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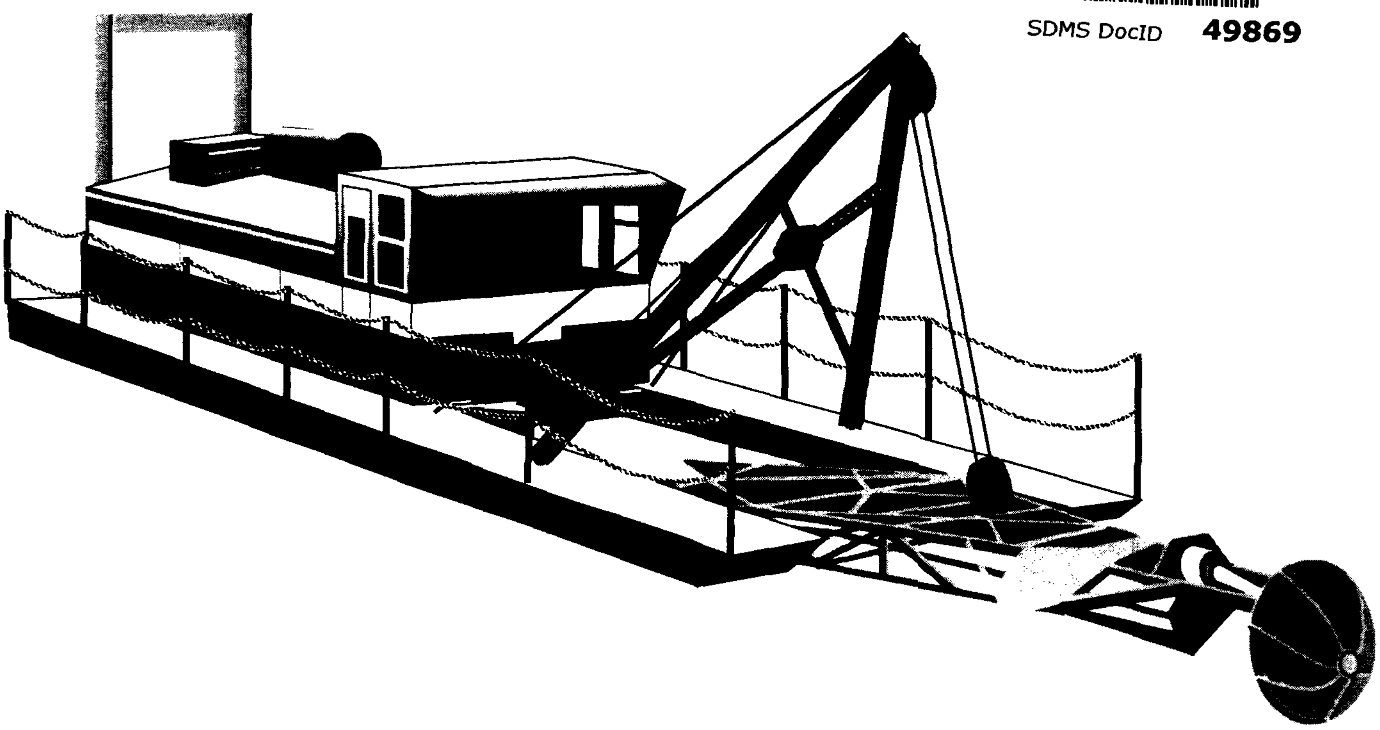
New Bedford Harbor Superfund Pilot Study:

Evaluation of Dredging and Dredged Materials Disposal



June 1989

US Army Corps
of Engineers
New England Division

Interim Report

Executive Summary

Bottom sediments in New Bedford Harbor, Massachusetts are contaminated with polychlorinated biphenyls (PCBs) and heavy metals to the extent that the site is currently being studied by the Environmental Protection Agency under the Federal Superfund program. As part of this study the Corps of Engineers is evaluating the feasibility of dredging and dredge material disposal alternatives for the upper estuary of New Bedford, an area where PCB concentrations in the percent levels have been detected in the sediments. A pilot study was performed in the upper estuary of New Bedford between May 1988 and February 1989. The Corps' New England Division managed this study and received technical assistance from the Waterways Experiment Station.

Three hydraulic pipeline dredges were used during the study; a cutterhead, horizontal auger and a Matchbox dredge. The dredges were evaluated on their ability to remove the contaminated sediments while minimizing sediment resuspension and contaminant release. The dredged sediments were placed in a confined disposal facility (CDF) constructed on the New Bedford shoreline and in a contained aquatic disposal (CAD) cell constructed in the upper estuary. The construction, filling and capping of the CAD cell were of special significance as only limited information was available on this method of disposal.

This interim report details the design procedures and construction techniques used for both the CDF and CAD. It also provides a detailed assessment of the operational characteristics of the three hydraulic dredges along with the results of their performance, their suitability for removing contaminated materials in New Bedford Harbor and recommends procedures for their proper operation. Finally, this report describes the various monitoring efforts used throughout the study and discusses the project's impact to water quality throughout the harbor. This report will be updated and finalized when monitoring of the CDF and CAD is completed.

All dredges were able to effectively remove the contaminated sediment while minimizing the total amount of sediment removed. PCB levels remaining in the sediment after two passes of the dredge were generally below 10 parts per million with less than two feet of material removed. Resuspension of sediment was also minimized with no plume of resuspended material moving away from the dredging area and no measured elevated levels of contaminants were detected in the water column outside the immediate vicinity of the dredging and disposal operations.

While all the dredges were effective, the cutterhead dredge is recommended for use should dredging be selected for removing the contaminated sediment from New Bedford. This recommendation is based on the dredge's ability to minimize resuspension as well as several operational advantages addressed in the report.

Both a CDF and CAD cell were successfully constructed and the contaminated dredged material was successfully contained in both disposal sites. Monitoring will continue to detect any leaching of contaminants at the CDF and contaminant migration into the cap covering the CAD cell. This report will be updated as additional information becomes available.

Based on the information received and the knowledge gained from the pilot project, it has been determined that the use of a hydraulic dredge is both a practical and effective method for removing contaminated sediments for New Bedford Harbor.

Acknowledgement

The U.S. Army Corps of Engineers, New England Division in cooperation with the Waterways Experiment Station (WES) performed the Pilot Study for the US Environmental Protection Agency (USEPA), Region 1 as a component of the comprehensive USEPA Feasibility Study for the New Bedford Harbor Superfund Site, New Bedford, MA. The Pilot Study field activites were conducted between May 1988 and February 1989.

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The NED Project Manager was Mr. Mark Otis.
The WES Project Manager was Mr. Daniel Averett.
On site supervision was performed by Mr. Maurice Beaudoin, Construction, Mr. Steve Andon, Dredging and Mr. Russell Bellmer, Environmental Monitoring.

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The New Bedford Superfund Project Office wishes to express its appreciation to the following for their efforts during the performance of the Pilot Study:

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AGM Marine Contractors, INC. - operation of the Cutterhead and Horizontal Auger Dredges.
Bean Dredging - fabrication of the Matchbox Dredgehead.

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*To be included in the final version of this report.

PART I INTRODUCTION

The city of New Bedford, as shown in Figures 1 and 2, is located in Bristol County, Massachusetts, about 50 miles south of Boston and approximately 30 miles southeast of Providence, Rhode Island. New Bedford Harbor, which separates New Bedford on the west from Fairhaven on the east, is the estuary of the Acushnet River. The harbor area comprises a broad outer bay, about 3 miles long and 2 miles wide and an inner harbor, about 2 miles long and 3/4 miles wide to the limit of navigation at the Coggeshall Street Bridge. A hurricane barrier was constructed at the harbor entrance in 1966 to protect the area from southerly storms The barrier constricts the opening of the inner harbor to 150 feet. The Acushnet River has its source in New Bedford Reservoir in the northern area of Acushnet, Mass. From its origin the river flows generally south about 4 miles to tidewater at the Wood Street Bridge and then continues south for about 1.6 miles to the Coggeshall Street Bridge. The river drains an area of 18.4 square miles above the head of tidewater and has a watershed which is relatively low and flat and contains large areas of wetlands.

Polychlorinated biphenyls (PCBs) are industrial compounds which were commercially manufactured and marketed in the United States between 1929 and 1977. Chemically stable, non-flammable, and having a number of other desirable characteristics made PCBs nearly ideal for many industrial uses. Unfortunately, however, the same properties result in PCBs persisting in the environment and creating potential hazards. In the New Bedford area, PCBs were used primarily in the production of electronic capacitors, with usage at New Bedford's industrial concerns peaking at about two million pounds per year during the years 1973, 1974 and 1975 (1).

PCB contamination in New Bedford was first documented by both academic researchers and the Federal Government between the years 1974-1976. Since the initial survey of the New Bedford area, a much better understanding of the extent of PCB contamination has been gained. The entire area north of the Hurricane Barrier, an area of 985 acres, is underlain by sediments containing elevated levels of PCBs and heavy metals including copper, chromium, zinc and lead. PCB concentrations range from a few parts per million (ppm) to over 100,000 ppm. Portions of western Buzzards Bay sediments are also contaminated, with concentrations occasionally exceeding 50 ppm. The water column in New Bedford Harbor has been measured to contain PCBs in the parts per billion range (1) . As a result of these investigations, New Bedford Harbor was designated a Superfund Site in 1982.

In August 1984 the Environmental Protection Agency (EPA) published a Feasibility Study of Remedial Action Alternatives for the Upper Acushnet River Estuary above the Coggeshall Street Bridge (2). The study proposed five alternatives for cleanup, four of which involved dredging of the estuary to remove the contaminated bottom sediments. Public and interagency comment on these dredging and disposal alternatives prompted the EPA to ask the Corps of Engineers to perform additional pre-design studies. This Engineering Feasibility Study (EFS) was performed by the Waterways Experiment Station (WES) with the assistance of the New England Division (NED). Conceptual designs of dredging and disposal alternatives were developed and evaluated for their implementability and potential for contaminant release.

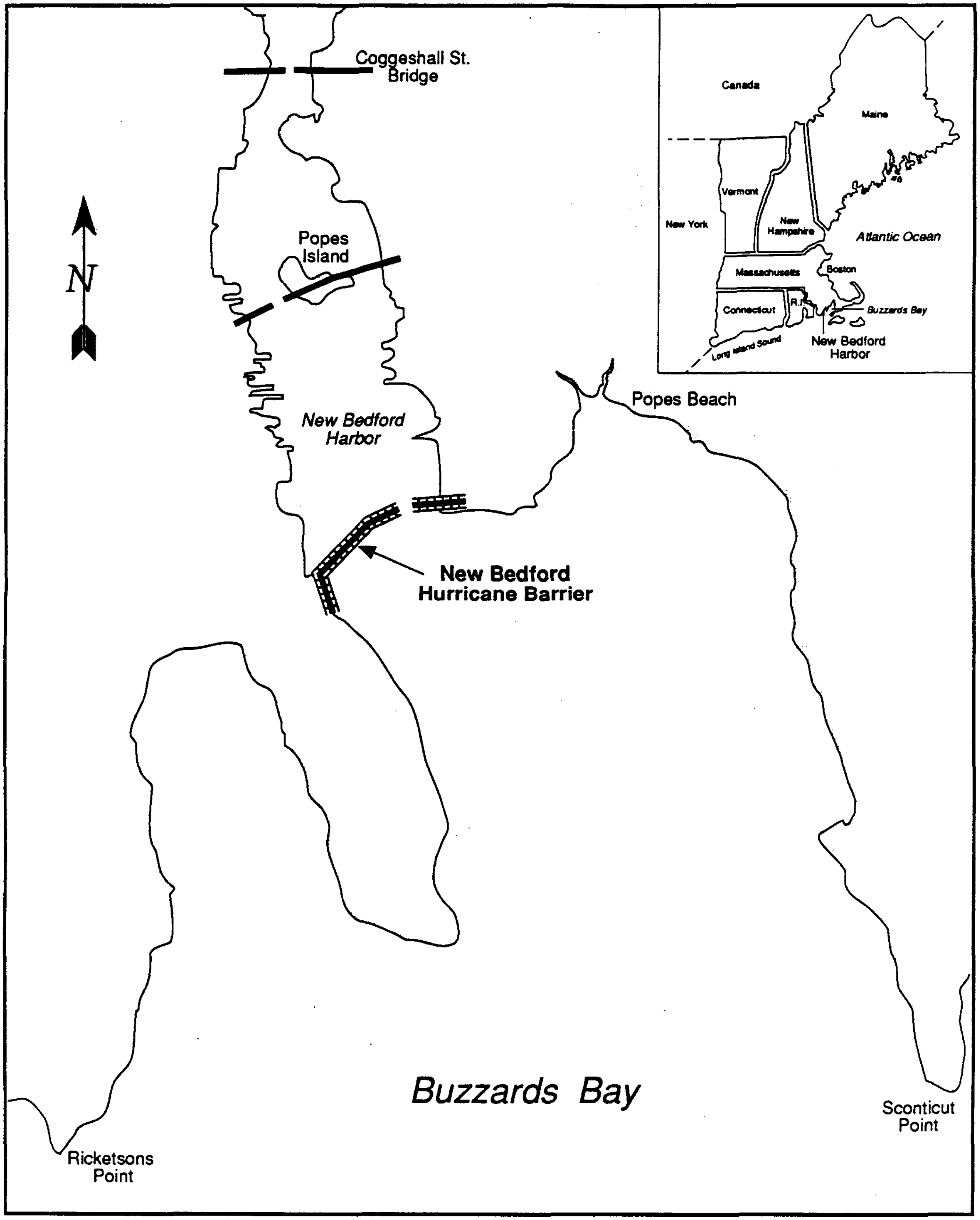
Coggeshall St.
Bridge
Popes
Island
N
New Bedford
Harbor
Popes Beach
New Bedford
Hurricane Barrier
Buzzards Bay
Ricketsons
Point
Sconticut
Point
Canada
Maine
Vermont
New York
New
Hampshire
Atlantic Ocean
Massachusetts
Boston
Connecticut
R.I.
Buzzards Bay
Long Island Sound
New Bedford
Harbor

Figure 1

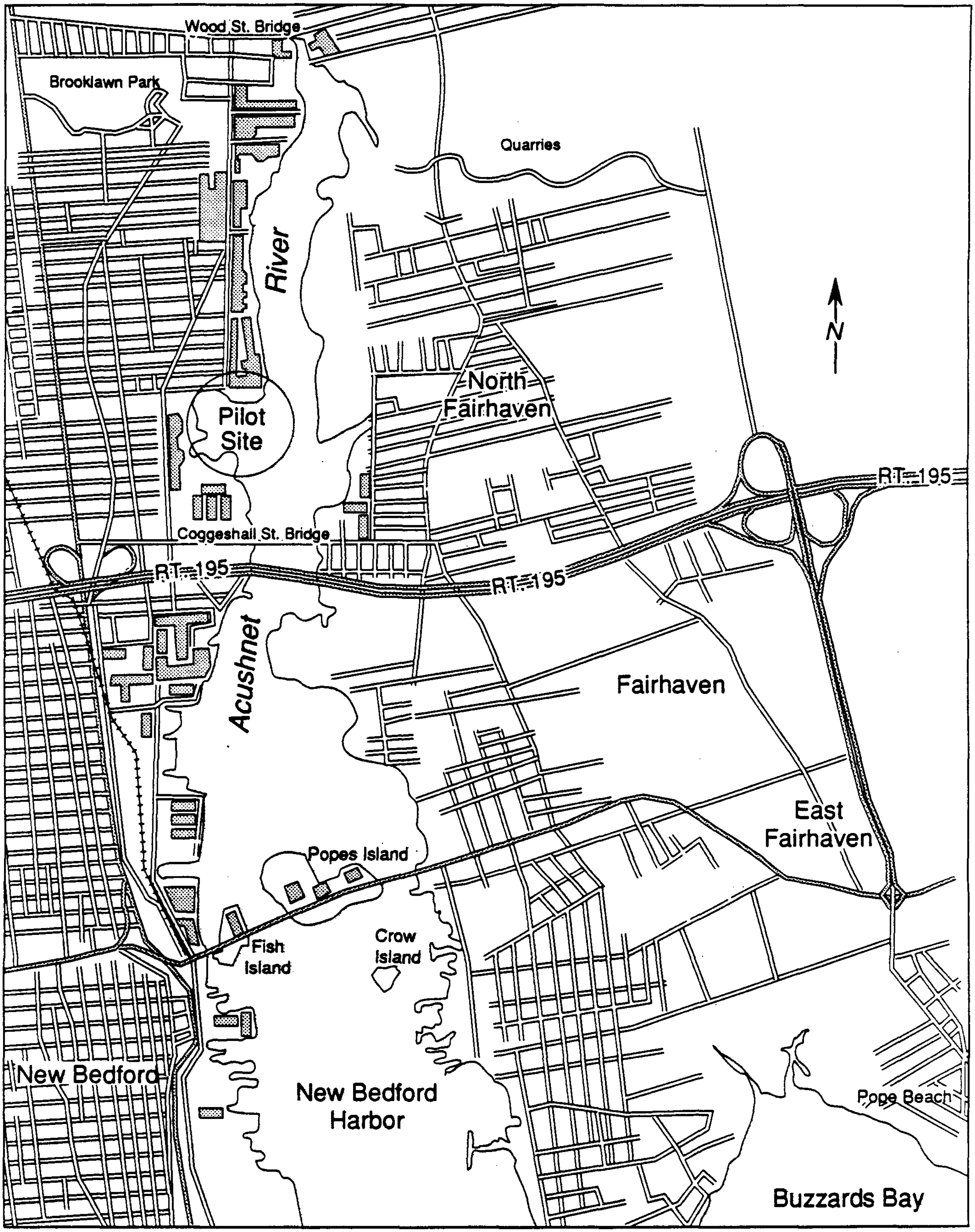

Figure 2 New Bedford Harbor

Substantial information on disposal alternatives already existed, along with an array of tests specifically developed for the comparison of disposal alternatives. These allowed for a site specific evaluation and design for appropriate disposal alternatives for New Bedford Harbor. The technical approaches used for the design of disposal options has been formally developed and is based on more than 10-years of research. A U.S. Army Corps of Engineers publication (3) presents this technical approach and recommends testing protocols for assessment of highly contaminated sediments.

Unlike the relatively large amount of data available on disposal impacts, information associated with the dredging of contaminated sediments is less advanced. Recognizing that the design of dredging alternatives would be critical to EPA's record of decision (ROD) it was determined to supplement the laboratory (bench scale) studies, literature reviews and desk top analyses with the performance of a pilot-scale field test. From May 1988 to February 1989 a pilot scale-field test was carried out in the Upper Acushnet River Estuary to determine if contaminated sediments could be efficiently removed by conventional and/or specially designed dredging equipment without triggering unacceptable releases of contaminants.

The information gathered during the study improved the capacity to address and to make decisions concerning the critical issues of removing and disposing of contaminated sediments. The pilot study achieved and/or evaluated the following specific technical objectives:

a. Evaluated the effectiveness of the dredging equipment in removing PCB contaminated sediment from New Bedford Harbor.

b. Evaluated actual sediment resuspension and contaminant release under field conditions for the selected dredging equipment, operational controls and turbidity containment techniques.

c. Refined and scaled-up laboratory data for design of disposal and treatment processes for contaminated dredged material from this field site.

d. Developed and field tested procedures for construction of contained aquatic disposal cells for contaminated dredged material under site specific conditions.

e. Established actual cost data for dredging and disposal of New Bedford Harbor sediment.

Attainment of these objectives achieved the project goals of providing site specific data which will reduce the uncertainty in the choice of alternatives for the ROD and of the final design. The information gained from the study will allow for a smoother transition as the project advances from the selection of alternatives into final design.

PROJECT DESCRIPTION

The dredging techniques of three types of hydraulic pipeline dredges were evaluated during the pilot study. A cutterhead, horizontal auger and Matchbox dredge were used to remove 10,000 cubic yards of sediment from the harbor, 2,900 cubic yards of which was contaminated. The dredged material was obtained from two separate sites designated as dredging areas 1 and 2 as shown on Figure 3. The two disposal methods used during the study were a confined disposal facility (CDF) and contained aquatic disposal (CAD). A CDF is a diked containment facility into

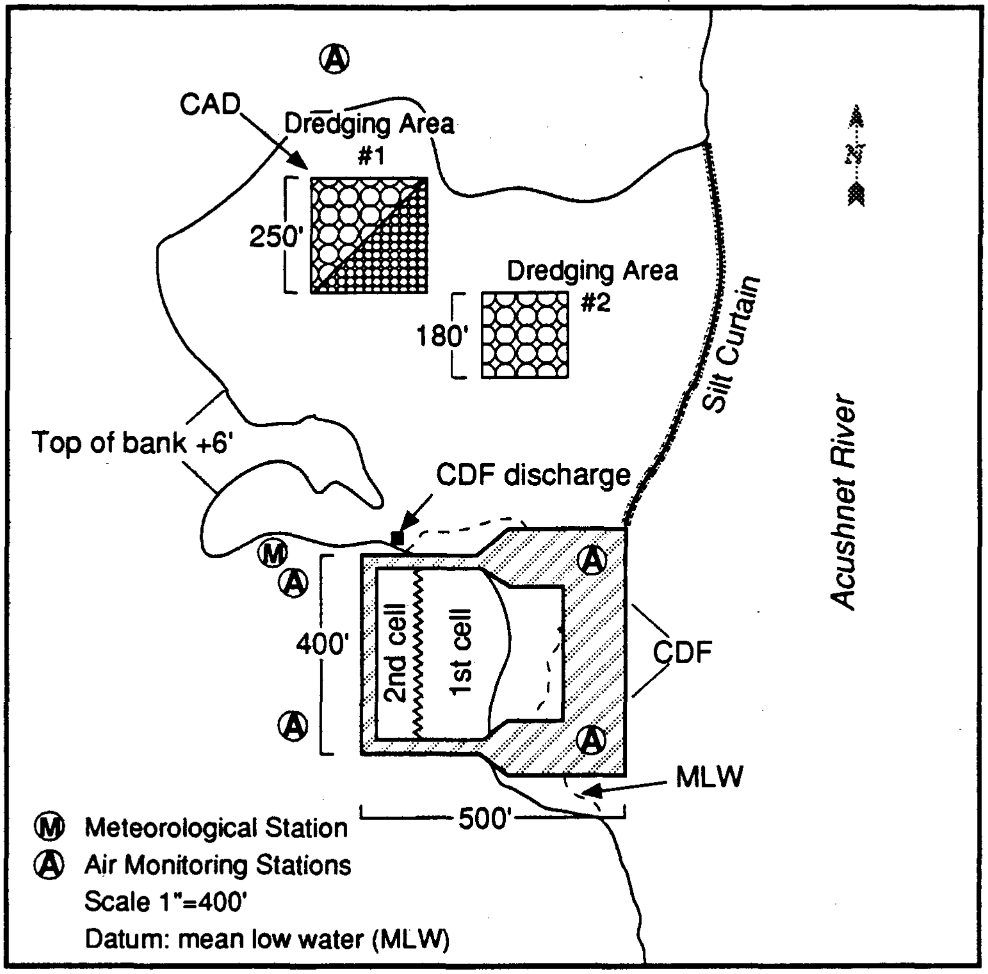

Figure 3 Confined Disposal Facility (CDF) and Contained Aquatic Disposal Area (CAD) in the upper Acushnet River Estuary

which dredged material is pumped. The sediments settle out and remain in the site and the excess water is drained off and returned to the harbor. CAD involves placing contaminated sediment in a pit or cell which has been excavated in the bottom of the estuary. Contaminated sediment is then placed along the bottom of the cell and subsequently capped with clean material.

Initially the CDF was constructed along the New Bedford shoreline. Each dredge then operated in area 1 removing contaminated sediment with disposal in the CDF. The cutterhead dredge then deepened area 1 to create the CAD cell with this clean dredged material being placed in the CDF to cap the contaminated sediment already there. All three dredges then operated in area 2 removing contaminated sediment with disposal in the CAD cell. The cutterhead dredge then removed clean sediment from area 2 and placed this material in the CAD cell as a cap.

The pilot study also included an extensive monitoring program that is described in Part II. This monitoring program consisted of physical, chemical and biological evaluations of sediment, harbor water, effluent from the CDF and leachate from the CDF. The monitoring program was designed to obtain sufficient data to address the technical objectives of the study while protecting public safety and the environment.

