has to be adjusted for different sediment types (bench test required for each material type)	• Minimal release of nonvolatile contaminants with treatment in controlled vessels (cells/barges) with implementation of spill prevention plan • Material may be beneficially reused • Sediments removed from aquatic environment	• Potential release of volatile contaminants during treatment	$4,566,000
Sediment Washing (see Appendix C)	• Sediment removed from aquatic environment • Leachability of chlorides reduced	• Higher likelihood workers would come in contact with sediment • No contaminant reduction	• Chloride reduction not reversible	• Potential for contaminant release	• Mostly standard equipment and techniques for passive technique	• Potential issues associated with transport and upland end use • Need to locate upland processing location • Need to manage waste-water stream • Need to locate final disposal site • Process has to be adjusted for different sediment types (bench test required for each material type)	• Upland use with less sensitive risk criteria • Material may be beneficially reused • Sediments removed from aquatic environment	• No chemical containment • Potential for losses during offloading and transport • Potential upland impacts	Passive Technique $3,448,000 Active Technique $8,209,000
Sediment Blending (see Appendix D)	• Sediment removed from aquatic environment • Improved geotechnical properties	• Higher likelihood workers would come in contact with sediment • No contaminant reduction (other than dilution)	• Beneficial use of material	• Potential for contaminant release	• Standard equipment and techniques	• Potential issues associated with transport • Need to locate upland processing facility • Need to locate final disposal site • Process has to be adjusted for different sediment types (bench test required for each material type)	• Nearshore landfill is end use so minimal potential for impact • Material may be beneficially reused • Sediments removed from aquatic environment	• No chemical containment • Potential for losses during offloading and transport • Potential upland impacts	$4,908,000

**Table was revised in July 2003 in response to comments that were received on the Nov 2002 version.*

Notes:
1/ Primary objectives for Aquatic Capping were isolation of contaminants and constructability, secondary objectives were environmental impacts during placement and over time; Primary objective for Cement Stabilization was chemical isolation, secondary objective was physical enhancement of material; Primary objective for Sediment Washing was chloride removal, secondary objective was chemical reduction; Primary objective for Sediment Blending was physical enhancement, secondary objective was chemical reduction.
2/ “Effectiveness” refers to the ability to meet the target objectives.
3/ “Implementability” refers to the ease at which the alternative can be physically implemented from a construction standpoint and does not account for issues associated with agency approval or public acceptance.
4/ “Approximate Present Worth” is the actual “hard” cost at the time the study was conducted. “Hard” costs include actual construction and treatment costs, “soft” costs not included are costs for engineering design, permitting, land acquisition, waste stream treatment (if needed) and field monitoring.

6.1 Short-Term Effectiveness

All four alternatives are generally considered equally effective in the short-term (i.e., during construction) at achieving their purposes. Each alternative will reduce the potential source of contaminants by removing contaminated sediments from the LARE. The Aquatic Capping Pilot Study demonstrated no significant loss of contaminated sediments during placement operations. The Cement Stabilization Pilot Study demonstrated that contaminant mobility was reduced for the target contaminants in the period immediately after cement additives were mixed in, but was increased for several non-target contaminants. The Sediment Washing Bench Study demonstrated a reduction in chloride concentrations during successive washing events. The Sediment Blending review identified increased engineering strength from increased quantities of added blending material.

6.2 Long-Term Effectiveness

The Aquatic Capping and Cement Stabilization alternatives are effective in the long-term by isolating or binding contaminants from exposure to the environment. Aquatic Capping isolates contaminated sediments from the marine environment, while Cement Stabilization generally reduces contaminant mobility, with some exceptions. Long-term monitoring of the NEIBP Aquatic Capping site is being implemented to assess site-specific long-term effectiveness; however, previous Aquatic Capping projects have demonstrated that this technology has been effective in the long-term at isolating contaminated sediments.

Cement Stabilization can bind contaminants to the sediments, in most cases reducing the contaminants' ability to mobilize. Leaching tests developed to simulate long-term exposures show that this treatment technology is likely to be effective over the long-term. Stabilized sediments have the potential to be used as regular construction fill at an open receiver site.

Sediment Washing is not considered as effective at reducing contaminant concentrations over the long-term as are Aquatic Capping and Cement Stabilization. Chloride reduction is the primary benefit of Sediment Washing, but other contaminants are not significantly reduced.

Sediment Blending alone is also not considered an effective method of reducing contaminant concentrations over the long-term. Sediment Blending with non-reactive agents (e.g., sand, sawdust, carpet fibers) may help to dilute contaminant concentrations, but does not reduce the contaminants in the sediments or bind or isolate the contaminants.

6.3 Implementability

Aquatic Capping is considered readily implementable. No specialized equipment is required, and it was demonstrated in the Pilot Study that the contractor could accurately place both the contaminated sediments and the isolating cap without excessive mixing.

Cement Stabilization is also considered readily implementable from a construction standpoint. However, this technology requires the use of specialized equipment that may not be readily available. For a land-based treatment process, this alternative requires adequate acreage of open land where treatment can be conducted. The requirement for land may become significant if treated sediments also need to be stockpiled. Therefore, Cement Stabilization is considered less implementable than is Aquatic Capping.

Sediment Washing is considered the least implementable of the four alternatives. Implementability issues include the large requirement for land, the large volume of fresh water required to wash the sediments, and the unknown water treatment required before water used in the treatment process can be returned to its original source or discharged to the ocean.

Sediment Blending is implementable when used in conjunction with an existing construction fill operation. The added blending operations can be performed using standard heavy equipment. Key issues include selecting the blending material (e.g., sand, sawdust) and gaining approval for use of the blended material in a fill site. Sediment Blending is considered more implementable than is Sediment Washing, equally as implementable as Cement Stabilization, and less implementable than Aquatic Capping.

6.4 Environmental Impacts

All four alternatives are generally considered to have equal levels of environmental impacts. The Aquatic Capping Pilot Study did not reveal any significant environmental impacts. Dredging-related impacts would be consistent across all alternatives, so can be eliminated from this discussion. Limited short-term water quality impacts occurred during placement of the contaminated sediments and the clean cap, but the impacts were not considered significant.

Environmental impacts associated with Cement Stabilization are considered to be of generally the same magnitude as those for Aquatic Capping. Contaminated sediment loss could occur during sediment rehandling from the haul barges.

Sediment Washing's environmental impacts are similar in magnitude to those of Cement Stabilization. One additional potential impact relates to the treatment of wash water if dissolved chemical concentrations result during washing. The Bench Study indicated no elevated dissolved chemical concentrations.

Sediment Blending would not be expected to create significant environmental impacts and would have impacts similar to those of Cement Stabilization and Sediment Washing.

6.5 Cost

To assess the alternatives, the construction costs (i.e., capital costs plus operations and maintenance) associated with the Baseline Case condition have been used. These costs include dredging (consistent for all alternatives), transport, treatment or isolation, and disposal. Table 8 lists the total estimated costs for each alternative's Baseline Case condition. Aquatic Capping was estimated to be the least costly alternative, followed by Sediment Washing (passive technique), Cement Stabilization, Sediment Blending, and Sediment Washing (active technique).

The highest degree of confidence regarding costs is with Aquatic Capping; the degree of confidence decreases with, in order, Cement Stabilization, Sediment

Blending, and Sediment Washing. Aquatic Capping was constructed using 105,000 m^3 of contaminated sediments, which is approximately the same volume as the Baseline Case; this lends a high degree of confidence to the estimated cost of the Baseline Case condition. Cement Stabilization was implemented as a field program in which only 1,850 m^3 were stabilized. There are uncertainties in scaling up from that size to a full-scale project. Therefore, the extrapolated costs for Cement Stabilization have a lower degree of confidence than those for Aquatic Capping.

There is greater cost uncertainty associated with implementing any of the three treatment alternatives (Cement Stabilization, Sediment Washing, Sediment Blending) than with implementing Aquatic Capping. Key issues that could affect treatment costs include obtaining space for treatment, the distance from the marine dock to the treatment site, the final disposal location for the treated sediments, and required tipping fees. The costs for the treatment alternatives all assume that the treated sediments would be disposed of at a nearshore fill site located within 4 miles of the treatment area.

7 CONCLUSIONS

The purpose of this Evaluation Report is to provide key information to help a potential user make informed decisions regarding each sediment management technology and the need for further evaluation. This report does not select a preferred alternative for the management of contaminated sediments. The purpose of evaluating the alternatives is only to identify the advantages and disadvantages of each and the key tradeoffs between them. This Evaluation Report will be used as technical information to support both the USACE Feasibility Study and the CSTF Strategy Report.