PILOT STUDY SITE

The dredging and disposal operations were conducted in and adjacent to a small cove located approximately 2,000 feet north of the Coggeshall Street Bridge on the New Bedford side of the Acushnet River. The general area is shown in Figure 2 with the dredging and disposal areas shown in Figure 3. The following factors were considered in selecting this site for the CDF:

- Availability – The City of New Bedford owned a parcel of land of approximately 4.9 acres, on the Acushnet River and adjacent to the selected dredging areas.

- Accessibility – The site was easily accessed via Sawyer Street and was located in a section of the city zoned for commercial activities which would minimize disruption to residential neighborhoods and the general public during the construction and dredging phases of the project.

- In-Water Dike Construction Experience – To accommodate the CDF and its attendant space requirements on the Sawyer Street site it became necessary to construct a portion of the dike below the mean high water line. While adding to the cost of the disposal facility this requirement did have the benefit of providing field experience associated with in-water dike construction. Especially since the construction of CDFs below the high water line is probable if this disposal method is selected as part of the full scale cleanup plan.

- Safety – The site had one additional advantage in that while located in a Superfund site, the on-shore soil was free of hazardous material. Personnel on site would therefore not be required to wear protective clothing nor would equipment be required to be decontaminated. Contaminated material was only encountered below the high water line. Appropriate precautions were taken when working in this area.

- Foundation Suitability – Field and laboratory investigations were conducted to provide data on the physical and chemical properties of the off-shore sediments and on the nature of the sub-soils beneath the land portion of the CDF. A detailed description of the field exploration program along with the results obtained are contained in the 13 November 1987 report prepared by Geotechnical Engineers Inc. under contract to New England Division (4) and in Appendix 6 of this report. Essentially, the field investigation work determined that sub-surface conditions were suitable for the on-shore portion of the dike but that poor foundation conditions below the high water line would require that section of the dike to be supported by a geotextile.

- Limited Impact to Wetlands – Many of the open areas along the shoreline of the estuary are environmentally significant wetlands. Construction activities at the selected site had a minimum impact on these wetlands.

As previously stated, the dredging areas were located upstream of and adjacent to the selected CDF site. These areas, as shown in Figure 3, were selected based on the following considerations:

- Contaminant Concentration – The level of contamination within the cove, while high, was considerably lower than in most areas of the estuary. PCB levels in the 0-6 inch horizon ranged from 150 ppm to 585 ppm and were not detectable below 24 inches. These levels were high enough to represent conditions in other portions of the upper estuary and required full observation of appropriate safety and decontamination procedures. Implementation of these procedures was considered significant in that it provided an opportunity to assess the practicality of existing safety practices, allowed for adjustments in the cost of doing business in a contaminated environment and adjusted the requirements and procedures for conducting day-to-day operations, particularly those tasks that would be considered routine in a non-contaminated environment.

- Configuration for Containment Measures – During the dredging operation the cove could be isolated from the main estuary through deployment of an oil boom and silt curtain. This feature may have reduced the spread of resuspended material had a significant plume been introduced into the water column.

- Bathymetry – The depth of water in the cove, ranging between 0.0 to 0.5 feet at mean low water (mlw), approximated the depths found in most areas of the upper estuary that were known to contain significant levels of PCBs.

- Sediment Physical Characteristics – The physical characteristics of the sediment (organic silts and clays) within the cove were representative of the sediment found throughout the upper estuary.

AGENCIES INVOLVED AND THEIR RESPONSIBILITIES

The pilot study was carried out under the general guidance of EPA Region 1 and was managed by the New England Division of the U.S. Army Corps of Engineers (NED). NED received technical support in planning and evaluating the project from the Corps' Waterways Experiment Station. Administrative support and policy guidance was provided by the Corps Omaha District and the Dredging Division of the U.S. Army Corps of Engineers. The EPA Environmental Research Laboratory in Narragansett, Rhode Island (ERLN) played a significant role in the design of the projects monitoring program and was responsible for the majority of the field work and sample analyses associated with this effort. Ebasco Services Incorporated designed and carried out the air monitoring program which is only briefly described in this report.

Beginning with preliminary planning efforts in the fall of 1986, numerous federal, state and local agencies along with private firms and organizations, citizens committees and private individuals became involved with the project. The principal involvement of these agencies and individuals concerned the siting of project facilities and the development of the project's monitoring program. The roles played by the representatives from the Massachusetts Department of Environmental Quality Engineering and Office of Coastal Zone Management along with the City of New Bedford's representatives were especially significant.

Three contractors participated in the project by constructing the CDF and providing and operating the dredging equipment. A crew for one of the dredges was also provided by the Corps St. Paul District.

PREVIOUS STUDIES

The principal reports which established the overall operating parameters for this document are provided in the reference section of this report. EPA's Environmental Response Team first measured PCB flux at the Coggeshall St. Bridge in 1983. Their report, which showed significant PCB loads transported seaward, prompted further investigation of New Bedford Harbor (5). The NUS Corporation conducted additional studies which resulted in a Feasibility Study being released in 1984 which identified several dredging and disposal scenarios for removing and containing contaminated material from the upper estuary (2). The recommendations in the NUS report prompted EPA to request the involvement of the U.S. Army Corps of Engineers. In response to EPA's request, the Corps of Engineers Waterways Experiment Station (WES), assisted by the New England Division (NED) began an engineering feasibility study to further evaluate dredging and dredged material disposal alternatives. The Engineering Feasibility Study (EFS), initiated in 1985, utilized the approach contained in a previously published technical report by WES and others as a basis for testing protocols and technical approaches to develop information for the initial evaluation of the alternatives.

The results of the EFS are contained in a series of 12 reports (WES TR EL-88-15) which are listed in the reference section of this document. These reports detail the technical approach, field studies, laboratory tests and conceptual designs which were completed as part of this effort. These reports indicate where the pilot study would provide additional information to supplement the results of the EFS. The NED prepared a pilot study proposal in 1987 which described the pilot study's goals and objectives, the project design and estimates of contaminant release (6). Much of the data obtained during the EFS was used in the design of the study and to make contaminant release estimates.

REPORT DESCRIPTION AND ORGANIZATION

This report details the results of the field operations conducted in New Bedford Harbor from May 1988 to February 1989. Developed as a component of and supplement to the EFS, the data generated during the pilot project will aid in developing the response to the three major questions that could not be adequately addressed by the EFS; specifically, what are contaminant release rates from dredging, what is the efficiency of dredging for contaminant removal and what are contaminant release rates during CAD operations.

Starting in November 1988, the NED operated three types of hydraulic dredges in the upper Acushnet River estuary. All major aspects of the study were conducted under close supervision and incorporating an extensive monitoring program. By the completion of the test in February 1989 over 140 hours of dredging had been accomplished with more than 9500 cubic yards of material disposed of in either a CDF or a CAD cell. This report provides a detailed description of the project's goals and objectives with the methods employed and the results achieved.

The material is organized into a main report with supporting technical appendices. The body of the main report provides an overview of the various project components which include project design, dredging, the CDF, CAD and the monitoring program and the conclusions drawn from the results obtained.

The report has seven technical appendices:

Appendix 1 contains data on the dredges utilized for the project and includes production rates, efficiency of operation, sediment resuspension and the operational difficulties encountered, along with recommendations should dredging be selected for the full scale cleanup of New Bedford Harbor.

Appendix 2 contains data on the CDF and provides data on effluent and leachate quality.

Appendix 3 describes the CAD site and includes information on sediment resuspension and evaluation of the cap.

Appendix 4 contains information on the water quality monitoring in the project area and provides a complete breakdown of all physical, chemical and biological testing performed and the results obtained.

Appendix 5 provides a detailed description of the dredging sites and contains information on the physical characteristics of the dredged material and the contaminant levels found therein.

Appendix 6 provides detailed information on the construction of the CDF including existing site conditions, design parameters and procedures, construction techniques and the instrumentation/monitoring system.

Appendix 7 contains the log of operations and includes a detailed calendar of daily activities.

PART II PROJECT DESIGN

This section presents the methodology and criteria used in the selection of dredging equipment and in the design of the disposal methods and monitoring program employed during the pilot study. This section also describes the type of physical control devices used during the construction and operational phases of the project to minimize impacts to the environment.

DREDGE SELECTION

Three hydraulic pipeline dredges were used during the pilot study: a cutterhead dredge, a horizontal auger dredge known as a Mudcat and a cutterhead dredge with its cutterhead replaced by a special dredgehead known as a Matchbox. This equipment was selected after a thorough evaluation that considered a wide range of dredging equipment. Input was received from Corps of Engineer personnel at the New England Division, Waterways Experiment Station, the Water Resources Support Center's Dredging Division as well as other Corps Districts and Divisions. Report 10 of the EFS provides detailed information on the dredge selection process (7).

The following factors were considered critical in evaluating the dredging equipment:

- General: Would the equipment be capable of accomplishing the overall clean-up of the upper estuary?
- Safety: Will the dredging process create additional environmental or health problems?
- Resuspension of material: To what extent will material be resuspended in the water column during the dredging operation?
- Clean Up: What is the ability of the equipment to effectively remove PCB contaminated sediment with a minimum mixing of clean and contaminated sediment?
- Shallow Water: Will the equipment be able to operate in the very shallow water (6" at low water) of the Acushnet River?
- Access: Will the equipment be able to reach the dredging site? Equipment must be able to pass through restricted bridge openings (10' vertical, 60' horizontal) or be capable of being transported by truck.

Equipment Selected for Pilot Study: Hydraulic dredges operate on the principal of the centrifugal water pump. A vacuum is created on the intake side of the pump and ambient pressure acts to force water and sediments through the suction pipe. The dredged materials are then hydraulically pumped via pipeline to the disposal site (7).

Although the three dredges selected for operation in New Bedford were all hydraulic dredges, they did have significant differences in the mechanical action at the point of dredging and in their movement through the water. These operational characteristics are detailed in Part III of the main report and in Appendix 1.

Other Equipment Evaluated: A detailed evaluation of other major types of dredging equipment considered for possible use in New Bedford is contained in Report 10 of the EFS (7). The other equipment evaluated were deemed inadequate because of their basic methods of operation, the amount of sediment resuspended, or their size, which made them impractical for use in the shallow water of the upper estuary.

Based on the established criteria and the operating characteristics of the various pieces of equipment evaluated, it was determined that the hydraulic dredges, specifically the cutterhead, horizontal auger and Matchbox, would be the best suited for the conditions prevailing in New Bedford.

DISPOSAL METHODS:

The pilot study utilized and evaluated two methods of dredged material disposal; a Confined Disposal Facility (CDF) and Contained Aquatic Disposal (CAD). The disposal facilities are shown in Figures 4 and 5, respectively. The design parameters were developed during the EFS by the Waterways Experiment Station (WES) and were based on laboratory studies, desk top analyses and literature reviews. Detailed descriptions of the construction and operations of the CDF and CAD are provided in Parts IV and V respectively, of this report.

Confined Disposal Facility (CDF): As shown in Figure 4, the CDF was divided into a primary and secondary cell. The dredged material enters the primary cell in a slurry of up to 40 percent solids. Once discharged into the primary cell, the dredged material solids were allowed to settle out and the excess water flowed over a weir into the secondary cell. The primary cell was designed with a capacity of approximately 25,000 cubic yards. As only 20,000 cubic yards of slurry was expected to be produced in removing the 5,000 cubic yards of contaminated sediment from dredging area 1, it was possible to retain all of the slurry in the primary cell until all of the contaminated sediment had been dredged.

This mode of operation was not expected to provide the desired estimate of effluent quality for prototype facilities under typical operating conditions. Therefore, an adjustable height weir was constructed to allow the overflow into the secondary cell to provide monitoring during the latter stages of contaminated sediment dredging. Water flowing over the adjustable weir between the cells was mixed with a cationic polymer emulsion (Magniflox 1596C) as it entered the secondary cell. Tests performed for the Engineering Feasibility Study indicated that as much as 82% additional suspended solids reduction could be achieved in the secondary cell following polymer addition (8). It was estimated that an effluent suspended solids concentration of 70 mg per liter could be attained (Appendix 2). A small portion (10 - 50 gal/min) of the water leaving the secondary cell also received additional treatment. A pilot scale filtration and carbon adsorption system and U.V. peroxidation system were utilized to evaluate the feasibility of this type of treatment.

Figure 4 shows a typical cross section of the CDF prior to filling. Based on the initial design it was anticipated that approximately 5,000 cubic yards of contaminated sediment would be placed in the site. The contaminated material was taken

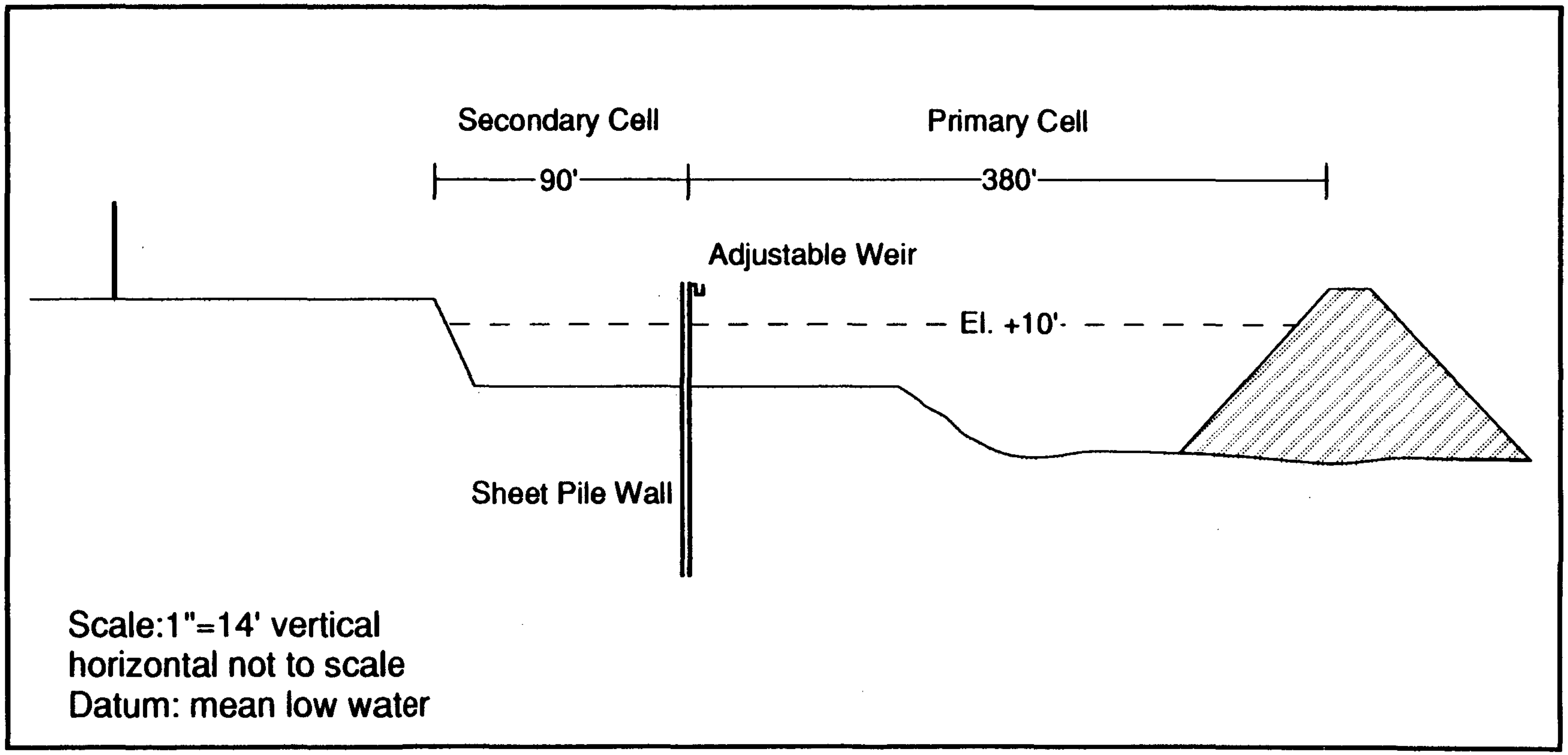

Figure 4 Typical cross section of a Confined Disposal Facility (CDF)

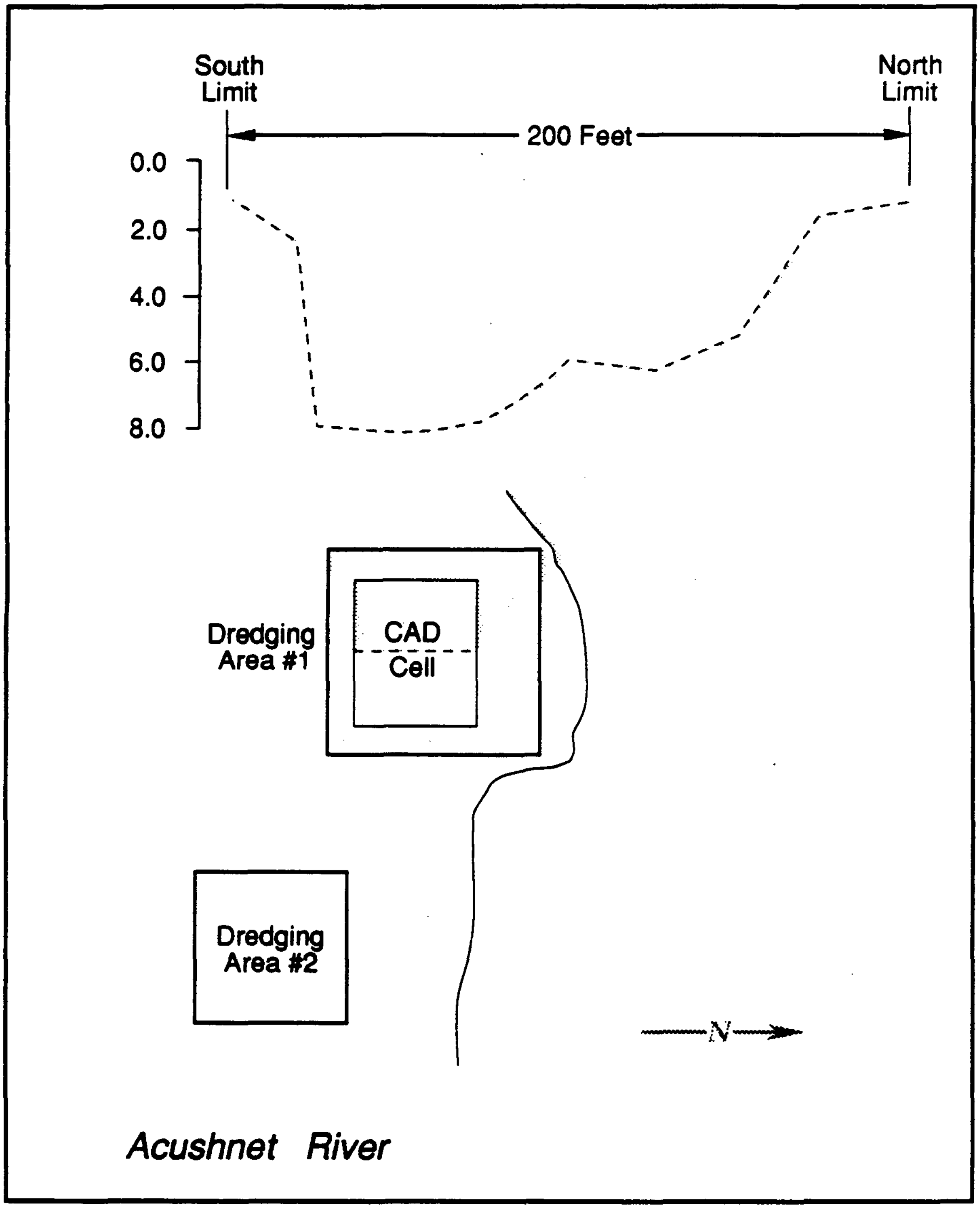

Figure 5 Typical Cross Section - Contained Aquatic Disposal Cell

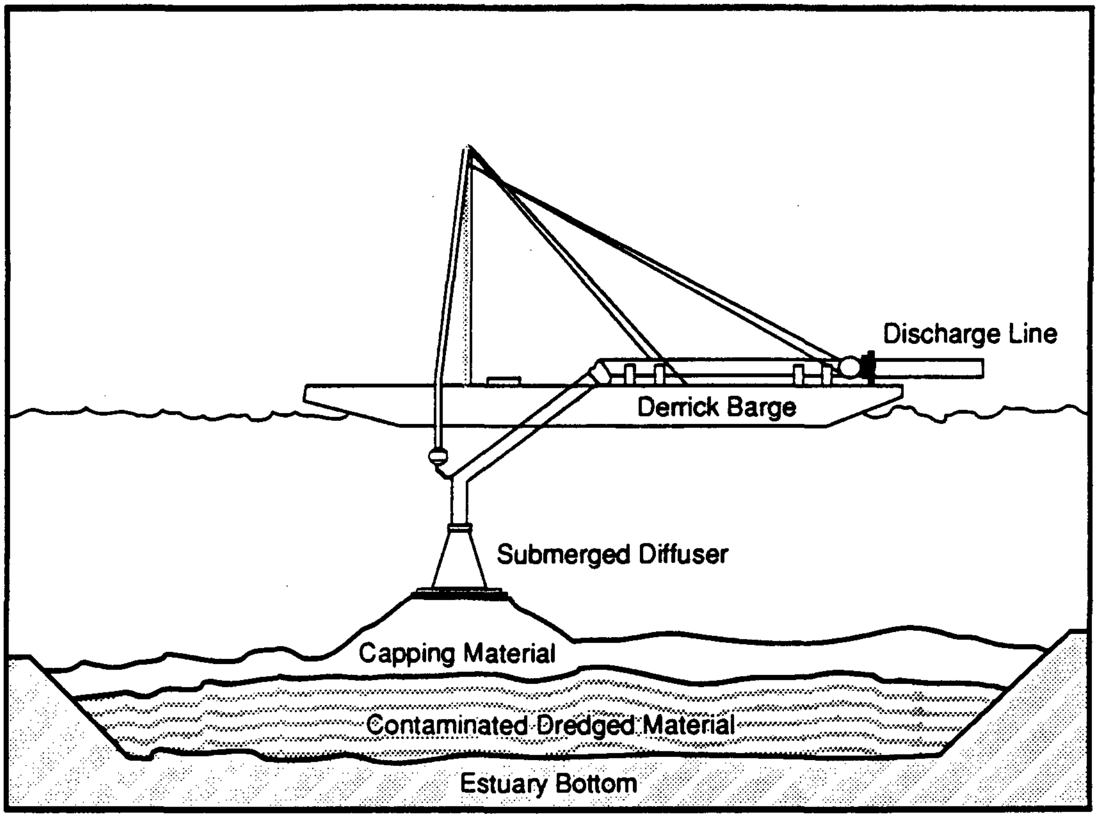

Figure 6 Contained Aquatic Disposal (CAD) Cell Filling with a Submerged Diffuser

from the top two feet of sediment from dredging area 1and was then capped with clean material taken from the 2-6 foot layer of dredging area 1.

<u>Contained Aquatic Disposal (CAD):</u> Contained aquatic disposal (CAD) involves the dredging of the contaminated sediments, placement in a pre excavated subaqueous pit, and capping with clean sediment. It is similar to level bottom capping but with the additional provision of the pit for lateral confinement to minimize the spread of material (9). The dredged material slurry is discharged through a submerged diffuser to control the placement of material and minimize contaminant release during placement. The concept is illustrated in Figure 6.

The CAD cell was created as a result of the dredging in area 1and is shown in Figure 5. Contaminated sediment from dredging area 2 was deposited in the cell using the submerged diffuser which was positioned approximately 2 feet from the bottom. The diffuser, described in more detail on page 23, was designed to release the slurry parallel to the bottom of the site and at a reduced velocity. The contaminated material was then capped by a layer of clean material which was also obtained from dredging area 2. The material for capping was also placed within the cell using the submerged diffuser.

Testing conducted for the EFS determined that a cap thickness of 35 cm was an effective seal that would physically isolate the contaminated sediment from the overlying water column (10). This thickness was expected to only prevent the contaminants from migrating through the cap and does not include allowances for bioturbation by burrowing aquatic organisms. The prime interest in this phase of the pilot study was to evaluate the practicality of placing contaminated sediment in a CAD cell and capping it with clean sediment. The 24 inch (61 cm) cap planned for the pilot study will be sufficient to allow for this evaluation of the CAD cell over the one year monitoring period. Report 6 of the EFS contains a complete discussion of the laboratory testing on capping effectiveness.

ENVIRONMENTAL MONITORING PROGRAM.