The following conclusions are based on the foregoing evaluation of the alternatives and the supporting documentation contained in the appendices:

- The Aquatic Capping and Cement Stabilization alternatives both appear capable of managing contaminated sediments to reduce potential contaminant loading to the environment.
- Field-scale pilot studies demonstrated that both Aquatic Capping and Cement Stabilization are viable alternatives for managing local contaminated sediments.
- Sediment Washing and Sediment Blending appear to be technically feasible alternatives. Neither technology was demonstrated in the field, so questions remain as to the difficulties of scaling each technology up to a full-scale project.
- There is less flexibility in implementing the treatment alternatives (Cement Stabilization, Sediment Washing, Sediment Blending) because of the need to consider how and where treatment would take place and where disposal of the treated sediments would occur.
- Sediment Washing and Sediment Blending have limited application for managing contaminated sediments because there is negligible reduction of contaminants beyond the chloride reduction of Sediment Washing.
- There is greater cost uncertainty associated with implementing a treatment alternative than with implementing Aquatic Capping. Key issues that could affect treatment costs include the chemical and physical characteristics of sediments being treated, obtaining space for treatment, distance from the marine dock to the treatment site, the final disposal location for the treated sediments, and required tipping fees.

8 REFERENCES

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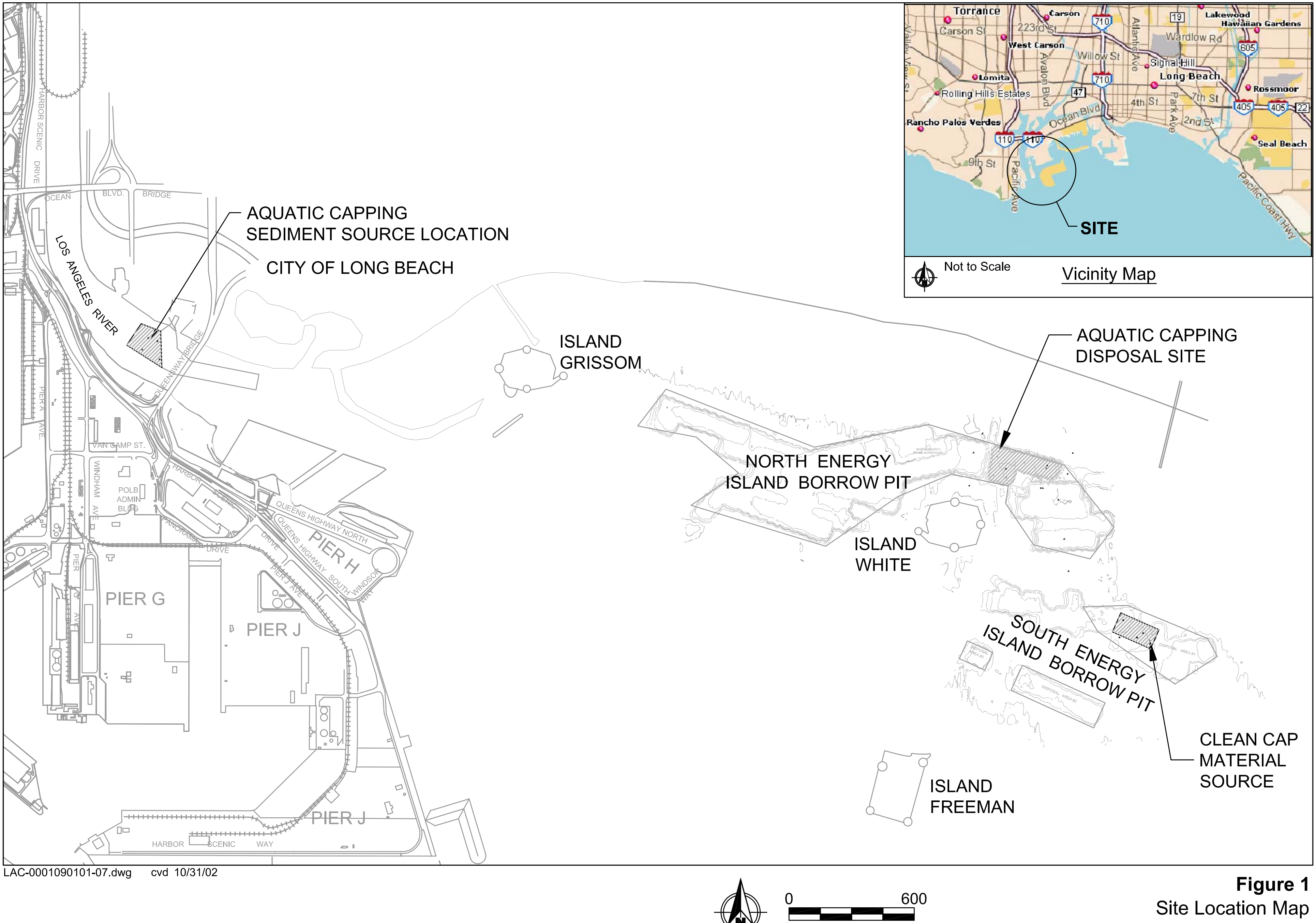