The environmental monitoring program was designed by personnel from NED, WES, and ERLN, with input from state and other federal agencies. The objectives of this program were to provide data to:

- evaluate the engineering and environmental effectiveness of the dredging and disposal techniques used;
- predict the magnitude and area extent of water quality effects during a full scale clean up operation;
- select optimum monitoring protocols for this study and full scale operations; and
- aid in the regulation of the daily pilot study operations.

The program included physical (hydrological and meteorological), chemical and biological (acute and chronic toxicity) evaluations of dredging area sediments, harbor water, effluent and leachate from the CDF, and air quality around the project area. This monitoring program was divided into five major tasks designed to address changes in water quality throughout the harbor and potential contaminant release pathways associated with the pilot construction operations and the proposed full scale dredging of the harbor. These five major tasks consisted of:

- Performance of preliminary sampling to determine background (condi tions in the absence of construction/dredging activites) characterization of water quality and sediment
- Evaluation of the CDF by determining effluent and leachate water qualty over time
- Evaluation of CAD by determining water quality effects during disposal and contaminant migration through the cap covering the CAD cell
- Evaluation of dredges by comparing remaining contaminant levels in the sediment after dredging and water quality impacts; and
- Water quality sampling to control operations to minimize the potential for contaminant release during the pilot study and to develop guidelines for use during the proposed full scale cleanup

OPERATIONAL CONTROLS

The following operational controls were devised to be used as necessary:

- During the course of the project all activities that could reasonably be expected to result in elevating contaminant levels would be suspended during severe weather conditions.
- If needed, CDF construction could be restricted to the flood tide period.
- If needed, dredging and/or CAD operations could be restricted to the flood tide.

- Should restricting the dredging and/or CAD operation prove ineffective the amount of scheduled down time between dredges could be extended.

- As a final procedure, if above control options proved ineffective or inadequate the operation of the dredges could be modified. Any or all of the operating parameters, ie; depth of cut, swing speed, rate of advance, etc., could be reduced or modified to further minimize turbidity or resuspension.

PHYSICAL CONTROLS

Several physical controls were also used:

- During construction of the CDF a silt curtain was deployed around the perimeter of the work area.

- During the disposal of contaminated material into the CAD cell a submerged diffuser was used.

Silt Curtains: A silt curtain or turbidity barrier is a flexible, impervious barrier that hangs down vertically from the water surface. The silt curtain consists of four major elements: a skirt that forms the barrier, flotation material at the top, ballast weight at the bottom, and a tension cable. (Figure 7) The flotation and ballast keep the curtain in a vertical position while the tension cable absorbs stress imposed by currents and other hydrodynamic forces. The fabric material is commonly nylon-reinforced polyvinyl chloride (pvc). The curtains are manufactured in 100-foot long sections that are joined together for the overall curtain length. The curtain may be attached to shore or held stationary with large anchors attached to mooring floats on the ends and smaller anchors at regular intervals along the length of the curtain. The primary purpose of the silt curtain is to reduce turbidity in the water column outside the curtain, not to retain the fluid mud or bulk of the suspended solids. The presence of a silt curtain results in a change of flow patterns in the vicinity of the curtain so that exiting flows are redirected. Under quiescent condition (currents less than 0.5 knots [0.85ft/sec] with no strong tidal action), turbidity levels outside a properly deployed and maintained silt curtain can be reduced by 80 to 90 percent of the levels inside (7). The curtain used for the pilot study was to have the skirt anchored to the bottom, with flotation material at the top to allow for adjustments necessitated by the rise and fall of the tide. An oil boom was used along with the silt curtain to contain the thin layer of floating oil or contaminant that appears on the water surface during such operations.

The silt curtains deployed during pilot study dredging sustained substantial damage as a result of severe weather conditions on 20 November. Rather than delay the start of dredging operations, the curtain was allowed to remain in a damaged, and therefore ineffectual, condition for the greater part of the dredging phase. As the suspended solids data in Appendix 1 indicates, the levels generated at the point of dredging dropped rapidly down to background levels. Based on visual observation and the suspended solids data, the only phase in which the curtain may have contributed to reducing turbidity would have been during the CAD operation. As a result of these observations the curtain was re-deployed during the placement of cap material in the CAD. Aligned in a crescent shape formation to the east and south-east of the CAD cell and located approximately 200 feet from the point of discharge, it was visually apparent that the curtain aided in reducing the turbidity levels. In all probability, however, these levels would have declined prior to reaching the Coggeshall Street Bridge. What was also readily apparent was that the initial deployment, periodic movement and final removal of the curtain resulted in some of the highest levels of sediment resuspension visually observed during the project.

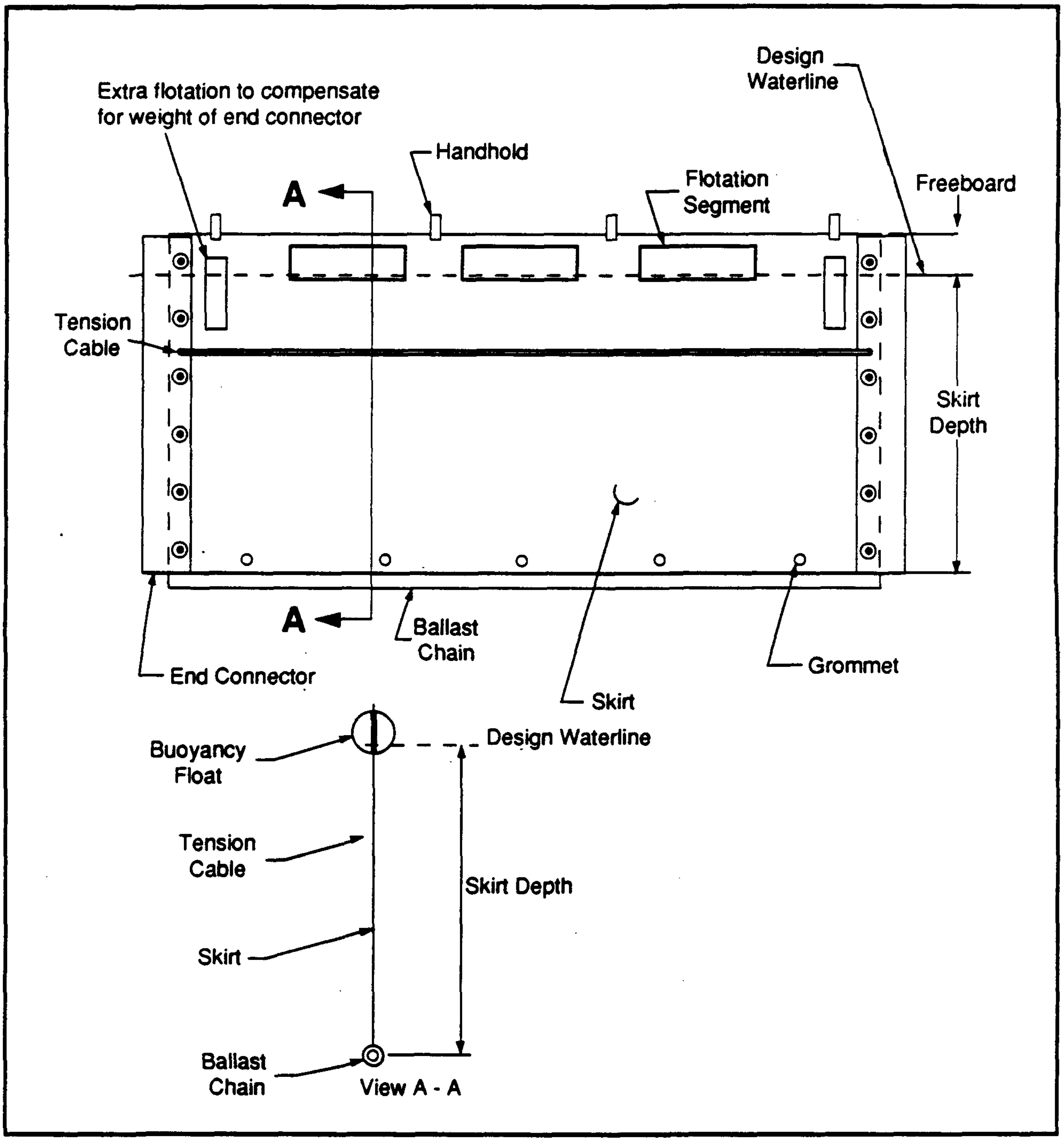

Figure 7 Typical silt curtain section

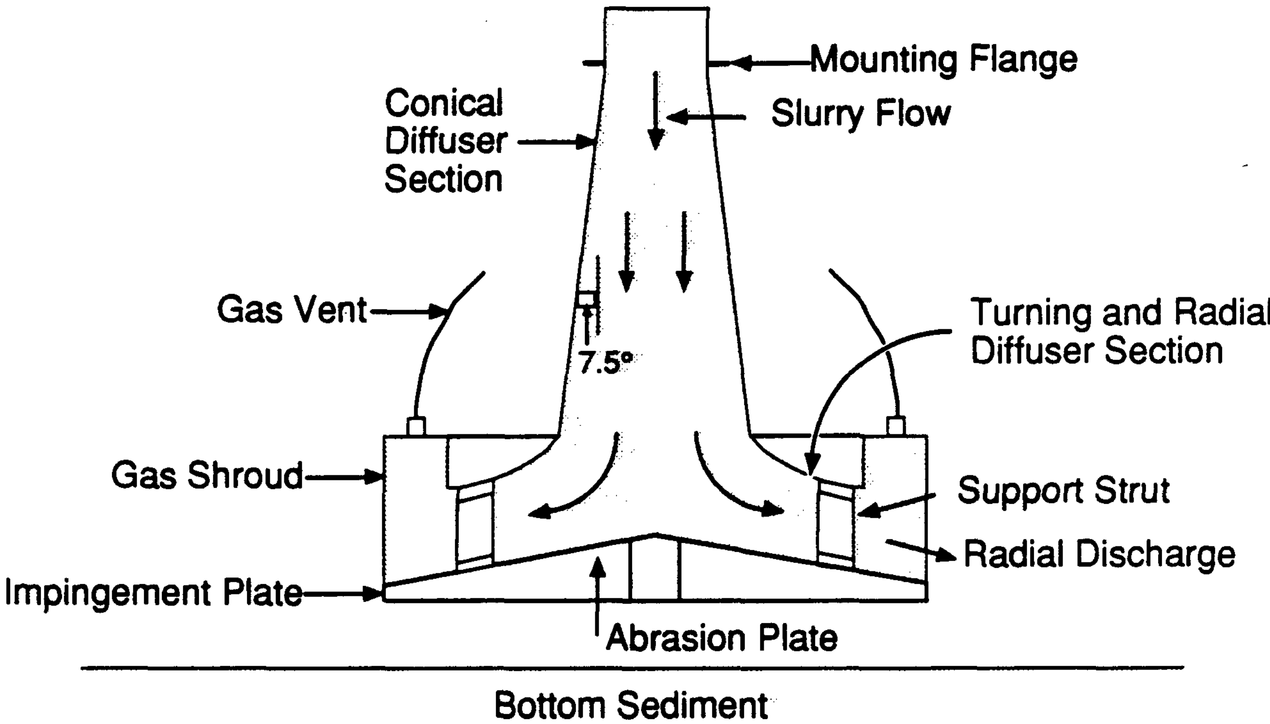

Figure 8 Submerged Diffuser

Diffuser: A submerged diffuser is a control technology used to reduce the impacts associated with the disposal of dredged material in open water during hydraulic pipeline dredging. The purpose of this device is to reduce the velocity of the dredged slurry as it exits the pipeline into the CAD cell. It also changes the flow direction to a radial release parallel to the bottom of the estuary. The lower discharge velocity and horizontal release reduces turbulence at the deposition area and minimizes the mixing of the dredged slurry and the water column. The pipeline for the dredged material slurry is turned downward through a 90 degree elbow and approaches the diffuser from above. The cross sectional flow increases gradually through the vertical section of the diffuser. The 15 degree expansion angle is the largest angle the flow can negotiate before separation sets in and causes the flow to jet. The flow is then turned from vertical to horizontal within the diffuser and discharges parallel with the bottom of the deposition areas (i.e. CAD cell). The dredged slurry does not come in contact with the water column until it is discharged at the bottom of the deposition area (14). A support barge is used in conjunction with the diffuser. A small crane mounted on this barge positions and adjusts the depth of the diffuser. A schematic view of the diffuser processor design is shown in Figure 8. The diffuser used during the pilot study is described in more detail in Part V of this report.

PART III DREDGING

As discussed in Part II, three hydraulic dredges were selected for the pilot study. This section describes how the equipment was used during the performance of the study, the modifications to operating procedures developed during the course of the project and the problems associated with each piece of equipment. Finally, a comparison of each dredge is provided, along with recommendations of how best to use the equipment should dredging be selected as the method for removing contaminated sediments from the upper estuary of New Bedford Harbor. Appendix 1 contains more detailed information on production rates, sediment resuspension, operational difficulties and a complete summary of daily operations.

The operational phase of the dredging program had four major objectives:

- to minimize the amount of sediment resuspension associated with the dredging operation.
- to minimize the total amount of sediment removed while maximizing the removal of contaminated sediment.
- to develop and refine the optimum operational characteristics to achieve the first two objectives while still maintaining effective production rates; and
- to develop and refine operating procedures to minimize the operating and support personnels exposure to contaminants.

CUTTERHEAD DREDGE

Operating procedure – A cutterhead dredge is not a self-propelled craft and as such requires a set of work boats to place the dredge in position and to re-align it each time the dredge completes one full advance. Once in position, the dredge is held stable by a set of stern spuds set into the sediment. Anchor cables are then placed in position and are used to control the swing of the cutterhead. The basic movement consists of a side to side movement (swing) of the rotating cutterhead. The dredge advances by the alternate raising and lowering of the stern spuds at the end of a lateral swing. One spud is raised and the dredge pivots on the lowered spud. The "walking" action permits the dredge to advance with a zig zag dredging action (7). The basic operation is shown in Figure 9 and the specifications for the dredge used at New Bedford are shown in Appendix 1, Table 21.

At the start of the operation different depths of cut, swing speed and advances per swing were experimented with. A depth of cut of two feet with a two foot advance per swing proved to be the most effective. Both visual observations and soundings confirmed these operating parameters to be very successful. The rotation of the cutterhead and the swing were maintained at a slow rate of speed throughout the operation and the pump was kept at maximum RPM to further assist in reducing resuspension. The width of the cut was held to 60-feet to assure maximum operator control.

The dredge was also required to make a second pass over the area, but did so with an increased swing speed and a rate of advance that was more than doubled that of the initial pass. During the second pass the dredge was required to remove only the surface layer of sediment and removed very little additional material.

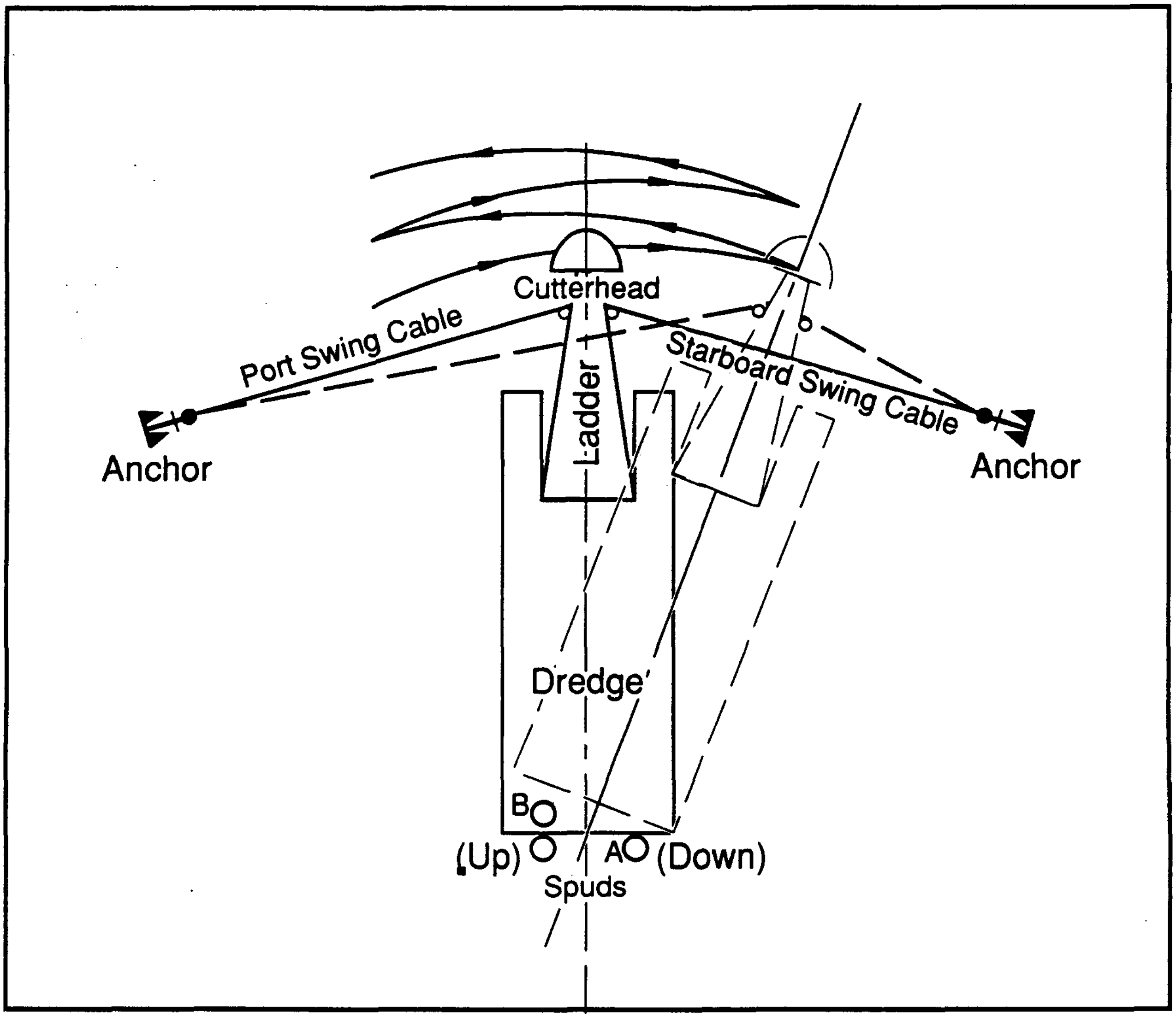

Figure 9 Operation of a Cutterhead & Matchbox Dredge (view from above)

The major operational problems encountered involved the depth of water in the cove and the swing anchors. Due to the very shallow depths only small work boats could operate. These vessels were severely limited in their ability to lift and maneuver heavy swing anchors and lighter anchors would not hold in place due to the soft bottom material. The problems with the anchors were alleviated by placing them on shore. By so doing, a heavier anchor could be used and the resuspension caused by slipping anchors was eliminated. Additionally, with the anchors being set from shore the turbidity caused by the work boats was significantly reduced. Should dredging be used in the upper estuary it is recommended that anchors be placed on shore. Such placement would offer the following advantages:

- The most appropriate sized anchors can be deployed.
- Small boat traffic, which causes a significant amount of resuspension, can be minimized.
- Additional resuspension would be reduced by not having the anchor dragging through the sediment.
- The dredge crew would not have to continually handle the anchors, thereby reducing their exposure to contaminants.

Production: The cutterhead dredge had a draft of 36 inches and in the shallow waters of the cove was limited to 3-5 hours of operational time around the high tide period. In addition to the restrictive depths, dredging area 1 contained a considerable amount of debris which further reduced the available dredging time. Actual dredging time was only 77 % of the total available time. This figure was increased to a 90% effective time in area 2 where the absence of debris minimized down time. Low temperatures also reduced production rates by necessitating a longer warm-up period for the dredges' hydraulic system and the need for the dredge to be "winterized" at the end of each work day, a procedure which took 30-40 minutes. Proper treatment of the equipment however, resulted in no mechanical problem being encountered during the period of performance.

Production rates were lower than initially estimated. During the initial cut an average of 37 cubic yards per operating hour was achieved. By taking the second pass into account, the production rate drops to 16 cubic yards per operating hour.

The percent solids of the dredged slurry was also lower than initially anticipated, achieving an average suspended solids concentration of 37 grams/liter at an average flow rate of 1,900 gallons per minute (GPM). The average flow rate however, was increased to just over 2,100 GPM when the diffuser was removed. It is quite possible that the higher flow rate could have been achieved with the diffuser attached had a rigid 90° pipe connection been attached to the diffuser rather than the flexible pipe used during the study. Based on field observations, it was the connection and not the diffuser which caused the constriction and hence the reduced flow rate.

The production rate increased significantly during the removal of the clean cap material. The cutterhead averaged over 75 cubic yards per hour with an average flow rate of 1,600 GPM (the diffuser was not used during this phase of the operation) with a suspended solids concentration of 150 grams/liter. This rise in production was attributable to the change in operational goals. Concern over resuspension and accuracy of cut was changed to one of achieving maximum movement of material.

Removal Efficiency: In area 1 the dredge was limited to one pass over the area and averaged a depth of cut of 1.5 feet. The level of PCBs remaining after dredging averaged 84 PPM. It was in area 2 that the second or sweep pass was made to further reduce the PCB levels. The average depth of cut was 1.1 feet and the PCB level was reduced to less than 10 PPM. The substantial difference in the results achieved between dredging areas 1 and 2 clearly displays the benefits gained by performing a second pass. The cutterhead proved quite successful at removing less than a two foot lift of material while achieving a significant reduction in the level of contamination.

Sediment Resuspension: The EFS estimated sediment resuspension rates at the dredgehead to be 40 grams per second. Generally, only a percentage of the smallest fraction of fine grained sediment was predicted to escape from the immediate vicinity of the dredging area (11). Sediment release rates are discussed in detail in Report 2 of the EFS.

A sampling device was installed at the dredgehead in an attempt to determine the sediment resuspension rate. Sampling was conducted on 5 days while the dredge operated in contaminated sediments. The suspended solid levels of these samples were used with the dredge swing speed and the water depth to develop the resuspension rate. The rates computed ranged from 2.6 - 75.9 grams per second and averaged 17.3 grams per second. The cutterhead dredge proved to be the most effective in minimizing resuspension.

Sampling from an array of stations situated around the dredge (Figure 12) provided substantial field data to compare with the predictions based on the sediment transport model. A well defined plume of resuspended material never developed and only minor increases above background were detected. These results indicate that the model provides a conservative estimate of the amount of material escaping the immediate vicinity of the dredging operation.

Contaminant Release: The estimated level of contaminant release associated with sediment resuspended by the dredge was based on the sediment generation rate and total and soluble contaminant concentrations from elutriate tests. The standard elutriate value was selected for PCBs because this test has been more often related to effects on the water column. Modified elutriate data were used for the metals where quality standard elutriate data were not available. Composite samples taken from the dredgehead sampler were analyzed for PCBs and metals. The mean PCB concentration for the various phases are shown below. These results indicate that the standard elutriate test is a conservative estimate of the contaminant levels in the water column adjacent to the operating dredgehead.

	Mean	Sd. Dev.	Min.	Max.	Num.	Stand.Elutriate
PCBs						
Total(ppb)	7.0	7.3	1.6	26.6	11	100.7
Dissolved(ppb)	0.6	0.2	0.5	1.0	5	9.4
Particluate(ppb)	22.3	24.6	0.6	66.7	6	91.3

Composite samples were prepared from a combination of samples taken at the individual stations arrayed around the dredge (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals. The averaged results are shown below for total PCB (ppb).

Station	Mean	Sd. Deviation	Minimum	Maximum	Number
1 - 5	0.6	-	-	-	1
6 - 10	1.5	0.2	1.4	1.7	2
11 - 15	1.1	0.6	0.5	1.9	4

The results show a considerable reduction from the contaminant levels at the dredgehead and are within the range of contaminant levels that occur in this area in the absence of dredging. This data and the data on resuspended sediment indicates that the movement of contaminants away from the point of dredging is likely to be less than estimates based on the sediment transport model.

HORIZONTAL AUGER DREDGE

Operating Procedure: The horizontal auger dredge used at New Bedford was the model known as the "Mudcat", manufactured by Ellicott Machine Corporation, the specifications of which are shown in Appendix 1, Table 22. The Mudcat required workboats for it to be moved into position and to be hooked up to its cable system, as shown in Figure 10. The Mudcat advances by winching itself along a single cable line and is capable of proceeding in both a forward and reverse direction. Under optimum operating conditions, the dredge is capable of making an 8-foot wide cut at a depth of 18 inches.