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Figure 1
Site Location Map
Aquatic Capping Pilot Study

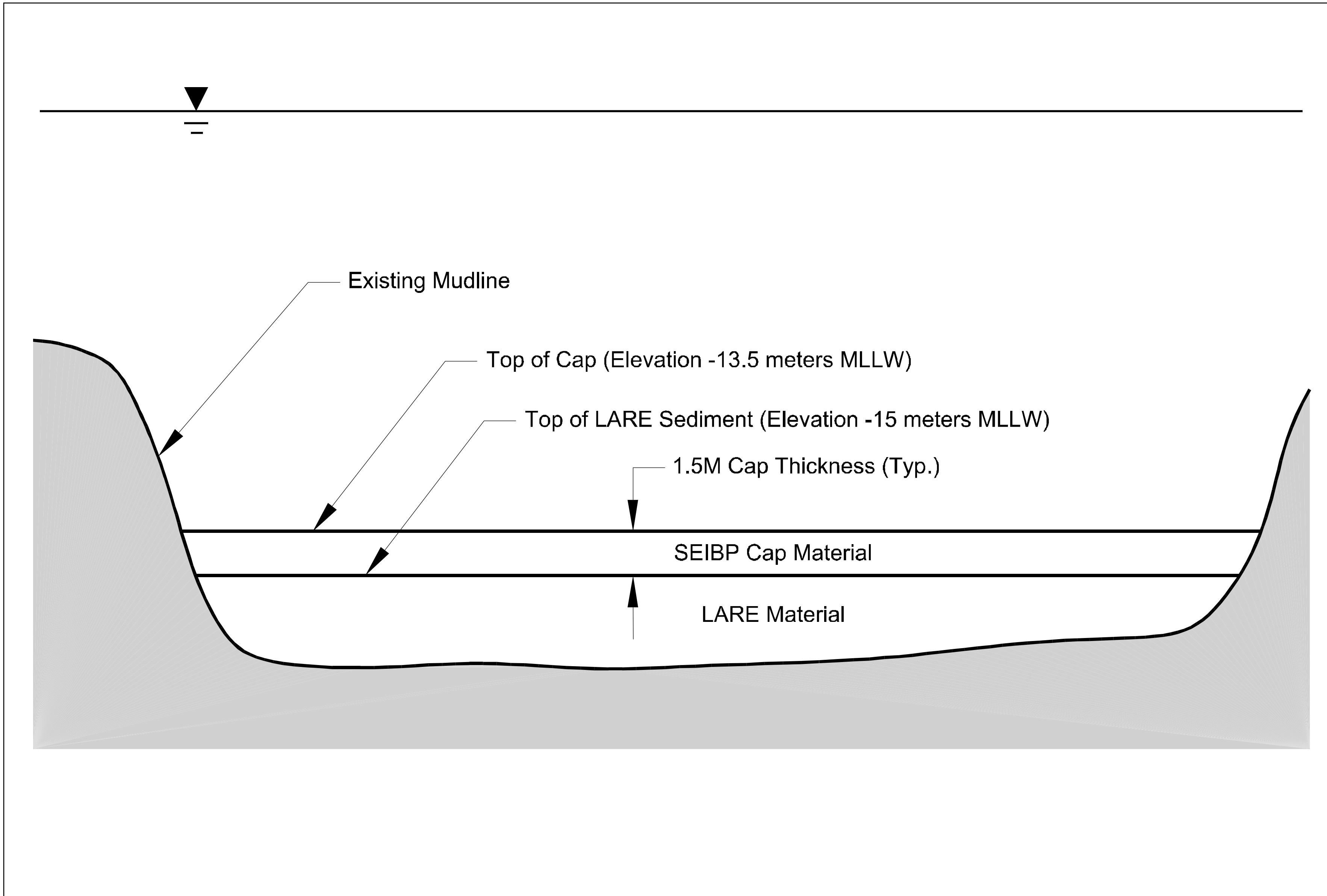

Figure 2
Typical Cross-Section through the NEIBP Disposal Cell
Aquatic Capping Pilot Study