As with the cutterhead dredge, the Mudcat was initally experimented with to determine the best operating parameters. A depth of cut of 6-inches per pass with four passes per cut proved to be the most effective. The average rate of advance that was eventually selected was 13-feet per minute. The dredge pump was run at full RPM and the auger was rotated at full speed in all of the operating modes that were experimented with.

The major operational problem encountered with this equipment was its susceptibility to being blown off-line by high winds. The resulting lateral movement of the dredge required constant readjustment in the width of the dredge cuts to compensate for the drift. While this movement did cause some operational difficulties, the relatively sheltered nature of the cove prevented significant delays from occurring. This problem however, could become significant in the more open reaches of the upper estuary. Locating suitable sites to hook up the 4-point cable system will also be difficult and may require the use of additional equipment to be used as or to install anchoring points.

An additional observation on the overall performance of the Mudcat concerns the effectiveness of the shroud which is an adjustable metal shield designed to maximize the percent solids passing through the pump and to assist in minimizing resuspension. The shroud appeared to contribute to a plume of resuspended material on both the starboard and port sides of the dredge.

Production: The Mudcat dredge was capable of working in depths of water as shallow as 21-inches. The operation still averaged only 4 hours per day however, as it was decided that safety considerations required that the dredge crew not be isolated on the dredge. When there was less than 22-inches of water in the cove the workboats became incapable of operating and therefore could not remove personnel from the dredge and return them to shore.

Production time was further hampered by the large amounts of debris encountered in area 1. The effective operating time within area 1 was 60%, but increased to 79% in area 2 where the amount of debris encountered was significantly less.

Rates of production also turned out to be lower than originally estimated. In dredging area 1, production averaged 41 cubic yards per hour with an average dredge slurry flowrate of 1709 GPM. The suspended solids concentration in the dredged material slurry averged 45 grams per liter.

Removal Efficiency: As mentioned previously, the Mudcat made 4 passes over its assigned dredging areas which resulted in an average depth of cut of 1.5 feet in area 1 and 1.2 feet in area 2. In area 1, the PCB level in the remaining sediment averaged 31 ppm.

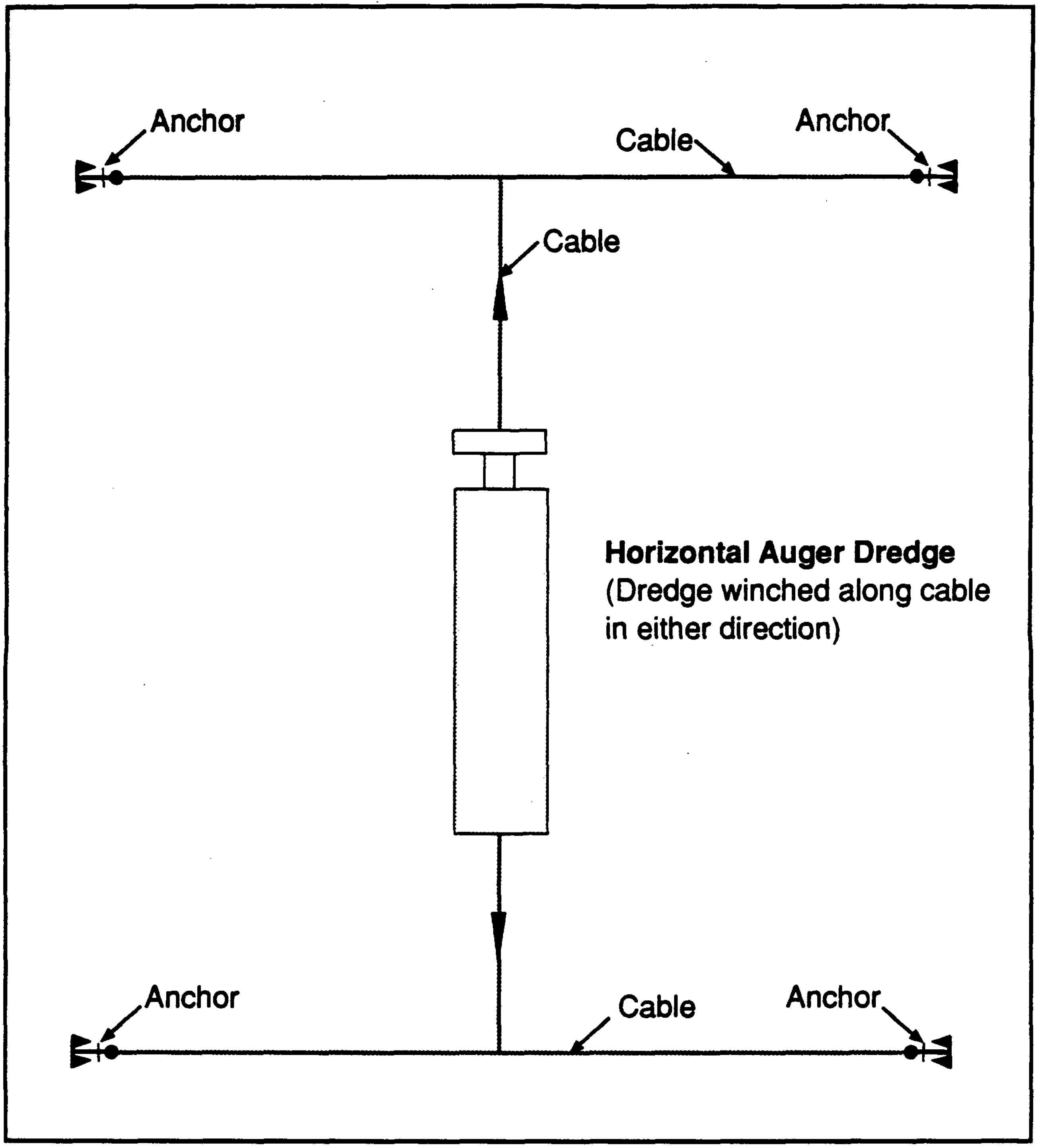

Figure 10 Horizontal Auger Dredge operation

Sediment Resuspension: A sampling device was installed at the dredgehead and sampling was conducted on four days while the dredge operated in contaminated sediment. The suspended solids level of the samples were used with the dredge's rate of advance and the water depth to develop a resuspension rate. The rates computed for the horizontal auger dredge ranged from 9 - 1136 grams per second and averaged 374 grams per second. This equipment had the highest sediment resuspension rates.

Sampling from the array of stations around the operating dredge did not detect a plume of resuspended material. Only minor increases above background were detected.

Contaminant Release: Composite samples taken from the dredgehead sampler were analyzed for PCBs. The mean PCB concentration for the various phases are shown below:

	Mean	Sd.Dev.	Min.	Max.	Num.	Stand. Elutriate
Total (ppb)	54.9	45.7	12.6	133.0	9	100.7
Dissolved (ppb)	10.1	9.2	1.0	22.9	4	9.4
Particulate (ppb)	200.3	199.8	18.2	382.0	4	91.3

These results are much higher than those obtained for the cutterhead and Matchbox dredges although the difference is not statistically significant due to the wide distribution of contaminant levels. The data does indicate that the horizontal auger dredge was less effective in reducing sediment resuspension and contaminant release at the point of dredging.

Composite samples formed from a combination of samples taken at the individual stations arrayed around the dredge were analyzed for PCBs. The averaged results for total PCB (ppb) are shown below:

Station	Mean	Sd. Dev.	Minimum	Maximum	Number
1 - 5	1.5	0.7	0.6	2.2	4
6 - 10	1.4	0.6	0.7	1.9	4
11 - 15	1.9	-	-	-	1

The results show a considerable reduction from the contaminant levels at the dredgehead and are similar to the conditions found while the cutterhead and Matchbox dredges were operating. This data is a further indication that contaminant movement away from the point of dredging is less than estimates based on the sediment transport model.

MATCHBOX DREDGE

Operating Procedure: The Matchbox dredge is a hydraulic dredge which operates in the same manner as described previously and as shown in Figure 9. The dredge's specifications are shown in Appendix 1, Table 23.

Initial operating parameters called for an 18-inch cut, but the presence of large amounts of debris significantly hampered operations. The depth of cut was reduced to 12-inches to reduce the problems caused by debris. Here again however, numerous shutdowns occurred due to the clogging of the dredgehead. Problems were also encountered with the dredge's hydraulic system and as a result the amount of data obtained for the Matchbox in area 1 was limited.

In dredging area 2, the dredge made 2 swings per advance at a cut of 6-inches per swing. The average width of the cut was 60 feet at a rate of advance of 15 feet per hour. The swing speed was kept low and the pump was run at a maximum RPM to minimize resuspension at the dredgehead. The dredge also made 2 passes over the area to aid in further reducing the level of contamination in the dredging area.

Operationally, the same problems with the swing anchors that effected the cutterhead dredge also impacted the Matchbox. The corrective measures to the swing anchors adopted for the cutterhead dredge were successfully applied to the Matchbox. An additional problem however, dealt with the plugging of the dredgehead with debris and sediment. While dredging area 2 had considerably less debris than area 1, the material in area 2 was more densely packed. To prevent frequent plugging of the dredgehead, vertical and horizontal bars were installed and removal of the material in 6-inch lifts enabled the dredgehead to more effectively avoid clogging. These measures were for the most part successful, enabling an effective operating time of 91 percent in dredging area 2 to be achieved. In those instances however, when the dredgehead did become clogged, the clearing operation required personnel to manually remove the sediment. This procedure placed personnel in direct contact with contaminated sediment thereby increasing the risk to the health and safety of the attendant plant personnel. While this problem should not be considered insurmountable, it is probable that similar material with higher levels of contamination will be encountered in the upper estuary. Therefore, any personnel required to remove debris and/or sediment from the Matchbox dredgehead would require suitable protection. Adequate protective clothing will minimize any risk of exposure but will reduce the response time and efficiency of the personnel assigned to this task.

<u>Production:</u> The Matchbox dredge, with a draft of 3-feet, could only operate during the higher stages of the tide, i.e., for 3-4 hours per day. Although restricted from operating at low tides, its actual effective operating time was 91 percent of the available time.

The production rate for work in dredging area 2 average 24.5 cubic yards per hour. This production rate was achieved with the dredge removing material in 6-inch lifts per swing with a total of 2 swings per advance. The dredge also made two passes over the area.

In dredging area 1 the dredge slurry flow rate averaged 2,410 GPM with a suspended solids concentration of 24.4 g/liter. These rates were achieved when the dredge was removing material in 12-inch lifts per swing.

<u>Removal Efficiency:</u> The dredge made two passes with an average final depth of cut of 1.5 feet. PCB levels in the remaining sediment were less than 10 ppm.

<u>Sediment Resuspension:</u> A sampling device was installed at the dredgehead and sampling was conducted on five days while the dredge operated in contaminated sediment. The suspended solids levels of the sample were used with the dredge swing speed and the water depth to develop a resuspension rate. The rates computed for the Matchbox dredge ranged from 2.1 to 205.1 grams per second and averaged 46.4 grams per second.

Sampling from the array of stations around the operating dredge did not detect a plume of resuspended material. Only minor increases above background conditions were detected.

Contaminant Release: Composite samples taken from the dredgehead samples were analyzed for PCBs. The mean PCB concentration for the various phases are shown below:

	Mean	Sd. Dev.	Min.	Max.	Number	Stand. Elutriate
Total (ppb)	2.6	2.2	0.2	4.5	4	100.7
Dissolved (ppb)	0.5	0.1	0.3	0.6	4	9.4
Particulate (ppb)	56.9	76.4	6.7	205.0	7	91.3

These results are similar to those obtained from the cutterhead dredge and indicate that the elutriate test is a conservative estimate of the contaminant levels in the water column adjacent to the operating dredgehead.

Composite samples formed from a combination of samples taken at the individual stations arrayed around the dredge were analyzed for PCBs. The averaged results for total PCB (ppb) are shown below:

Station	Mean	Sd. Dev.	Minimum	Maximum	Number
1-5	1.3	0.20	1.1	1.6	3
6-10	0.2	0.04	0.21	0.26	2
11-15	1.1	0.06	1.05	1.13	2

The results show a considerable reduction from the contaminant levels at the dredgehead and are similar to the conditions found while the other dredges were operating. The data indicates that contaminant movement away from the point of dredging is less than estimates based on the sediment transport model.

CONCLUSIONS

The three dredges used during the pilot study were able to effectively remove the contaminated sediment while minimizing the amount of material that was removed. PCB levels after two passes of the cutterhead and matchbox dredges were less than 10ppm while only 1.1 - 1.5 feet of material was removed. Resuspension rates and contaminant release at the point of dredging varied as shown below:

	Ave. Resuspension Rate (g/sec)	Ave. PCBs (ppb)		
		Total	Dissolved	Particulate
Cutterhead Dredge	17.3	7.0	0.6	22.3
Horizontal Auger Dredge	374.0	54.9	10.1	200.3
Matchbox Dredge	46.4	2.6	0.5	56.9

Impacts less than 200-300 feet away from the point of dredging were minimal for all dredges. Sampling at the array of stations within the cove did not detect a plume of resuspended material moving away from the operating dredges and PCB levels in composite samples from these stations were similar to background conditions. The following table shows the results of sampling at the Coggeshall Street Bridge during dredging operations. These results do not show an increased level of PCBs escaping from the upper estuary during dredging operations when compared to background conditions.

COGGESHALL STREET BRIDGE MONITORING STATION

Date	Dredging Time (Hours)	Ebb Tide Composite Sample Total PCB (ppb)
11-22	1.87	0.97
11-23	2.83	0.54
11-25	3.18	0.26
12-02	1.90	0.57
12-03	4.25	0.44
12-04	1.55	0.91
12-05	3.43	0.69
12-10	3.00	0.36
12-12	1.40	0.39
		Ave. 0.57

Mean PCB concentration for pre-operational samples 0.60 ppb

The results of sampling on 3 days prior to the start of dredging are shown below:

11-11	0.90
11-12	0.43
11-13	0.22 particulate 0.15 dissolved

1. Note: On the dates shown in the above Table, the dredges operated in contaminated sediment for a period that exceeded 1 hour. Disposal was into the CDF.

Different operating procedures were experimented with during the first days of each dredge's work period. The procedures selected for each dredge resulted in reduced production rates over what was anticipated prior to the study. The following information summarizes the results for all dredges.

Dredge	Production Rate	Surface Area Covered	Effective Time
Cutterhead	20	444	84%
Horizontal Auger	41	1024	65%
Matchbox	25	410	81%

1) Production Rate: This term refers to cubic yards of sediment removed per hour of operation and assumes that the dredge is making two passes over an area.

2) Surface Area Covered: This term refers to square feet of area covered per hour of operation and assumes that the dredge is making two passes over an area.

3) Effective Time: This term reflects the percentage of the available time that the dredge was operating. Set up time is not considered when deriving this term.

Modifications to standard dredging procedure minimized resuspension and reduced the quantity of sediment removed. These included reducing the dredge's swing speed and/or rate of advance as much as possible, reducing the RPMs of the dredgehead on the cutterhead dredge, running the dredge's pump at full RPM and minimizing the depth of cut.

RECOMMENDATIONS

A comparably sized cutterhead dredge is recommended for use in New Bedford should dredging be selected for removing the contaminated sediments from the upper estuary. This recommendation is based on the equipment's performance in the following areas:

- Contaminants were removed while minimizing the quantity of material removed
- Sediment resuspension and contaminant release at the dredgehead were minimized
- This equipment was impacted the least by debris that was encountered in the dredging area
- Worker exposure to contaminated sediment was minimized
- Production rates were comparable to the other equipment
- The equipment was able to gain access to the upper estuary with ease

Some additional advantages to this equipment include:

- It is the most common dredge in the U.S. and there are numerous contractors with the equipment
- The equipment should not be unduly hampered by weather conditions within the upper estuary

The following operating procedures for the cutterhead dredge should be used when developing plans for the upper estuary.

Operating time per day (A)	3 - 4 hours
Number of passes	2
Width of cut	60 feet
Rate of advance	11 ft/hr (first pass)
	25 ft/hr (second pass)
Production rate (B)	35 cubic yards/hour
Flowrate	2100 gallons/minute
Solids concentration in dredged slurry	40 grams/liter
Cost (C)	$1120.00 /day

A) This work period could be extended in areas where the water depth exceeds 3 feet at mean low water.

B) This production rate is for the dredge's first pass over an area. Very little additional material is removed on the second pass.

C) This was the rental rate for the dredge with operator and attendant plant.

PART IV CONFINED DISPOSAL FACILITY

The following is a discussion of the construction of the Confined Disposal Facility (CDF) and the methods and procedures used for the disposal of contaminated and clean dredged materials within the facility. Appendix 2 provides additional information on the effluent and leachate quality and Appendix 6 provides a detailed presentation of the project site conditions, the in-water dike design, the construction techniques employed and the results of the geotechnical monitoring program.

The CDF, as shown in Figure 11, required the construction of approximately 1,800 linear feet of dike, 700 feet of which was located below the high water line. Due to the poor foundation conditions this 700 foot section was constructed on a geotextile.

The CDF was divided into a primary cell of approximately 145,000 square feet and a secondary cell of approximately 32,500 square feet. Separating the cells is a steel sheet pile wall, approximately 400 linear feet in length, at the southern end of which was located the first or primary weir. Used to pass water between the two cells, the primary weir had boards installed to elevation +8.0 MLW prior to the start of dredging. During the dredging operation the boards reached a maximum elevation of +10.0 MLW.

A second weir, located in the northeest corner of the secondary cell, was used to release water back into the cove. The boards at the secondary weir were installed to elevation +8.0 MLW and did not require adjustment during the dredging phase.

The physical characteristics of the CDF are shown below:

Area of site	250,000 square feet
Area of site initially below high water line	125,000 square feet
Top elevation of in water dike	+15 MLW
Top elevation of upland dike	+12 MLW
Top elevation of dredged material	+8 MLW
Quantity of material excavated from site	27,000 cubic yards
Quantity of sediment placed in site	6,100 cubic yard (A)
Quantity of dike material	45,000 cubic yards
Quantity of gravel bedding	1,900 cubic yards
Quantity of stone protection	1,800 cubic yards

(A) Refers to in-situ volume prior to dredging.

Construction: Construction of the CDF commenced on 5 May 1988 and was completed on 4 January 1989. The critical phases of the project are shown below.

Activity	Period
Stage I In-Water Dike Construction	23 June to 5 August
Consolidation Period	6 August to 19 October
Stage II In-Water Dike Construction	20 October to 2 November

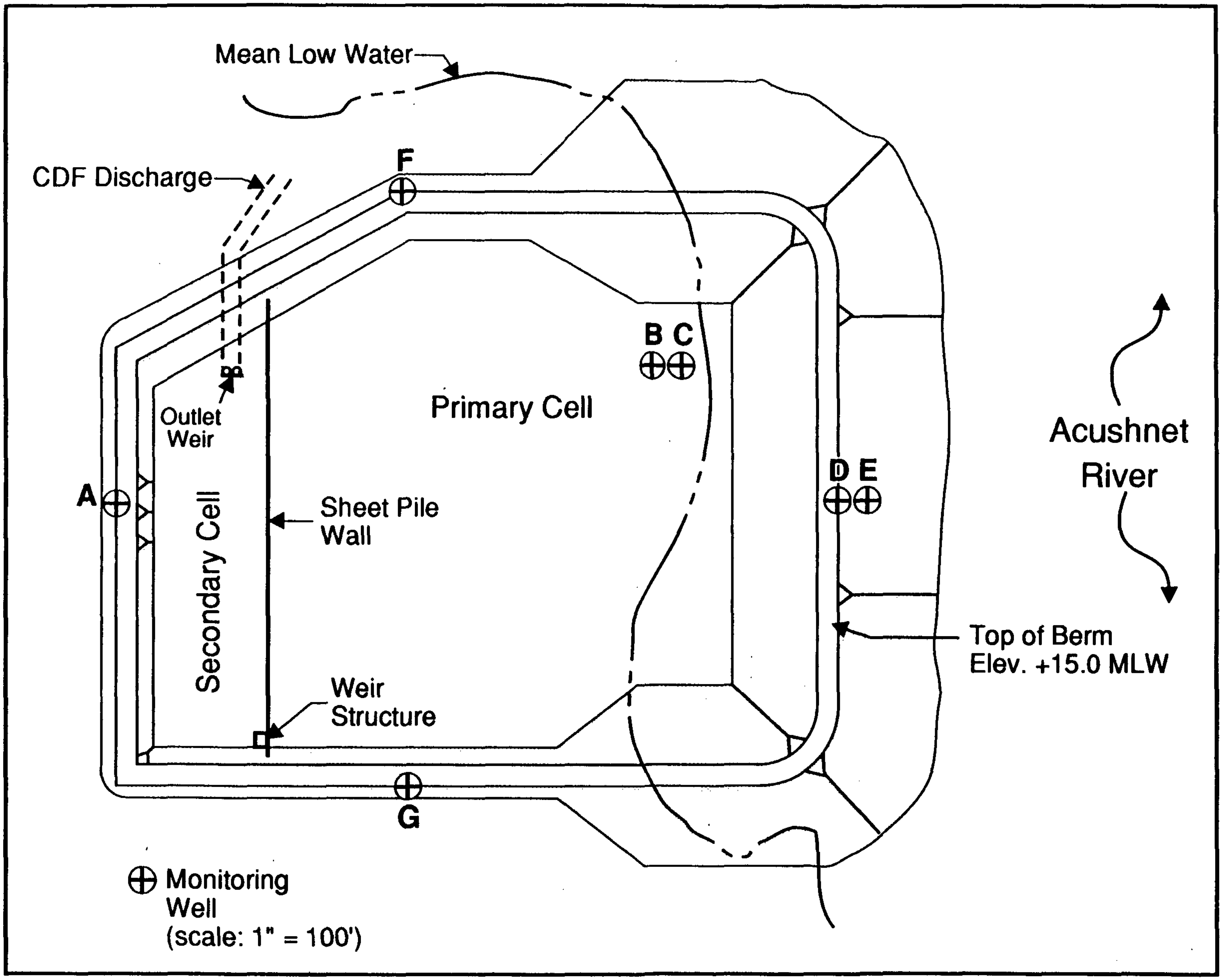

Figure 11 Confined Disposal Facility

As previously stated, the limited area available for construction of the CDF required that a portion of the dike be placed below the high water line where foundation conditions were known to be poor. These conditions required the placement of a high-strength geotextile along the dike alignment prior to placing any fill.

The geotextile is manufactured in 12-foot wide strips and is stitched together to achieve the desired lengths. For the New Bedford site, three separate sections were prepared at the factory and delivered to the site in a large roll. Each section was situated on an appropriate corner of the dike and was positioned such that a floating dredge pipeline could be secured to the leading edge of the fabric. The pipeline was attached by cables to a winch on an off-shore barge which pulled the fabric into position. Assisted by the floating pipeline, the material retained adequate buoyancy until the work crew had properly unfolded and aligned the fabric. Once positioned and aligned, the fill operation was immediately initiated to ensure that the fabric did not drift.

For the fill operation, the project specifications called for the contractor to place reasonably well graded granular material in shallow lifts of 2-feet or less. These specifications were altered, however, to allow for an accelerated construction process. Located below the high-water line, the fill operation was initially restricted to the lower stages of the tide. To minimize the inevitable down time, the material was placed in lifts of 3+ feet. Along with the larger lifts, the contractor encountered difficulties in obtaining the specified low ground pressure equipment which resulted in the use of heavier than specified equipment. These modifications to the specified construction procedures resulted in the displacement of soft foundation material and uneven settlement of the geotextile. A wave of unconsolidated material formed along the perimeter of the fabric and may have contributed to elevated contaminant levels detected in the water column during this phase of the dike construction.

Foundation conditions in other portions of the upper estuary are similar to those encountered at the pilot study site and it is likely that high strength geotextile will be required for the construction of additional CDFs. Procedures used for geotextile placement during the pilot study should be appropriate for other locations within the upper estuary. Fill placement should follow the original specifications for the pilot study which called for shallow lifts to be placed by low ground pressure equipment. (See Appendix 6). This will initally restrict operations to the period around low water but will minimize the displacement of foundation material.

The first stage of fill placement brought the elevation of the dike up to +5.0 MLW. Wick drains were then installed to drain the layer of weak foundation material and accelerate the process by which this layer could consolidate and gain strength. A period of 74 days was required before the strength gain was sufficient to allow the second stage of fill placement to begin. Completion of the second stage brought the dike up to its final elevation of +15 MLW.

Operation: The CDF was designed to have a capacity of 25,000 cubic yards. Settling tests, described in EM 1110-2-5027 (12) and EFS Report 7 (8), were performed on material from the upper estuary and, were used with estimated dredge production rates, to arrive at a dredged materials bulking factor of 2.0. Dredging areas were then surveyed to provide 10,000 cubic yards of material for the CDF.

The dredging operation within area 1 was performed over a 45 day period and is summarized below:

	Contaminated Material	Cap Material	Total
No. of days CDF received material	23.0	11.0	34.0
Average dredging hours per day	2.6	4.7	3.3
No. of days required	29.0	16.0	45.0
Cubic yards dredged(1)	2,208.0	3,929.0	6,137.0

A) refers to in-situ volume prior to dredging.

As the above information illustrates, the actual production rates were less than originally estimated. As more fully discussed in Part III of the this report, the dredges were restricted to operating at the higher stages of the tide and the dredge slurry had a lower than expected solids content. Funding considerations also necessitated that dredging area 1 be reduced in size by approximately 30 percent. The CDF, therefore, was not filled to capacity and the design condition of a minimum 2-foot ponding depth was not approached.

As shown in Figure 11, the CDF was constructed with two weirs. The first or primary weir was situated between the primary and secondary cells on the south side of the facility and was used to pass water between the two cells. The second weir was located within the secondary cell and was used to control the release of water back into the estuary.

In the primary weir, boards were installed to elevation +8.0 MLW prior to the start of dredging and did not have to be lowered during the course of the project. Water began to flow over the weir beginning on the 27th day of dredging; and additional boards were periodically added until the water elevation reached a maximum of +10.0 MLW during the last 2 days of dredging.

During the early stages of the operation, water was constantly leaking through the weir boards and the sheet-pile wall and was discharged back into the estuary. As the project progressed, material built up along the sheet-pile wall and significantly reduced the flow from leaks. In addition, increased dredging time during the capping phase allowed the water level to reach the weir elevation. The water level never exceeded the height of the boards (elevation +8.0 MLW) installed at the secondary weir. Substantial flow through the boards however, provided for the adequate discharge of water from the site. Although significant amounts of water passed into and through the two weirs, there was no observable buildup of material in the secondary cell.

Effluent Quality: Effluent at both the primary and secondary weirs was sampled and analyzed for total suspended solids, PCBs, metals and toxicity. This effort provided additional information to verify laboratory methods for predicting contaminant loads in CDF effluents.

In a procedure outlined by Palermo in 1985 (13), laboratory settling column data is used to estimate the suspended sediment load in the effluent being discharged from the primary cell of a CDF. The suspended sediment load is used with the dredge flow data, suspended sediment contaminant concentrations and dissolved contaminant concentrations observed in the modified elutriate test to calculate contaminant release from a CDF. Furthermore, based on laboratory tests, the addition of a polymer at a primary weir should achieve a percent reduction in the suspended solid load prior to discharge from a CDF.

At New Bedford, the primary weir was sampled over a 19-day period and the secondary weir was sampled for 15-days. Samples at both locations were taken hourly and analyzed for total suspended solids. The daily total of samples were then batched to form a composite sample from each weir. This composite sample was analyzed for Total Suspended Solids, PCBs (whole & filtered) and metals (Cu, Cd, Pb). The CDF discharge was also monitored for toxicity using the tests described in Appendix 5.

During the sampling period, a polymer was used to determine the efficiency and practicality of this flocculation process in reducing suspended solids. The polymer used at New Bedford was MAGNAFLOC 1596-C and was selected based on study results detailed in Report 7 of the Engineering Feasibility Study.

The results indicate that our estimate of 70 mg per liter for the suspended solids load in the effluent was accurate. Daily averages ranged from 27 to 152 mg/l with the mean being 75 mg/l. The polymer has a significant effect on the suspended solids levels during the later stages of CDF operation. During this period the suspended solids levels were high (800 mg/l) at the primary weir and the polymer significantly reduced these levels prior to discharge from the site The polymer appeared to have only minimal impacts when suspended solids levels were in the 100 mg/l range at the primary weir.

PCB concentrations in the CDF discharge indicate that the modified elutriate test provides a conservative estimate of the contaminant loading of the effluent. The means for the two fractions analyzed are shown below and compared to the elutriate test results.

	CDF Effluent	Modified Elutriate Test
Dissolved PCBs (ppb)	1.4	8.2
Suspended PCBs (ppb)	10.7	65.6

CONCLUSIONS

Dike Construction: The construction of shoreline CDF's for a full-scale clean-up effort appears feasible based on the results of the pilot study. In water dikes would be constructed on geotextiles following procedures specified for the pilot study. These procedures (fill placement in shallow lifts, low ground pressure equipment, consolidation periods) will extends the construction period but will result in stable dikes with minimal impacts to water quality.

Bulking Factor: A bulking factor of 2.0 was used in sizing the CDF. This bulking factor was based on the settling characteristics of the sediment and estimated projection rates and solids content of the dredged slurry. The actual builking factor appeared to be much less than 2.0. The reduced working time (3-5 hours/day) and low solids content of the dredged slurry (40grams/L) varied considerably from initial estimates and likely influenced the bulking factor.

Effluent Quality: Suspended solids levels in the effluent averaged 75 mg/l which was very close to the estimate of 70 mg/l. The polymer was effective in reducing suspended solids levels during the later stages of CDF filling when levels of the primary weir were high (800mg/l). When levels at the primary weir were in the 100 mg/l range, the polymer had little effect. PCB levels in the effluent were considerably lower than estimates based on the modified elutriate test.

These results indicate that the procedures for estimating contaminant levels are conservative, especially during periods when the CDF is not operating at capacity. The CDF was filled to capacity for only several days and clean cap material was being placed in the site at that time. The design condition of a minimum 2 foot ponding depth was never attained. Several concrete foundations located within the primary cell of the CDF also had a positive effect on settling by increasing detention time and minimizing resuspension within the cell.

RECOMMENDATIONS:

The size of the secondary cell in relation to the primary cell can likely be significantly reduced in future CDFs. Very little material accumulated in this cell and detention time was more than adequate due to the limited dredge operating periods. The barrier separating the two cells should be watertight along with the weirs. During the pilot study, the CDF was continuously discharging water due to leaks in the sheetpile wall and the weirs. With the limited dredge operating time, it was impossible to maintain the water level within the CDF.

PART V CONTAINED AQUATIC DISPOSAL

Contained aquatic disposal (CAD) involves the dredging of the contaminated sediments, placement in a pre excavated subaqueous pit, and capping with clean sediment. It is similar to level bottom capping but with the additional provision of a pit to minimize the spread of material (9). The dredged material slurry is discharged through a submerged diffuser to control the placement of material and minimize contaminant release during placement. The concept is illustrated in Figure 6.

The following is a discussion of the construction of the CAD site and the methods and procedures used for the disposal of contaminated and clean dredged materials within the site. Appendix 3 provides detailed information on the sediment plumes generated during CAD along with an evaluation of the completeness and integrity of the cap.

<u>Construction:</u> Construction of the CAD cell began with the dredging of material for the CDF from area 1 on 20 December, 1988 and was completed on 4 January 1989. As Figure 5 illustrates (page 14), the CAD cell was dredged to an average depth of
-6.0 MLW and measured 180 feet by 140 feet. Within this area a 50 foot by 50 foot section was dredged to elevation -8.0 MLW.

<u>Operation:</u> Placement of contaminated material within the confines of the CAD cell began on 7 January 1989. The dredged material was discharged into the cell using a diffuser attached to the end of the dredge pipeline. The diffuser was located approximately 2 feet above the cell floor to minimize resuspension and to ensure that the bulk of contaminated sediment remained within the boundaries of the cell. The diffuser was moved on four occasions to different locations inside the CAD cell perimeter to provide for equal distribution of the sediment.

Dredging of contaminated material ceased on 20 January 1989. Approximately 719 cubic yards of sediment were placed within the CAD cell over the 12 day dredging period. The bottom elevation was raised an average of 1.0 foot as a result of the fill operation. Placement of the cap material began on 25 January. Initially, the diffuser was placed just below the water surface to minimize disturbance of the contaminated bottom. However this procedure was discontinued because it resulted in the formation of a significant plume of suspended sediment. For the remainder of the cap operation, the diffuser was situated approximately 2 feet above the layer of contaminated sediment; a move that resulted in an immediate and pronounced reduction in resuspension. To provide for a uniform cap thickness the diffuser was relocated on 7 occasions.

Dredging of the cap layer ceased on 11 February 1989. Visual observation and lead line soundings indicate that a 2-3 foot cap has been placed over the contaminated sediment. Surveys of the site will continue, and this section of the report will be updated when additional information is obtained.

<u>Sediment Resuspension:</u> An array of stations were established around the CAD operation and sampled hourly during the filling operation (as shown in Appendix 3, Figures 3-4 and 3-5). During the CAD operation the suspended solids levels within the cove were elevated above background and increased as the length of the dredging period increased. Background levels in the cove are generally less than 10 mg/l. Averages for the10 sampling stations for the last sampling event for each day are shown on the next page:

STATION	TOTAL SUSPENDED SOLIDS (mg/l)
1	153
2	248
3	458
4	97
5	68
6	30
7	383
8	89
9	107
10	72

Sampling conducted at monitoring station 7 (located just east of the cove and approximately 800 feet from the point of discharge) also detected elevated levels of suspended sediments. This data indicated that a plume of resuspended sediments was moving away from the CAD cell. Levels ranged from 12-98 mg/l. Background levels at this station are less than 10 mg/l.

Contaminant Release: Composite samples were formed from a combination of samples taken at the individual stations (example: station 1-5, hour 3). These samples were analyzed for PCBs and the levels detected were elevated above background and also exceeded levels found during other phases of the project. This data is summarized below:

Total PCB (ppb)

Station	Mean	Std. Dev.	Minimum	Maximum	Number
1-5	13.4	12.0	2.5	31.8	5
6-10	6.8	5.1	1.5	15.3	4

PCB levels detected at monitoring station 7 and station 2 during the CAD operation are compared with background conditions and other phases of the pilot study:

Average PCB Level (ppb)

	Station 7	Station 2
Background	--	0.6
Dredging with disposal in CDF	1.1	0.6
Dredging with disposal in CAD	2.6	0.9

CONCLUSIONS:

Contaminated sediment was successfully placed in a CAD cell and capped during the pilot study. As anticipated, sediment resuspension and PCB levels were elevated in the vicinity of the disposal operation (CAD site) as compared to background conditions and other phases of the study. However, a statistically significant increase in PCB levels was not detected at the Coggeshall Street Bridge. The submerged diffuser appeared to be effective in reducing sediment resuspension and in controlling the placement of contaminated and capping material. It was most effective when held approximately two feet above the sediment over which material was being placed. A silt curtain was not in place while suspended solids were being sampled. Monitoring results indicates that a curtain deployed around the disposal point would likely be an advantage.

Additional sediment sampling will be conducted over the next year to monitor the integrity of the cap and detect contaminant migration into the clean cap material. This report will be revised when this additional information becomes available.

PART VI ENVIRONMENTAL MONITORING PROGRAM

The objectives of this program were to provide background data to aid in the evaluation of the effectiveness of the dredging and disposal techniques and to assist in the regulation of the pilot study daily operations. This program included physical, chemical and biological evaluations of sediment, water, effluent and leachate from the CDF, and air quality monitoring. The toxicity testing undertaken by ERLN will be published at a later date. Air monitoring was performed by EBASCO Services, Inc. and will be published elsewhere.

The monitoring program was divided into several major tasks designed to record changes in water quality throughout the harbor and contaminant releases associated with the proposed pilot construction operations. The program consisted of: evaluation of the CDF by determining effluent and leachate water quality; evaluation of the CAD by determining water quality effects during disposal and contaminant migration through the cell; evaluation of dredges by comparing remaining contaminant levels in the sediment and water quality after dredging.

PRELIMINARY SAMPLING AND WATER QUALITY CHARACTERIZATION:

This effort conducted by ERLN was used to determine the exsiting ranges of specified physical, chemical and biological response variables which occur within the system. These background conditions were then used as monitoring program assessment points and as input to management during the operational phase of the pilot project. The preliminary sampling was conducted on nine separate days between July 9, 1987 and June 23, 1988. The results of these efforts show that the protocol was appropriate for this project and that the water chemistry parameters were measurable, with relatively low variability.

The basic sample component used to characterize water quality in the harbor were hourly water samples taken at 4 locations over one tidal cycle and pooled into ebb and flood composites. These 4 stations were sited throughout the harbor (Figure 12). During the construction activities, station 3 was moved outside the cove and relabled station 7. The Coggeshall Street Bridge sampling points were considered a control measurement due to the location (the boundary between the more heavily contaminated upper estuary and the less contaminated lower harbor) and water circulation restriction point. At this station upper estuary in flow and out flow were measured for each sampling event and samples were then composited proportional to velocity for each of the 6 cross-sectional sub areas (Figure 13). The five hourly samples were then composited equally into one sample to represent either the ebb or flood condition. Samples from the other stations were taken hourly at 3 depths. The five hourly composites were then composited into one sample for each station which represented the ebb or flood condition. The following parameters were determined:

Physical measurements:
- total suspended solids
- water temperature
- salinity

Chemical measurements:
- whole water PCB
- cadmium (Cd), copper (Cu), and lead (Pb) in 50% of the samples
- TOC on 10% of the samples
- filterable PCB and heavy metals (Cd, Cu, Pb) in 25% of the samples

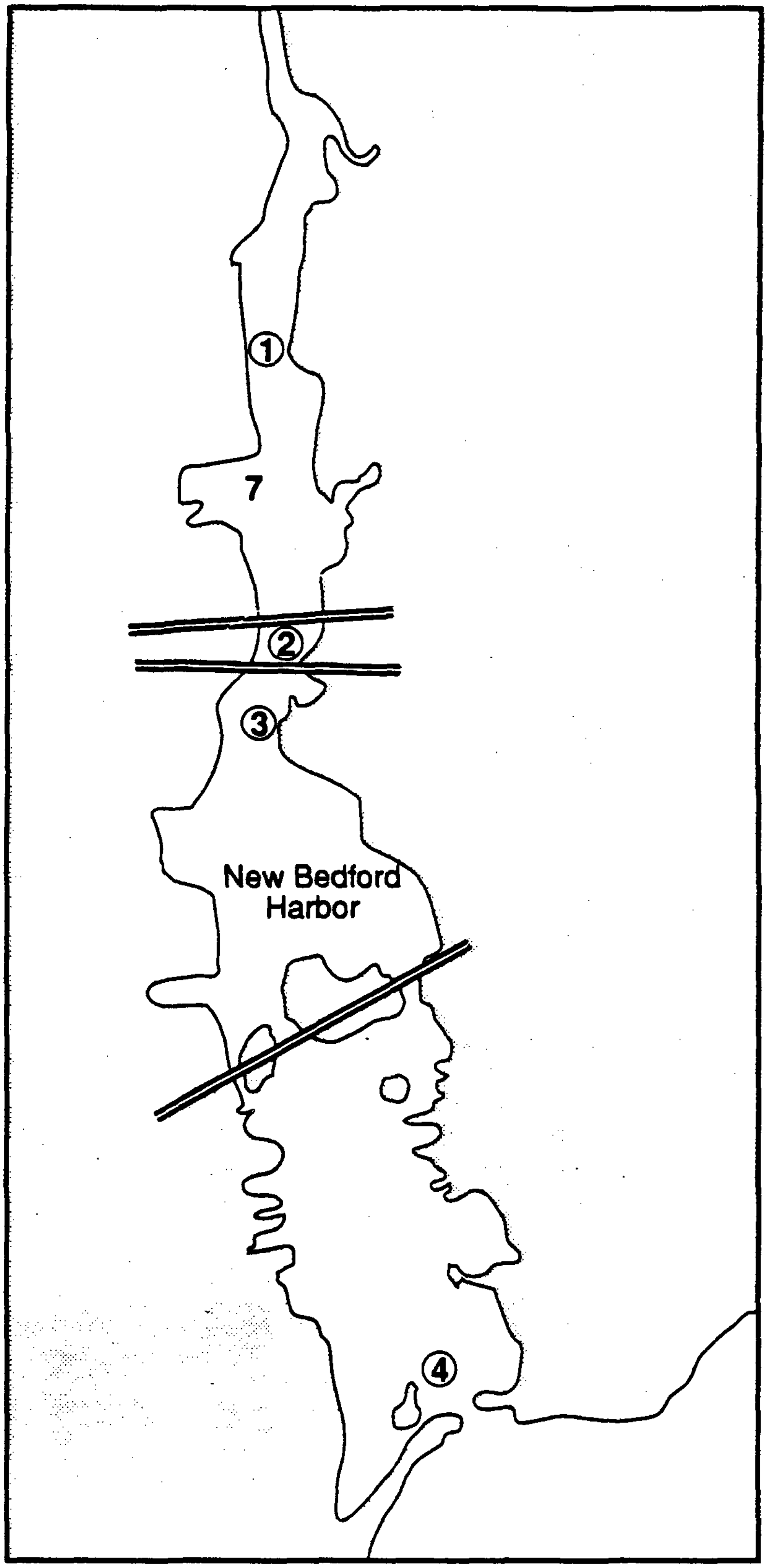

Figure 12 Locations of ERLN
Operational Monitoring Stations

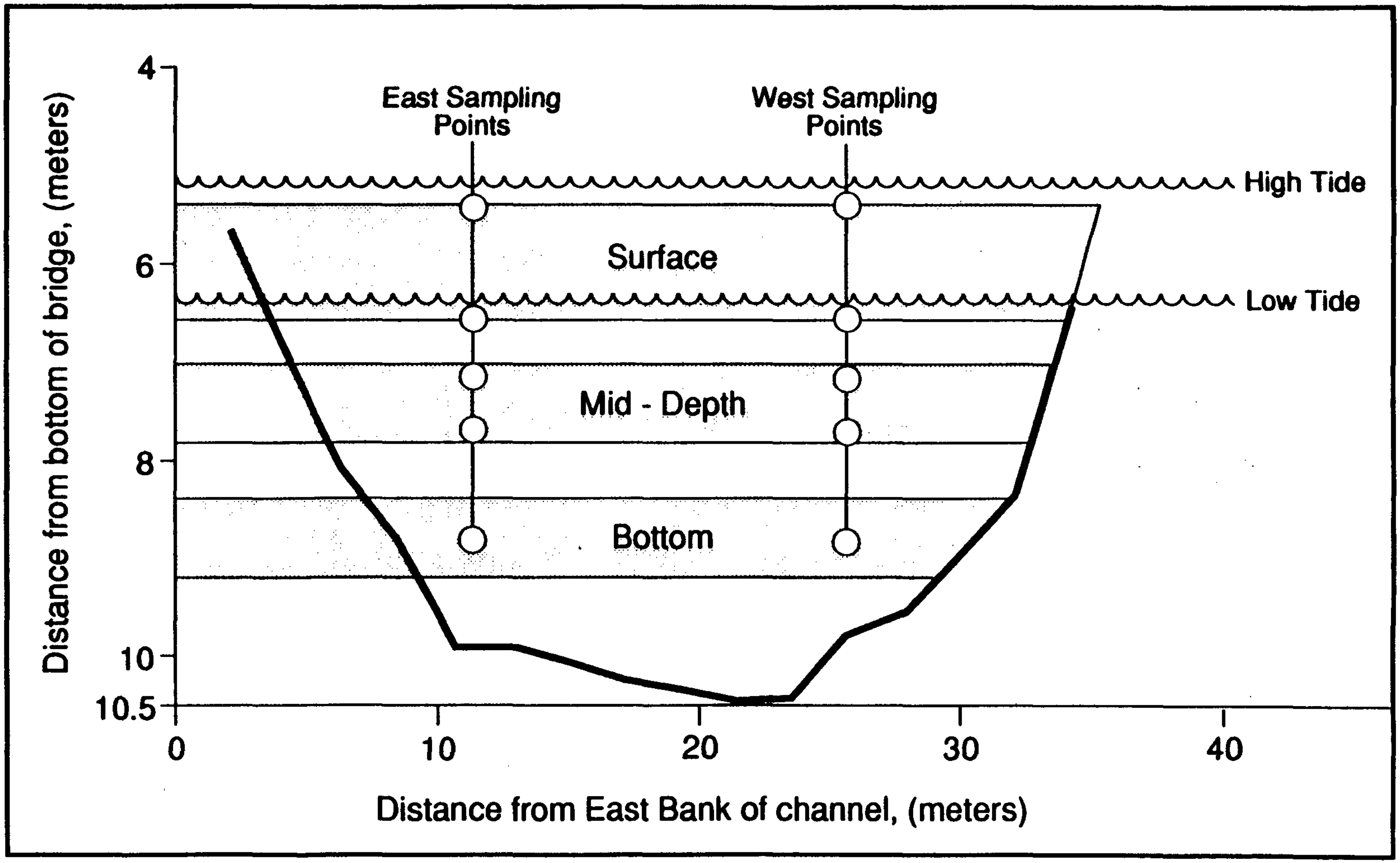

Figure 13 Channel bottom profile, (Coggeshall St. Bridge) at ERLN Station 2 with approximate sampling locations

The results of these measurement showed the harbor to be hydrodynamically very complex. The seawater temperature varied between 18.5°C and 23.5°C during the pre-operational monitoring. The salinity ranged from 24 ppt to 33 ppt. The tidal fluctuation was approximately 1.6 m. The TSS were 6.4 -10.2 mg/l. at station 2 and 4.4 -7.9 mg/l. at station 4. The whole water total PCBs averaged 0.607 ug/l. for station 2 ebb tide and averaged 0.114 ug/l. for station 4 ebb tide. Cd, Cu, and Pb averaged 0.20 ug/l., 3.4 ug/l., 6.5 ug/l. (station 2) and 0.11 ug/l., 2.3 ug/l., 2.9 ug/l. (station 4) respectively.

Receiving water toxicity was evaluated using 5 testing methods. These tests were selected and designed by ERLN and are described in detail in Standard Methods (1985), except for the mysid tests which will be in the next Standard Methods (1989). The following test were performed:

Arbacia punctulata (sea urchin) sperm cell fertilization test
Champia parvula (red algae) reproduction test
Cyprinodon variegatus (sheepshead minnow) growth and survival tests
Mysidopsis bahia (mysid) growth and reproduction tests
Mytilus edulis (mussel) scope for growth (SFG); and uptake of PCBs and metals

No environmentally significant toxicity effects were detected by the *A. punctulata* sperm cell test, *C. parvula* reproduction test, *C.variegatus* growth and survival tests, *M. bahia* growth test. The *M. bahia* test had significant mortality at station 2. The *M. edulis* SFG test indicated an inverse relationship with PCB levels in the water column and mussel tissues.

DECISION CRITERIA

Regulatory personnel were concerned over the potential for contaminant release due to the experimental nature of the pilot project and the fact that no known real time field data existed from a site with similar conditions to New Bedford. The main concern was that the proposed dredging and disposal activities may release an unacceptable level of contaminants, which would worsen the existing poor water quality. It was decided to develop a monitoring protocol with a relatively short analyses time (within 24 hrs) to allow regulatory personnel (state and federal) an opportunity to have input into the daily operation of the project. The decision criteria were based on data from the pre-operational (background) monitoring and were intended to aid the decision makers in: limiting transport of contaminants from the upper estuary to the lower harbor, preventing excesssive mortalities of marine organisms below the upper estuary, and limiting sublethal biological effects. The Coggeshall Street Bridge station (station 2) and the hurricane barrier station (station 4) were the focal decision criteria monitoring points.

The decision criteria were a statistical comparison of background chemical and biological parameters with daily operational measurements which if exceeded, required a decision to be made by committee regarding the suspension, continuation and/or modification of operations. The decision criteria represented a statistically significant increase in: total PCBs, Cd, Cu, Pb, in the water column and unsuccessful *A. punctulata* sperm cell fertilization (for 24 hrs) and acute and chronic effects for the other test organisms (for >8 days) over background conditions. The decision criteria committee chaired by EPA, with representatives from ERLN, the Massachusetts Office of Coastal Zone Management (MACZM), and Department of Environmental Quality Engineering (DEQE) and the NED reviewed the monitoring data daily and made decisions regarding ongoing pilot study operations. The committee did not have to meet during the operational period of the project. The decision criteria was exceeded on several occasions and these events were related to either weather conditions or obvious operational problems which were promptly changed.