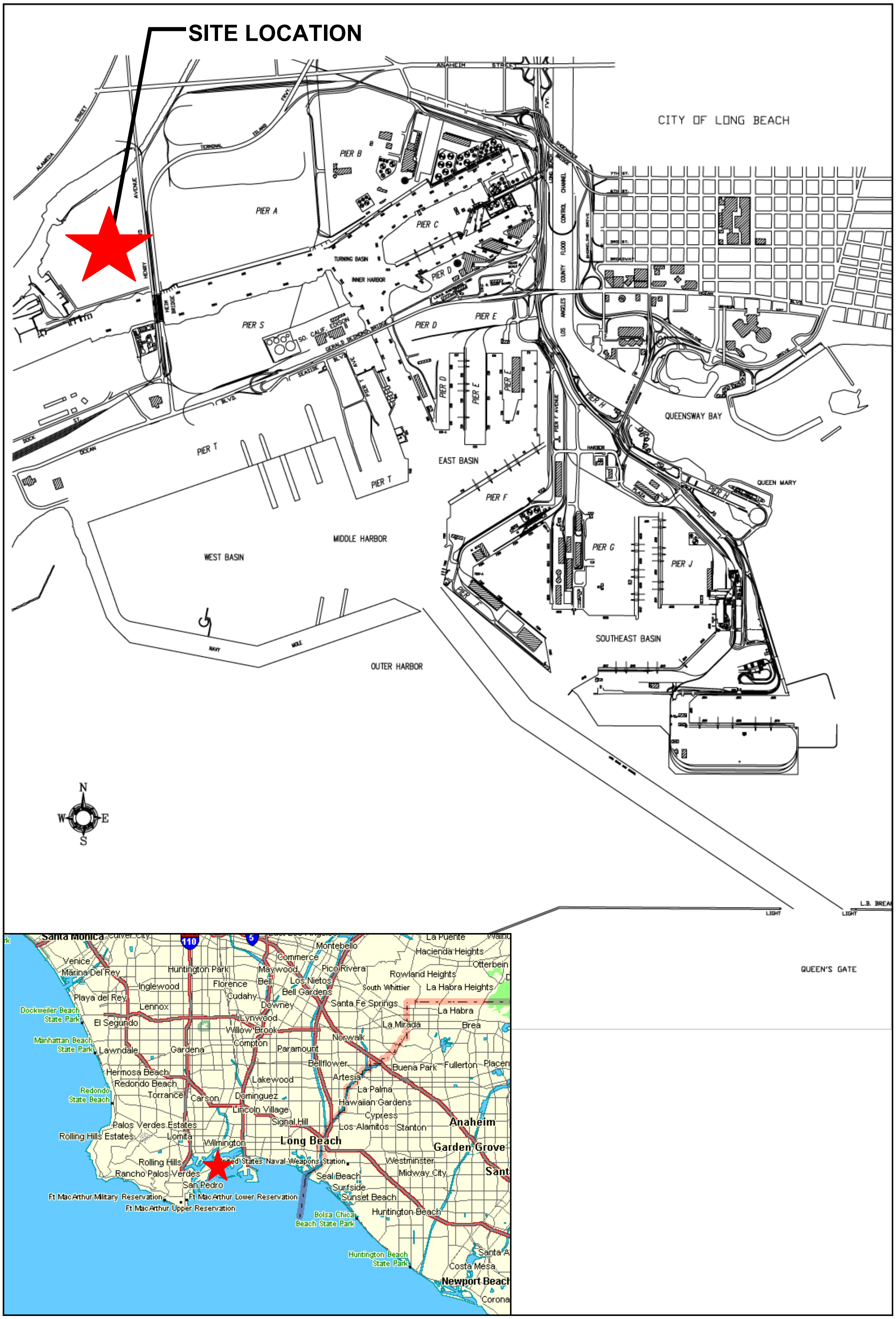

Figure 3
Site Location Map
Cement Stabilization Pilot Study

Attachment List

Appendix A

- Attachment A – Final Aquatic Capping Pilot Study Monitoring Plan
- Attachment B – Monitoring Results Report
- Attachment C – LTFATE Modeling Report for LARE Dredging
- Attachment D – Ghost Shrimp White Paper
- Attachment E – Recovery Modeling Report

Appendix B1

- Attachment A – Field Sampling Plan
- Attachment B – Stabilization Mixing Procedure
- Attachment C – Physical Test Results
- Attachment D – Chemical Test Results

Appendix B2

- Attachment A – Operations and Laboratory Analyses Summary Report
- Attachment B - Laboratory Geotechnical Analyses (Smith Emery GeoServices) – *Available from U.S. Army Corps of Engineers, Los Angeles District*
- Attachment C - Laboratory Chemical Analyses (ToxScan) – *Available from U.S. Army Corps of Engineers, Los Angeles District*

Appendix C

- Attachment A – Soil Washing for Delineation of LA River Sediment

Appendix D

- Attachment A – Personal Communication Source Information Summary
- Attachment B – Literature Review Source Information

Project Photos