PRELIMINARY SEDIMENT SAMPLING

The sediment from within the dredging areas was sampled prior to the start of the pilot study and characterized both physically and chemically. Six sediment cores were taken from each area and split into samples representing six horizons (0-0.5', 0.5'-1.0',1.0'-1.5', 1.5'-2.0, and 2.5'-3.0'). Physical and chemical parameters measured on these samples included:

- water content and specific gravity
- Atterberg limits and grain size
- PCB levels
- heavy metals (Cd, Cu, Pb)
- elutriate tests (standard and modified)
- *Ampelisca abdita* toxicity test

The results of these analyses indicated moderate to high levels of pollution in the cove and that the proposed dredging and disposal activities could be undertaken without significantly effecting the existing water quality of the upper estuary. These data are presented in Appendix 5.

CONFINED DISPOSAL FACILITY (CDF)

Three potential contaminant release pathways associated with the CDF were identified and monitored during dredging and disposal to this facility. They were: the facility effluent discharge into the cove, seepage and leachate through the dike and bottom of the site, and volatilization over the surface of the 2 cells. The following gives more detail of monitoring associated with each pathway.

The CDF was divided into 2 cells with primary settling taking place in the first cell and additional settling in the second. An attempt to chemically assist clarification in the second cell took place during some of the discharge time. The effluent passing over the weir separating the primary and secondary cells and effluent being discharged from the facility were sampled hourly over varying daily periods. The effluent at the weir was sampled on 19 days and the effluent at the facility's discharge was sampled on 15 days. Each hourly sample was analyzed for total suspended solids with 10 daily composites from each location being analyzed for the following:

- total suspended solids (TSS)
- whole water and filterable PCBs
- Cd, Cu, and Pb on 50% of samples
- TOC on 10% of samples
- A. punctulata (sea urchin) sperm cell test
- 2 &7 day toxicity tests on effluent

The TSS ranged from 8.48-577.4 mg/l. with an average of 80.1 mg/l. (sd. 63.4). The PCB levels (filtered water component) averaged 6.4 mg/l. (sd. 5.7) with a range of 0.1-19.2 mg/l. The toxicity testing showed no significant effects related to disposal operations. At one point polymer was added to the water in the second cell as an experiment to reduce TSS levels in the effluent. This polymer was extremely toxic to the test organisms selected for this dredging and disposal monitoring.

To monitor site seepage seven wells were installed in and around the CDF (Figure 11) see page 34. The wells were sampled on three occasions prior to the placement of dredged material within the facility to determine the background condition. They were then sampled three times per week while the CDF was being filled and once a week for four weeks after the facility was filled. The wells will continue to be sampled to obtain long term monitoring data. Samples were analyzed for PCB, TOC (10% of samples), pH, salinity, and Cd, Cu, Pb (50% of samples). These data are not available. They will be incorporated with the post operational data and presented in an updated version of this report.

AIR MONITORING

Six polyurethane filters (PUF) samplers and two total particulate samplers were employed at 5 monitoring stations. One station employed 2 PUF and 2 total particulate samplers, collocated for quality assurance. Figure 3 on page 5 shows the locations of the samplers. The local climatology of the area indicates a predominance of wind having a northwest through southwest component (2). However, the seasonal variability associated with the proposed length of the program coupled with the ocean location of the site and inherent variability of the wind (i.e. sea-breezes) made the siting of samplers based on climatological data difficult. Therefore, the sampling locations were selected with emphasis on siting the stations as near to the potential sources of contaminants as feasibly possible.

Real-time odor and organic vapor monitoring occurred on days when particulate/PCB sampling took place. During daily particulate/PCB sampler set-up, initial odor H2S, and organic vapor levels were measured at each of the 5 stations. During the day, the follow up hydrogen sulfide (H_2S) and organic vapor readings were taken at each station during particulate/PCB sampler quality assurance flow checks. Since all compass points were covered in the 5 station configuration, one of the stations was upwind and one downwind of dredging activities. This allowed for an evaluation of source odor and organic vapor emissions from dredging and CDF/CAD operations. This data will be presented in a report being prepared by Ebasco Services Inc. and will be summarized in an updated version of this report.

METEOROLOGICAL DATA

A meteorological station was located at station 1 as shown in Figure 3 on page 5. This station was established to evaluate potential contaminant transport and conditions conducive to particulate release. Wind data provided guidance as to which air quality monitors were downwind. All data was recorded onto strip chart paper, which served as a permanent record of meteorological conditions. The strip chart data will be reduced and entered into a microcomputer for compilation and quality assurance checks.

The meteorological instrumentation was installed on a 10 meter tower. The strip chart recorder was located at the base of the tower in a location that allowed for easy access to collect meteorological data.

The following parameters were collected:

wind speed (assess dilution and transport)
wind direction (assess transport)
sigma theta of wind direction (indicates atmospheric stability and particulate plume dispersion)
temperature (access CDF drying)
solar radiation (access CDF drying)
precipitation (access CDF wetting)

These data are presently not available. They will be published with the air monitoring data.

CONTAINED AQUATIC DISPOSAL (CAD)

This evaluation was divided into 2 phases. The first phase involved monitoring the operation while contaminated sediment was being pumped into the CAD cell. An array of stations located around the discharge point were sampled while the operation was ongoing. This was undertaken on 3 separate days. These samples were taken at mid-depth and were analyzed for TSS. In addition composite samples were taken representing a cross sectional area of the cove mid-way through the days dredging and analyzed for TSS, PCBs, and heavy metals (50% of samples). These results are presented in Appendix 3.

The second phase will involve sampling of the CAD cell to determine if a cap has been effectively placed and if contaminants are migrating into the cap material. Sediment cores will be taken over a period of time and compared to each other to make rate determinations. These cores will be analyzed for PCBs, heavy metals, and *A. abdita* toxicity over 6 horizons.

DREDGE TYPES AND DISPOSAL TECHNIQUES

This phase of the program focused on the contaminant release pathways associated with the dredging operation and on the effectiveness of the dredging operation in removing the contaminants.

Removal Efficiency: A grid of sediment core sampling stations were located within each area that had been dredged by each dredge type. Each station was randomly assigned a number from either 1-4 or 1-8 depending on the size of the area. A sample representing the top 3 inches of sediment was taken at each location and added to the appropriate composite sample. These composite samples were then analyzed for PCBs and *A. abdita* toxicity. These data will then be used in determining the effectiveness of each dredge to remove contaminated sediment.

Plume and Dredgehead Sampling: These monitoring efforts were carried out to determine the development and extent of suspended sediment and contaminant plumes generated at the point of dredging. A multi port sampling device was installed on each dredge to allow for six locations around the dredge head to be sampled at once. Samples were taken at 15 min. intervals during operating periods.

Each individual sample was analyzed for TSS. Composite samples were taking randomly from the mid depth ports and analyzed for TSS, PCBs, and heavy metals (Cd, Cu, Pb).

An array of stations located around the dredge were sampled hourly while the equipment was operating to assess any plume development. These efforts were undertaken on the first 3 days of dredging operations for each dredge. These samples were taken at mid-depth and were analyzed for TSS. Composite samples were collected representing a cross sectional area of the cove mid-way through the days dredging activities. These samples were analyzed for TSS, PCBs, and heavy metals (50% of samples).

Far Field Water Quality: Samples were taken at the 4 ERLN stations. The sampling procedures were the same as those of the preliminary monitoring program to allow for comparison. This sampling effort was conducted just prior to the start of each distinct phase of the pilot study(e.g. CDF construction, dredging) and during the first 4 days of each operation. The composite samples from the 4 stations were analyzed in the same manner as during the preliminary sampling.

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NOTES

APPENDIX 1

Dredges

June 1989 Interim Report

APPENDIX 1 - DREDGES

Three hydraulic pipeline dredges were evaluated during the pilot study. These included a cutterhead dredge, horizontal auger dredge and a modified version of the cutterhead called a Matchbox dredge. They were selected for use in New Bedford based on performance in the following critical areas:

- Ability to minimize resuspension of sediment while operating.
- Ability to remove the layer of contaminated sediment while minimizing overdredging.
- Ability to work in shallow water.

These dredges all operate on the principal of the centrifugal water pump. A vacuum is created on the intake side of the pump and ambient pressure acts to force water and sediment through the suction pipe. The dredged materials are then hydraulically pumped via pipeline to the disposal site.

This appendix provides a detailed discussion of dredge operations during the pilot study with emphasis on the following factors:

- Operating procedures and production rates
- Dredging effectiveness and efficiency
- Sediment resuspension and contaminant release
- Sediment and contaminant transport

Operating procedures and production rates: The dredges were all operated to minimize sediment resuspension while removing only the top two feet of sediment. Each dredge's operating parameters were adjusted at the start until a combination that appeared to be meeting the project goals was achieved.

Dredging effectiveness and efficiency: The project goal was to minimize the level of contamination in the remaining sediment while removing less than two feet of material.

Sediment resuspension and contaminant release: For the Engineering Feasibility Study, a sediment resuspension rate of 40 grams per second was used with elutriate test results to estimate the contaminant release at the operating dredge. During the pilot study a sampling apparatus was installed on each dredge to sample the water column immediately adjacent to the operating dredgehead. The results of this sampling effort were used along with the dredge operating procedures to develop a sediment resuspension rate at the dredgehead. Several samples per day were analyzed for PCBs and metals, and this data was then compared to the elutriate test results. This data will improve our ability to estimate contaminant release from an operating dredge at other locations within the upper estuary.

Sediment and contaminant transport: Numerical sediment transport modeling carried out during the EFS derived escape probabilities for resuspended sediment. Generally 52-76 percent of a small grain size fraction of suspended sediment escaped from the immediate vicinity of the dredging. These escape probabilities were used with the contaminant release estimate at the dredge to estimate the flux of contaminants escaping from the upper estuary during dredging. An array of sampling stations was established around the dredging areas and sampled hourly while the dredges were operating. The purpose of this effort was to detect any plume of resuspended sediment and contaminants moving away from the operation. This information could then be compared with estimates based on the sediment transport evaluations.

CUTTERHEAD DREDGE

This is the most common dredge type in use in the United States today. The name refers to the rotating basket that is fitted to the suction head of the dredge. The dredge size is determined by the discharge diameter of the dredge pump. An Ellicott 370 Dragon Series was used during the pilot study. It has a 10-inch diameter discharge on the dredge pump which was fitted to the 8-inch diameter pipeline used by all the dredges during the study. The physical dimensions of the equipment are shown in Table 21.

The dredge is moved into position by a work boat and is held stable by a stern spud which is driven into the sediment. Anchor cables set at a distance from the dredge are used to control the swing of the cutterhead. The dredging operation consists of the side to side movement (swing) of the rotating cutterhead. (Figure 1-1). The dredge is advanced by lowering a second stern spud at the end of a lateral swing. The first spud is then raised and the dredge advances and pivots on the lowered spud. This walking action allows the dredge to advance with a zig-zag motion (7).

Operating procedures and production rates: The dredge's operating procedures are listed below:

Swing Speed: This represents side to side movement of the dredge. It was kept steady and as slow as allowable.

Cutterhead Rotation: 50% of maximum (approx. 20 RPM)

Depth of Cut: 2 feet

Width of Cut: 60 feet

Dredge Pump: Run at maximum RPM

This dredge was operated in five distinct work areas which are discussed separately in the following paragraphs.

Dredging area 1 (Figure 1-2): This area was 125 feet by 170 feet and the dredge made only one pass over the area to remove the contaminated sediment. The following table summarizes operations.

	Date	Operating Time (hrs)	Downtime (hrs)
	11-21	1.00	-
	11-22	1.87	-
	11-23	2.83	0.58
	11-25	3.18	2.35
	11-26	3.33	1.50
	11-27	4.22	0.92
	11-28	5.75	1.00
	11-29	3.45	1.13
Totals:	8 days	25.63 hours	7.48 hours

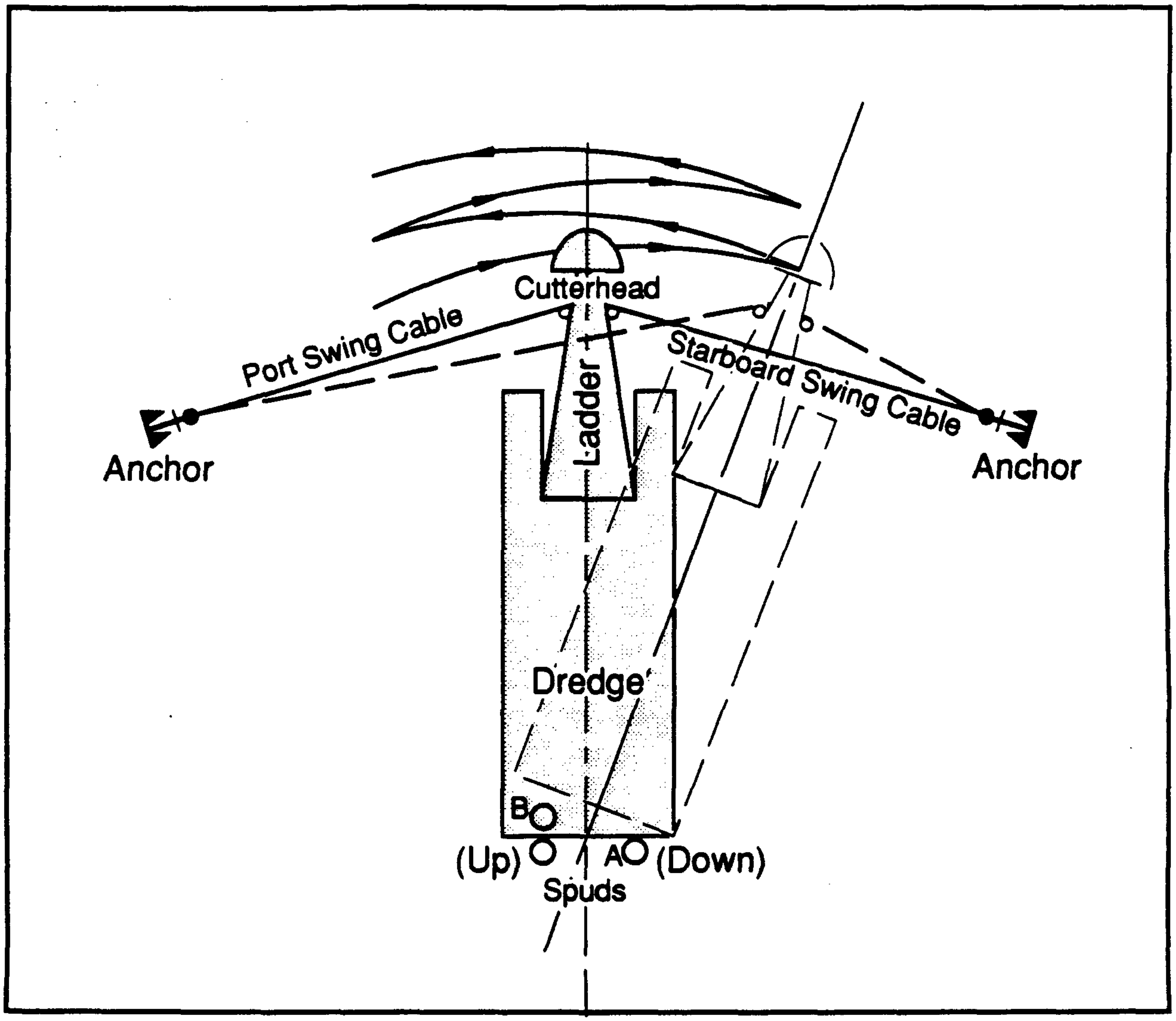


Figure 1-1 Operation of a Cutterhead & Matchbox Dredge (view from above)

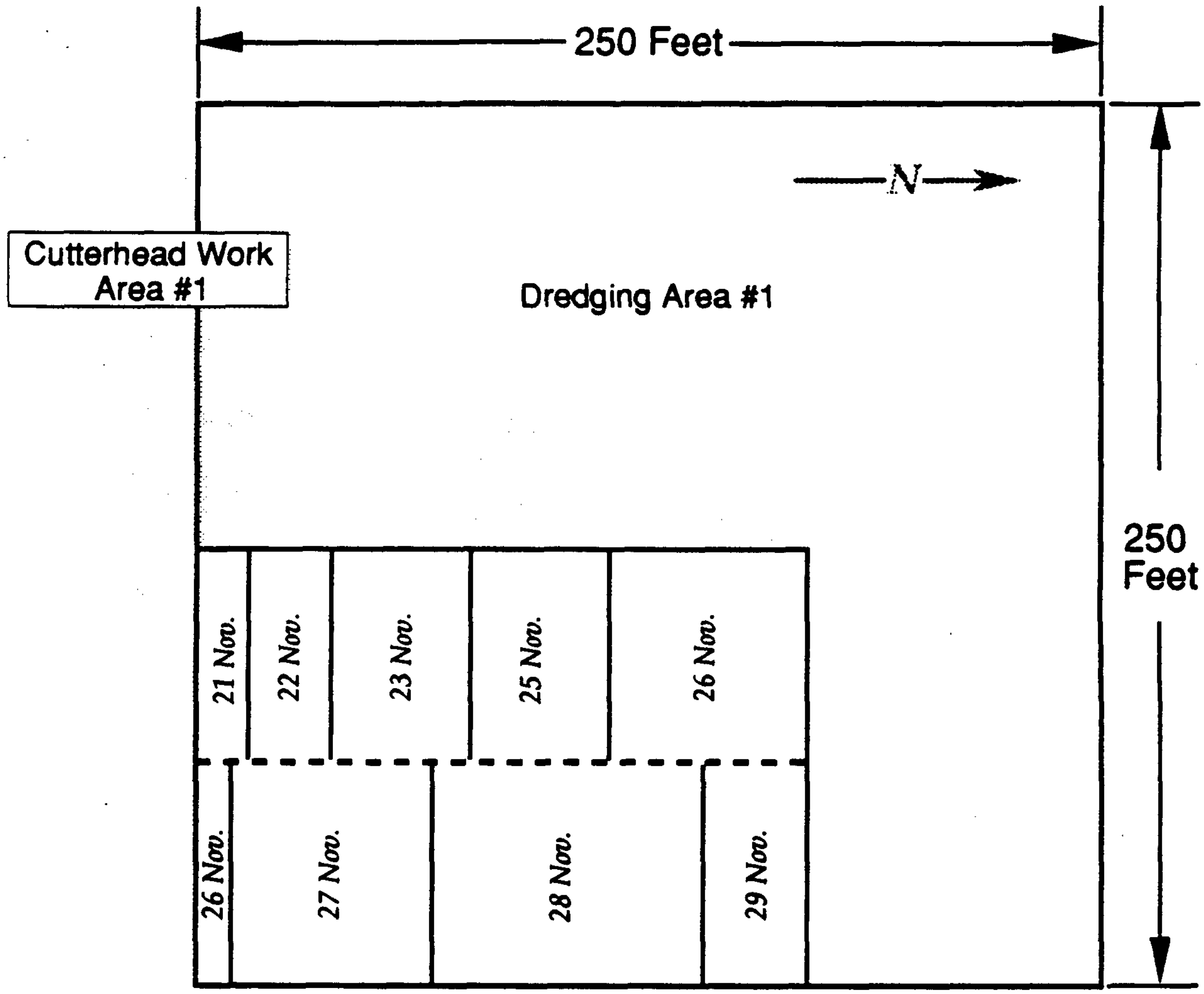


Figure 1-2 Cutterhead Work Area #1

1. A considerable amount of debris was encountered in dredging area 1. The debris plugged the dredge's suction line and caused most of the downtime.

2. Total quantity of material removed: 951.0 cubic yards

3. Production rate: 37.0 cubic yards/hour

4. Average flowrate into CDF: 1891.0 gallons/min

5. Dredge slurry total suspended solids concentration: 37.9 g/liter

6. Rate of advance 13.3 feet /hour

Dredging area 1- work area #2 (Figure 1-3): This area was 90 feet by 95 feet and was a portion of dredging area 1 in which the Matchbox dredge was originally scheduled to work . The cutterhead made only one pass over this area to remove the contaminated sediment. The second cut through the area was only 30 feet in width. The following table summarizes operations:

	Date	Operating Time (hrs)	Downtime (hrs)
	12-16	2.25	0.08
	12-17	3.67	0.08
	12-18	3.83	0.58
	12-19	2.97	0.17
Totals:	4 days	12.72 hours	0.91 hours

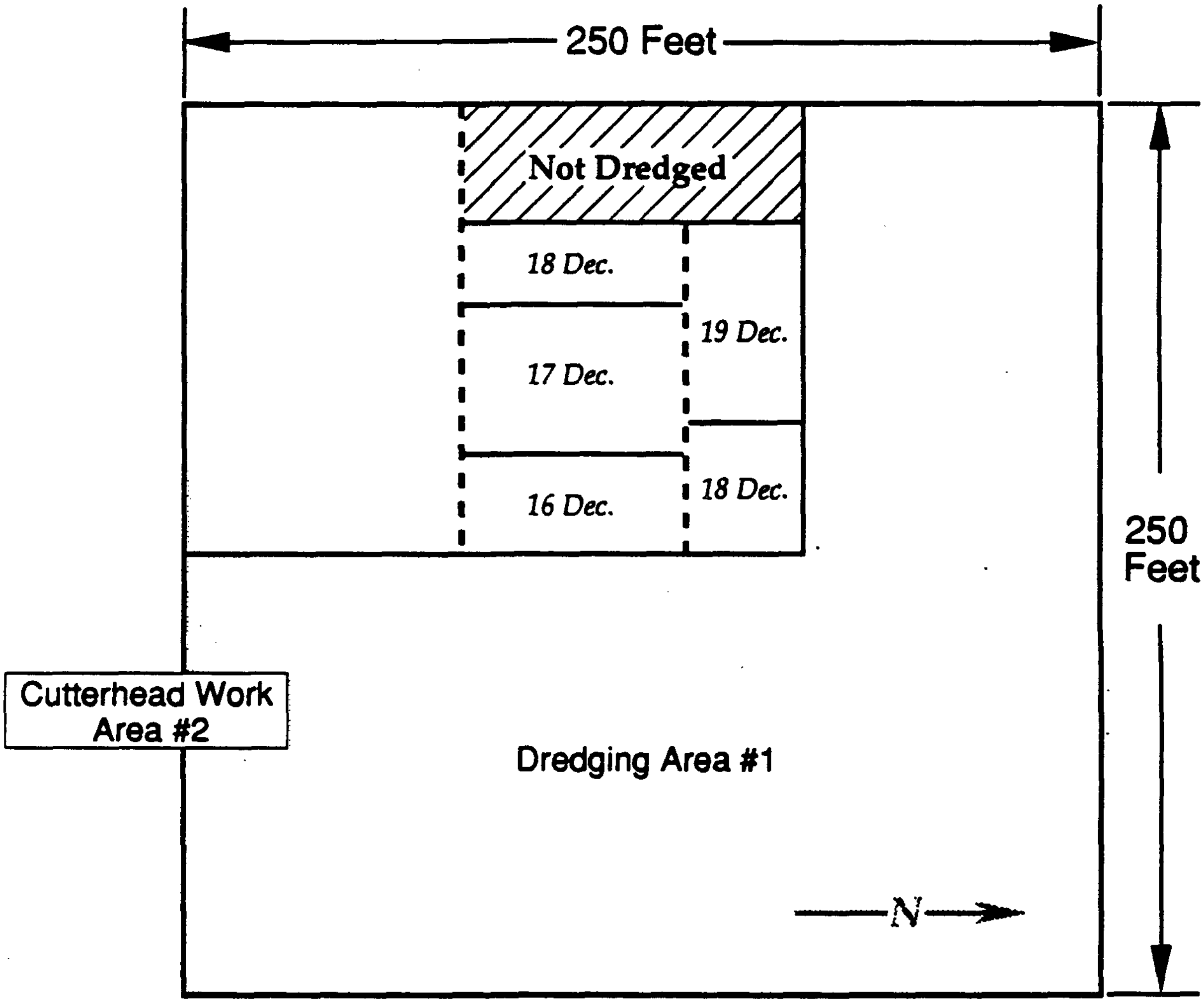
1. Total quantity of material removed: 462.0 cubic yards

2. Production rate: 36.0 cubic yard per hour

3. Average flowrate into CDF: 2122.0 GPM

4. Dredge slurry total suspended solids concentration: 32.3 grams/liter

5. Rate of advance: first cut: 11.7 feet/hour; second cut: 17.6 feet/hour



Scale: 1"= 50'

Figure 1-3 Cutterhead Work Area #2

Dredging Area 2 - work area #3 (Figure 1-4): This area was 90 feet by 60 feet and the dredge made two passes over the area to remove the contaminated sediment. The material from this area was placed in the Contained Aquatic Disposal (CAD) cell. The following table summarized operations.

	Date	Operating Time (hrs)	Downtime (hrs)
	1-07	0.67	-
	1-08	4.25	0.42
	1-18	3.50	0.67
	1-19	3.25	0.25
	1-20	3.00	-
Totals:	5 days	14.67 hours	1.34 hours

1. Total quantity of material removed: 233.0 cubic yards

2. Production rate: 15.9 cubic yards/hr

   This lower production rate results from the dredge making two passes over the area. Very little material was removed on the second pass as the dredge attempted to remove just the surface layer of sediment.

3. Rate of advance: First pass 8.2 feet/hour; Second pass 24.5 feet/hour

   On the second pass the swing speed was increased as the dredge attempted to remove just the surface layer of sediment.

Dredging area 1 (Clean Material): This 180 foot by 150 foot area was dredged to create the Contained Aquatic Disposal (CAD) cell with the removed material being used to cap the Confined Disposal Facility (CDF). The dredge was operated differently in this area as the focus changed from minimizing resuspension and overdredging to moving as much material as possible. The following table summarizes operations:

	12-20	3.33	0.47
	12-21	4.17	0.38
	12-22	3.67	0.42
	12-23	4.37	0.55
	12-27	4.22	0.45
	12-28	5.77	0.40
	12-29	5.00	0.50
	12-30	6.00	0.42
	12-31	2.42	0.42
	1-03	5.50	-
	1-04	7.05	1.28
Totals:	11 days	51.50 hours	5.29 hours

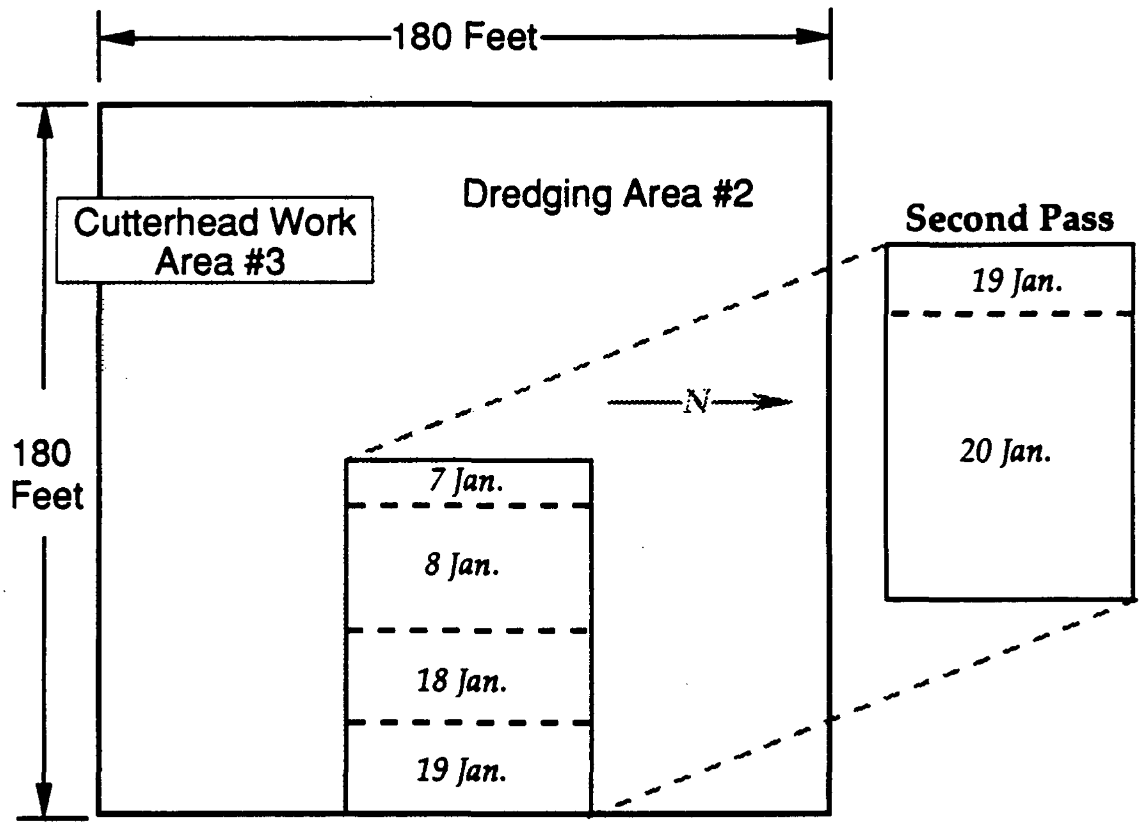


Figure 1-4 Cutterhead Work Area #3

1. Total quantity of material removed: 3929.0 cubic yards

2. Production rate: 76.3 cubic yds/hr

3. Dredge slurry total suspended solids concentration: 154.4 g/liter

Dredging Effectiveness and Efficiency: The dredge made only one pass over dredging area 1 which resulted in an average depth of cut of 1.5 feet. PCB levels in the remaining sediment averaged 84 ppm. The dredge made two passes over area 2 which resulted in an average depth of cut of 1.1 feet. PCB levels in the remaining sediment averaged less than 10 ppm. This indicates that two passes of the dredge are necessary to reduce the contaminant level to an acceptable level. The second pass of the dredge resulted in the removal of very little additional material, as the dredge attempted to just skim the surface. Figure 1-5 shows typical cross sections of the cutterhead dredge area.

Sediment Resuspension and Contaminant Release: A sampling device was attached to the dredge adjacent to the dredgehead and the results of this sampling effort were used with the dredge swing speed and the water depth to develop a generation rate for resuspended sediment. Dredgehead sampling was conducted on 5 days while the dredge was operating in contaminated sediment. The results are summarized below with the data used in deriving these values contained in Table 1.

Date	Range of Resuspension Rates (grams/sec)	Average Resuspension Rate (grams/sec)
11-21	35.7 - 9.0	16.1
11-23	7.8 - 3.5	5.4
11-25	14.6 - 2.6	7.2
12-17	34.9 - 5.1	11.3
1-8	75.9 - 26.7	46.6

The cutterhead dredge proved to be the most effective in minimizing the resuspension of sediment.

Composite samples taken from the dredgehead sampler were analyzed for PCBs with the results shown in Tables 2 and 5. This data is then compared to the standard elutriate test data shown in Table 6. The results indicate that the elutriate test conservatively estimates the contaminant levels in the water column adjacent to the operating dredgehead.

Sediment and Contaminant Transport: Tables 7 - 9 show the results of both dredgehead and plume sampling during the dredges first three days of operation. Figure 1-6 shows the location of the plume sampling stations. A well defined plume of resuspended material never developed and only minor increases above background were detected 500 feet from the operating dredge.

Composite samples were prepared from a combination of samples taken at the individual stations. (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals. The results are shown in Tables 3 and 4. The contaminant levels are within the range that naturally occurs in the cove. This data and the data on resuspended sediment indicates that movement of contaminants away from the point of dredging is likely to be less than estimates based on the sediment transport model used during the EFS.

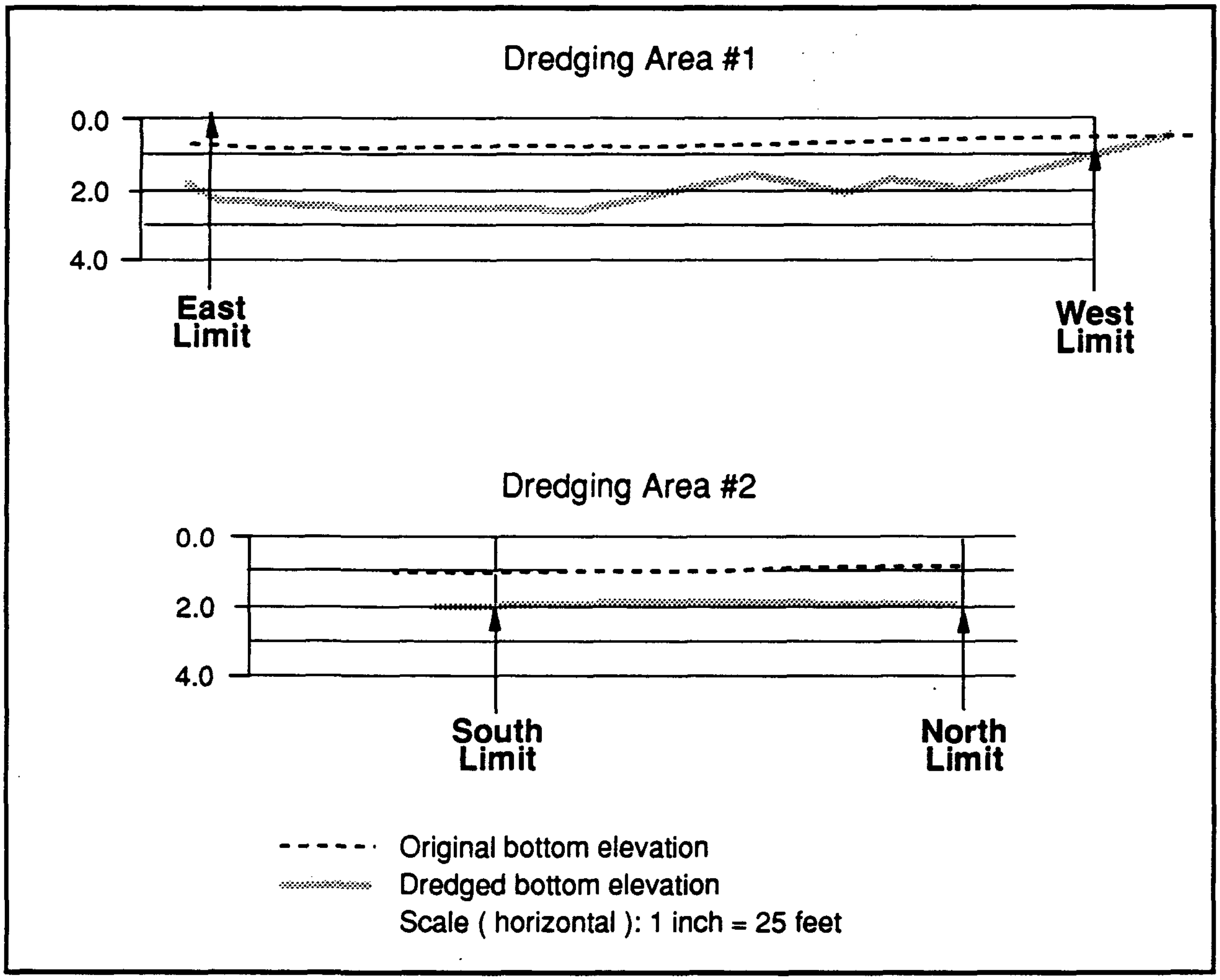


Figure 1-5 Typical cross section of a Cutterhead Dredging Area

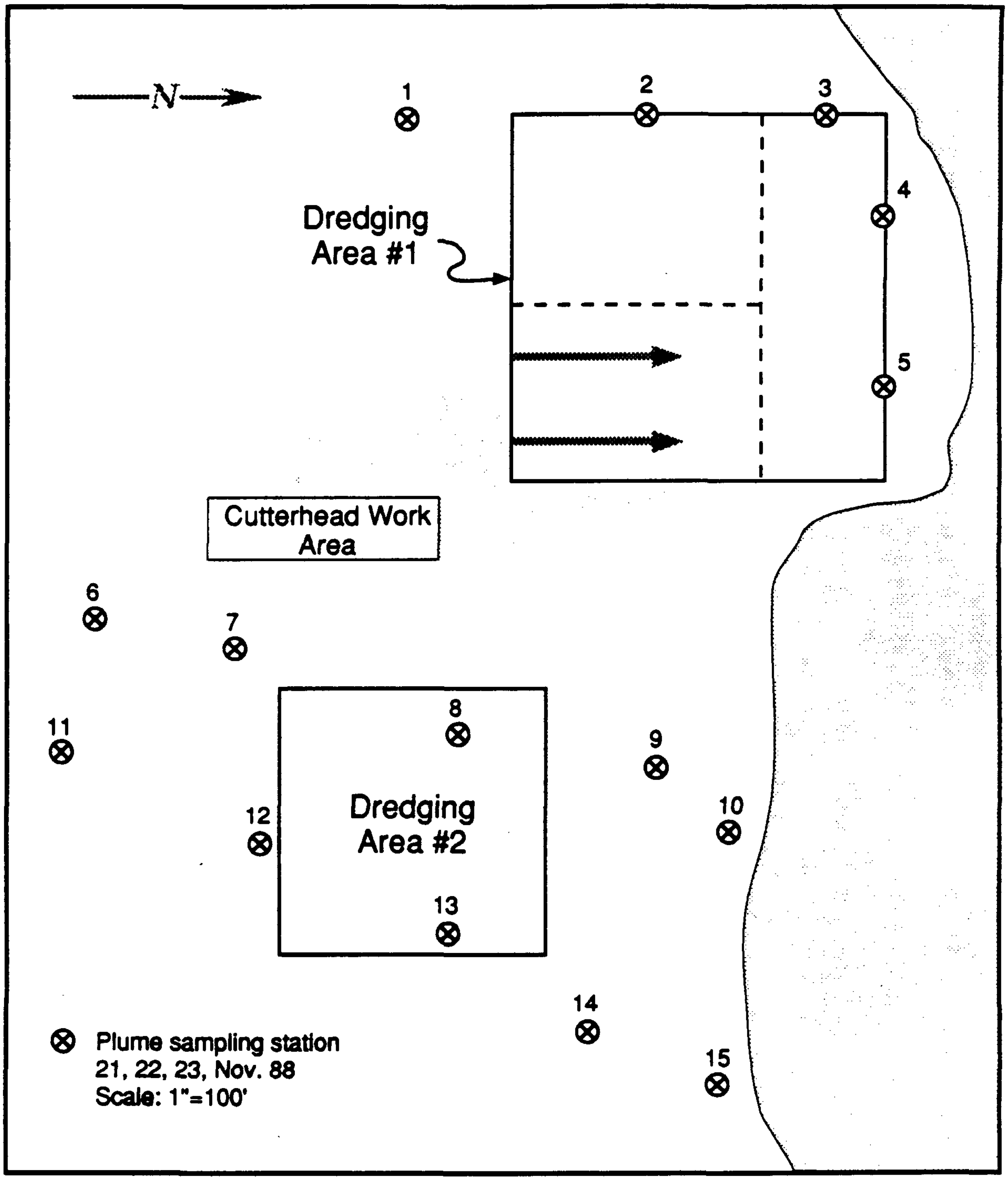


Figure 1-6 Plume Sampling Stations-Cutterhead Work Area

Problems: The only problem encountered with this dredge involved the swing anchors. The soft bottom material would not hold the anchors in place and the slipping anchors resuspended a large plume of sediment. Heavier anchors could not be used because the small work boats could not handle them. The work boats themselves resuspend a considerable amount of sediment while operating in the shallow water. It is recommended that swing anchors be set on shore during future dredging work. This will reduce dredge downtime, sediment resuspension and worker exposure to contaminated sediment.

HORIZONTAL AUGER DREDGE

An Ellicott SP-915 Mudcat dredge was used during the study. This equipment has a horizontal cutterhead equipped with cutter knives and a spiral auger that cuts and moves the material laterally toward the suction located in the center of the auger. Its movement through the water is controlled by winching along a cable system that is anchored to shore (Figures 1-7). The dredgehead is surrounded by a mudshield designed to minimize turbidity by entrapping suspended sediment. This dredge makes a cut eight feet wide and up to 18 inches deep. The physical dimensions of the equipment are shown in Table 22.

Operating Procedures and Production Rates: The dredge operating procedures are listed below:

Rate of Advance: 15 feet per minute

Cutterhead/Auger Rotation: Full Speed

Depth of cut: Six inches per pass

Number of passes: Four - two in the forward direction and two in reverse

Dredge pump: Run at maximum RPM

This dredge was operated in two distinct work areas which are discussed separately in the following paragraphs.

Dredging area 1 (Figure1-8): This area was 80 feet by 250 feet. Several different operating procedures were experimented with over the first two days of operation prior to settling on four passes per cut. The following table summarizes operations:

	Date	Operating Time (hrs)	Downtime (hrs)
	12-1	0.97	0.38
	12-2	1.90	1.60
	12-3	4.25	1.25
	12-4	1.55	1.17
	12-5	3.43	1.93
	12-6	1.68	2.68
Totals:	6 days	13.78 hours	9.01 hours

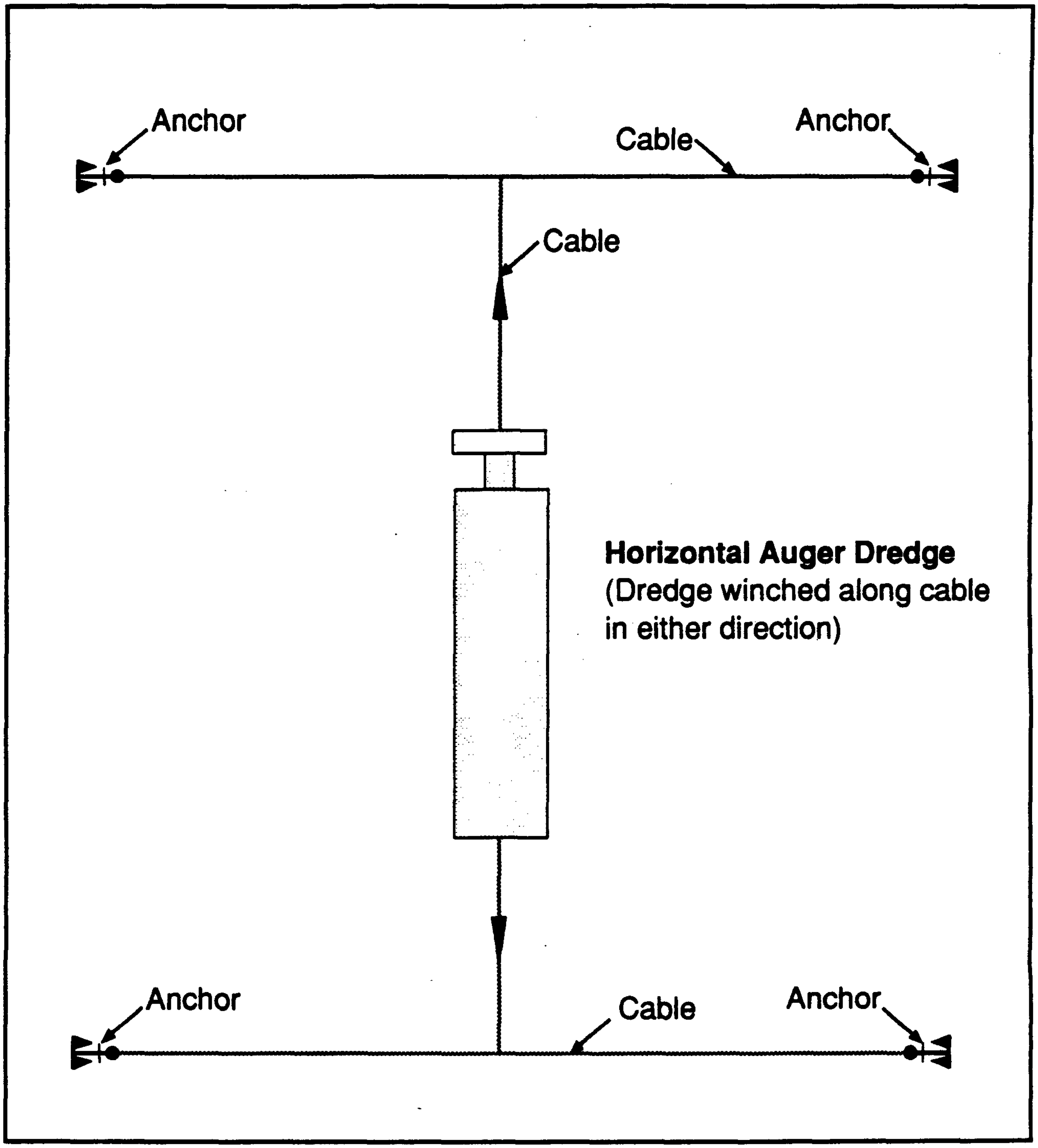
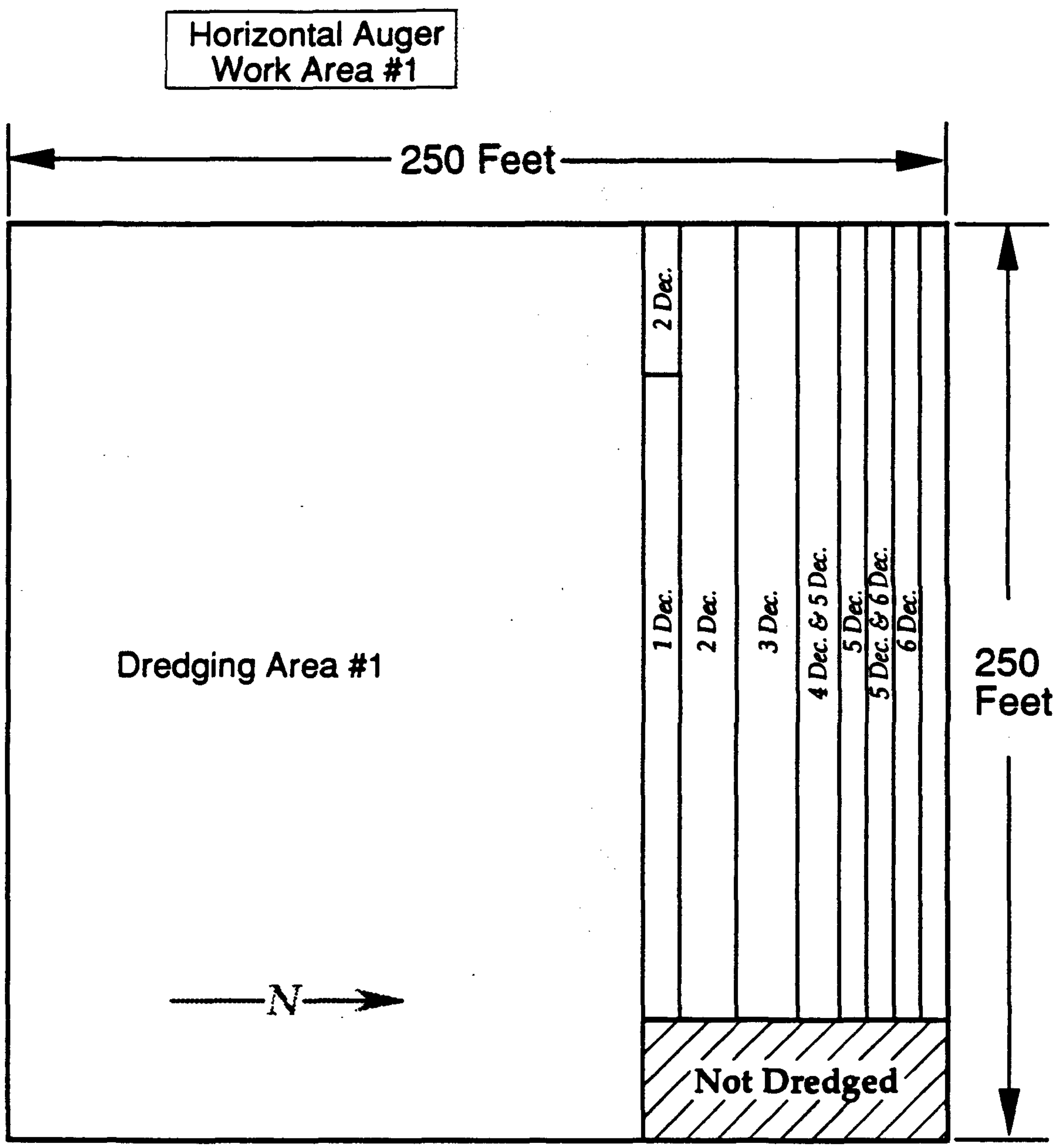


Figure 1-7 Horizontal Auger Dredge operation



Scale: 1"= 50'

Figure 1-8 Horizontal Auger Work Area #1

1. Debris was encountered in this area which contributed to the amount of downtime.

2. Total quantity of material removed: 568.0 cubic yards

3. Production rate: 41.2 cubic yards/hour

4. Average flowrate into CDF: 1709.0 GPM

5. Dredge slurry total suspended solids concentration: 44.8 g/liter

6. Rate of advance: Range: 6.1 to 20.4 feet/min
Average (4 passes per cut): 13.0 feet/min

Dredging area 2: The dredge was operated over two days in this area for the purpose of obtaining additional dredgehead samples. The following table summarizes operations:

	Date	Operating Time (hrs)	Downtime (hrs)
	1-14	0.75	-
	1-15	5.67	1.75
Totals:	2 days	6.42 hours	1.75 hours

1. Total quantity of material removed: 127.0 cubic yards

2. Production rate: 19.8 cubic yards/hour

3. Rate of advance: 9.3 feet/min

Dredging Effectiveness and Efficiency: In dredging area 1 the dredge attempted to remove two feet of contaminated sediment by making four passes over each cut. Two of the passes were made in the forward direction and two in reverse. This resulted in an average depth of cut of 1.0 feet. PCB levels in the remaining sediment averaged 31 ppm. Figure 1-9 shows a typical cross section of the horizontal auger dredge area.

Sediment Resuspension and Contaminant Release: A sampling device was attached to the dredge adjacent to the dredgehead and the results of this sampling effort were used with the water depth and the dredge's rate of advance to develop a generation rate for resuspended sediment. Dredgehead sampling was conducted on 4 days while the dredge was operating in contaminated sediment. The results are summarized below. The data used in deriving these values is contained in Table 10.

Date	Range of Resuspension Rates (grams/sec)	Average Resuspension Rate (grams/sec)
12-2	1136 - 217	690
12-3	541 - 78	187
12-4	680 - 175	245
1-15	926 - 9	213

This dredge produced the highest sediment resuspension of the three.

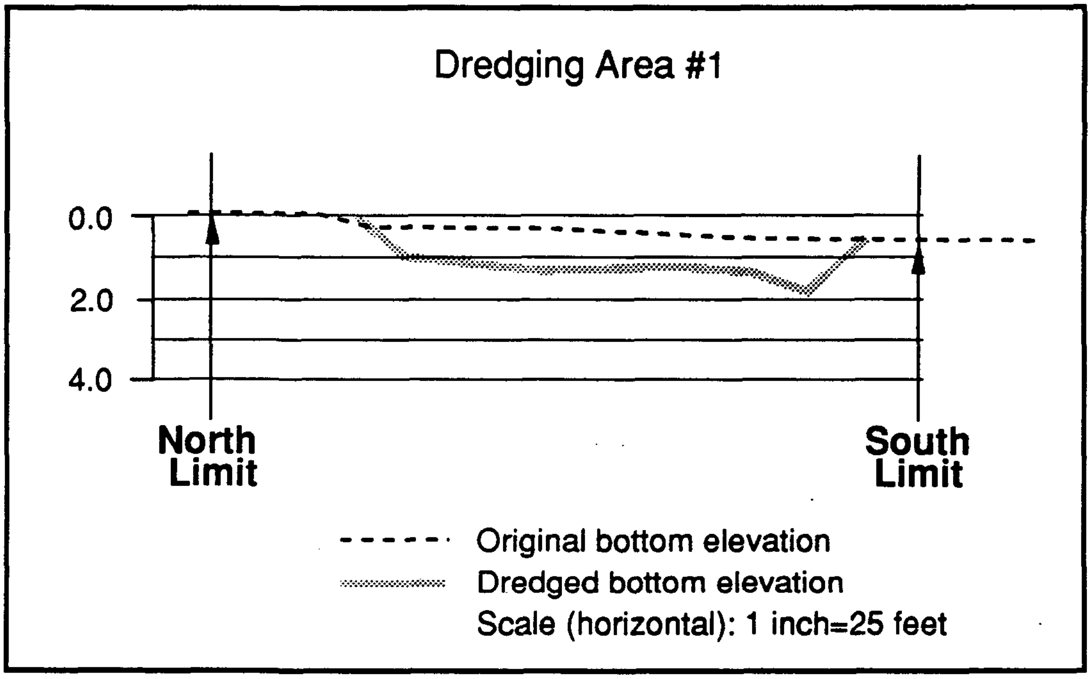


Figure 1-9 Typical cross section of a Horizontal Auger Dredging Area

Composite samples taken from the dredgehead sampler were analyzed for PCBs with the results shown in Tables 11 and 5. This data is then compared to the standard elutriate test data shown on Table 6. While the differences between the dredges are not statistically significant due to the wide distribution of contaminant levels, it is apparent that the horizontal auger dredge was less effective in reducing sediment resuspension and contaminant release at the point of dredging.

Sediment and Contaminant Transport: Tables 12 - 14 show the results of both dredgehead and plume sampling during the dredge's first three days of operation. Figure 1-10 shows the location of the plume sampling stations. A well defined plume of resuspended material never developed and only minor increases above background were detected.

Composite samples were formed from a combination of samples taken at the individual stations (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals. The results are shown on Tables 15 and 4. The contaminant levels are within the range that naturally occurs in the cove and are similar to the levels detected while the other dredges were working. This information is a further indication that the movement of contaminants away from the point of dredging is likely to be less than estimates based on the sediment transport model and elutriate tests.

Problems: The dredge was working in an open area and was susceptible to being blown off line by high winds. This required the operator to constantly adjust the width of his cuts and thereby reduced the production rate.

The dredge's cable system must be anchored in four locations. These locations must be out of the water so personnel can get at them to shift the dredge. This would be a problem in more open areas of the harbor well removed from the shoreline. Additional floating plant would be required or piles would have to be driven in place for use as anchoring points.

MATCHBOX DREDGE

This piece of equipment operates in the same manner as the cutterhead dredge (Figure 1-1 on page 1-3). A special dredgehead which resembles a matchbox replaces the cutterhead on the suction dredge plant. This dredgehead was developed by a Dutch firm and has been used in the Netherlands to dredge contaminated sediment. It is designed to dredge fine grain sediments at near in-situ density and keep resuspension at a minimum. Bean Dredging of New Orleans, Louisiana has proprietary use of the design of this dredgehead in the United States. Bean Dredging was contracted to design, build and install this dredgehead. Because there is no mechanical action at the dredgehead, the Bean plant had to be considerably larger than either the cutterhead or horizontal auger. The equipment had to be transported to New Bedford in sections and assembled on-site. Using a launch ramp constructed adjacent to the south-east corner of the CDF, the plant was floated at high tide into the estuary upstream of the Coggeshall Street Bridge. The physical dimensions of the equipment are shown in Table 23.

Operating Procedures and Production Rates: The dredge operated in both dredging areas 1 and 2. The equipment had numerous mechanical problems while working in area 1 which made it impossible to make a proper evaluation of the dredging operation. The operating procedures shown below are based on dredging in area 2.

Swing Speed: This represents the side to side movement of the dredge. It was kept steady and as slow as allowable.

Depth of Cut: Six inches per swing.

Width of Cut: 60 feet.

Dredge Pump: Run at maximum RPM.

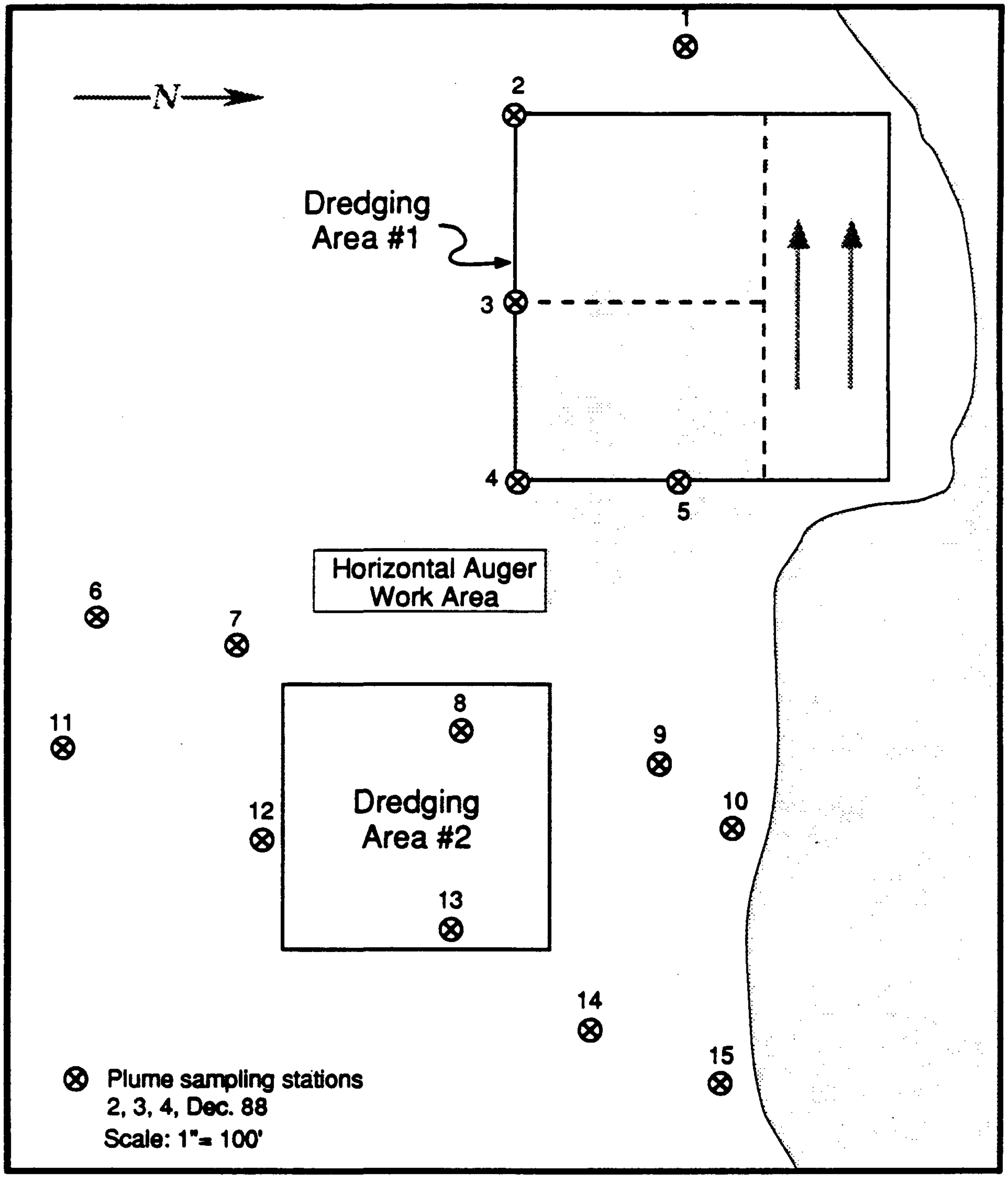


Figure 1-10 Plume Sampling Location-Horizontal Auger Work Area

Work in both dredge areas is discussed separately in the following paragraphs.

Dredging area 1: (Figure1-11) The dredge had numerous mechanical problems while working in this area which required it to be removed prior to completion of work. The dredge completed one pass over a 125 foot long by 60 foot wide area.

	Date	Operating Time (hrs)	Downtime (hrs)
	12-9	0.75	1.30
	12-10	3.00	1.45
	12-11	0.18	-
	12-12	1.40	-
	12-13	2.27	1.13
Totals:	5 days	7.60 hours	3.86 hours

The downtime shown in the above table does not include periods when the dredge was inoperable due to mechanical breakdowns.

1. Debris was encountered in this area which contributed to the amount of downtime.
2. Quantity of material removed: 227.0 cubic yards
3. Production rate: 29.9 cubic yards/hour
4. Average flowrate into CDF: 2300.0 GPM
5. Dredge slurry total suspended solids concentration: 24.4 g/liter
6. Rate of advance: 16.4 feet/hour

Dredging area 2: (Figure 1-12) The dredge was repaired prior to working in this area. The operating procedures discussed earlier in this section were used. The dredge made two passes over this 100 foot long by 60 foot wide area. Six inches of sediment was removed per swing and the dredge made two swings prior to advancing. The dredged material was disposed of in the contained aquatic disposal cell during this period.

	Date	Operating Time (hrs)	Downtime (hrs)
	1-9	1.48	1.18
	1-10	3.78	-
	1-11	4.00	0.33
	1-12	4.17	-
	1-13	1.30	-
Totals:	5 days	14.65 hours	1.51 hours

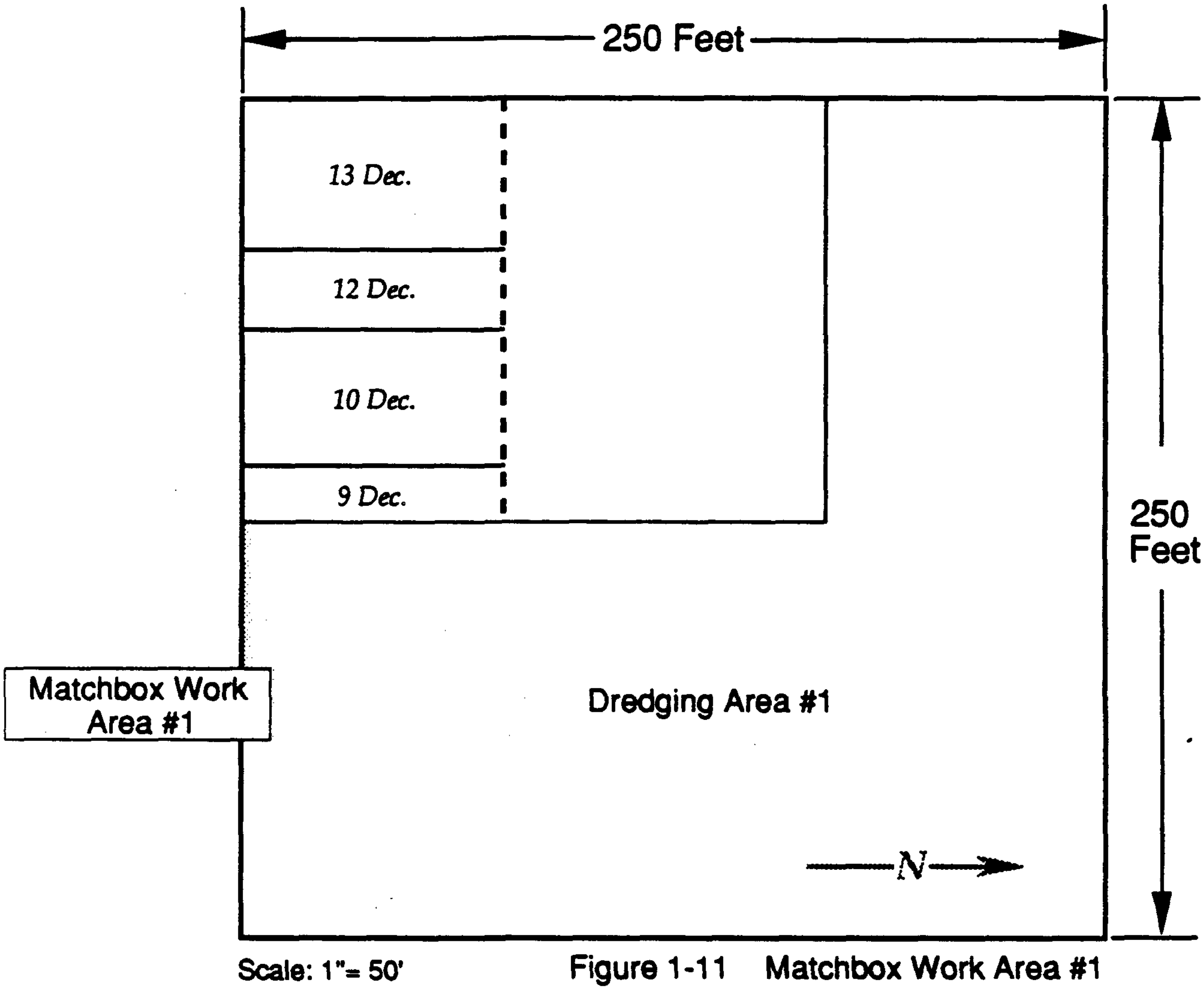


Figure 1-11 Matchbox Work Area #1

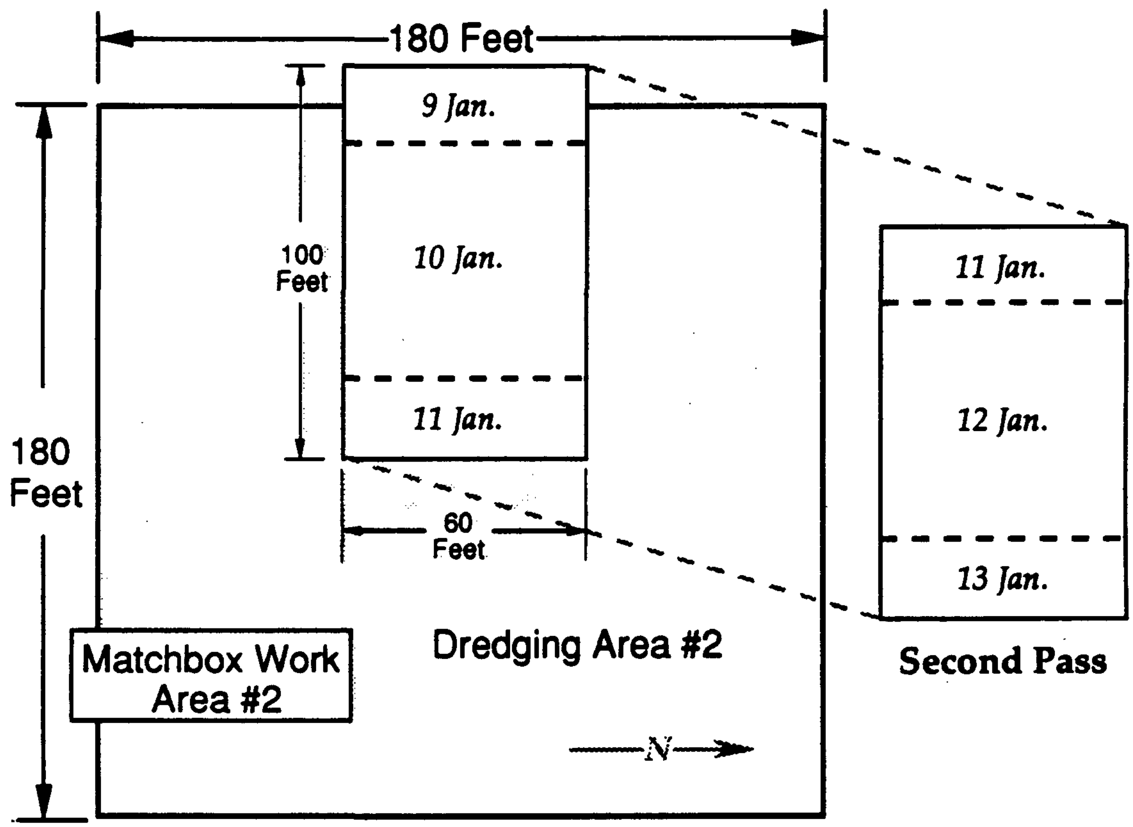


Figure 1-12 Matchbox Work Area #2

1. Quantity of material removed: 359.0 cubic yards

2. Production rate: 24.5 cubic yards/hour

3. Rate of advance: 14.9 feet/hour

Dredging Effectiveness and Efficiency: The dredge made two passes over the area attempting to remove two feet of contaminated sediment. This resulted in an average depth of cut of 1.5 feet. PCB levels in the remaining sediment were less than 10 ppm. Figure 1-13 shows a typical cross section of the matchbox dredge area.

Sediment Resuspension and Contaminant Release: A sam;ing device was attached to the dredge adjacent to the dredgehead and the results of this sampling effort were used with the water depth and the dredge's swing speed to develop a generation rate for resuspended sediment. Dredgehead sampling was conducted on 5 days while the dredge was operating in contaminated sediment. The results are summarized below. The data used in deriving these values is contained in Table 16.

Date	Range of Resuspension Rates (grams/sec)	Average Resuspension Rate (grams/sec)
1-9	16.4 - 205.1	78.4
1-10	7.1 - 110.8	45.7
1-11	4.2 - 165.3	42.3
1-12	20.4 - 115.4	47.7
1-13	2.1 - 96.1	26.2

Composite samples taken from the dredgehead sampler were analyzed for PCBs with the results shown in Tables 17 and 5. This data is then compared to the standard elutriate test data shown on Table 6. The results indicate that the elutriate test conservatively estimates the contaminant levels in the water column adjacent to the operating dredgehead.

Sediment and Contaminant Transport: Tables 18 and 19 show the results of both dredgehead and plume sampling during the dredges first days of operation. Figure 1-14 shows the location of the plume sampling stations. A well defined plume of resuspended material never developed and only minor increases above background were detected 500 feet from the operating dredge.

Composite samples were formed from a combination of samples taken at the individual stations. (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals. The results are shown in Tables 20 and 4.

The contaminant levels are within the range that naturally occurs in the cove. This data and the data on resuspended sediment indicates that movement of contaminants away from the point of dredging is likely to be less than estimates based on the sediment transport model.

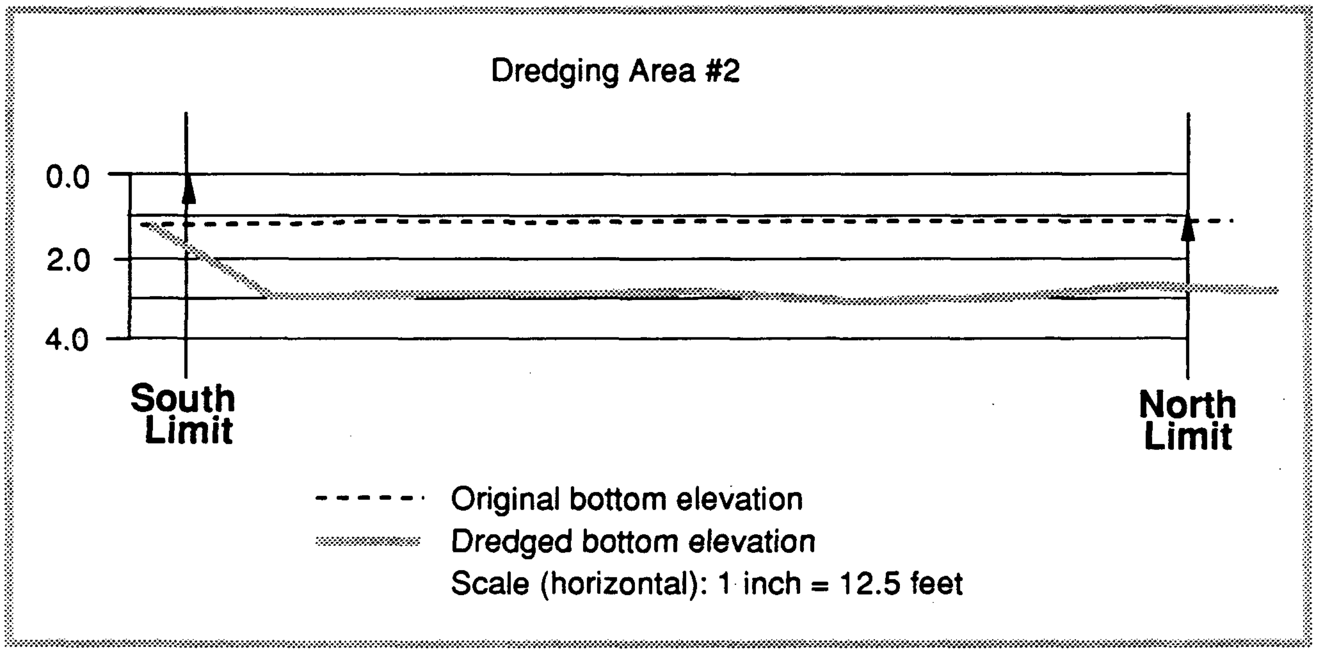


Figure 1-13 Typical cross section of a Matchbox Dredge Area

Problems: This dredge encountered the same problems with swing anchors as did the cutterhead. The problem was exacerbated by the larger size of the dredge plant and the fact that the Matchbox head must be pulled through the sediment by the cable system without the mechanical aid of a rotating cutter that is available on the cutterhead and Mudcat dredges. An additional problem involved the clogging of the dredgehead and suction line with debris and sediment. Steps taken to prevent this included welding vertical and horizontal bars across the dredgehead to keep out debris and reducing the digging depth to six inches per swing. These steps reduced the downtime but also reduced the dredge's production rate.

Several additional problems resulted from the clogging of the dredghead. A large plume of susupended material was formed when the dredgehead was lifted out of the water to be cleared. Personnel were also required to remove the sediment and debris from the dredghead by hand which put them in contact with contaminated sediment. In areas of higher contaimination, workmen would be required to wear protective clothing and repiratory protection when cleaning the dredgehead.

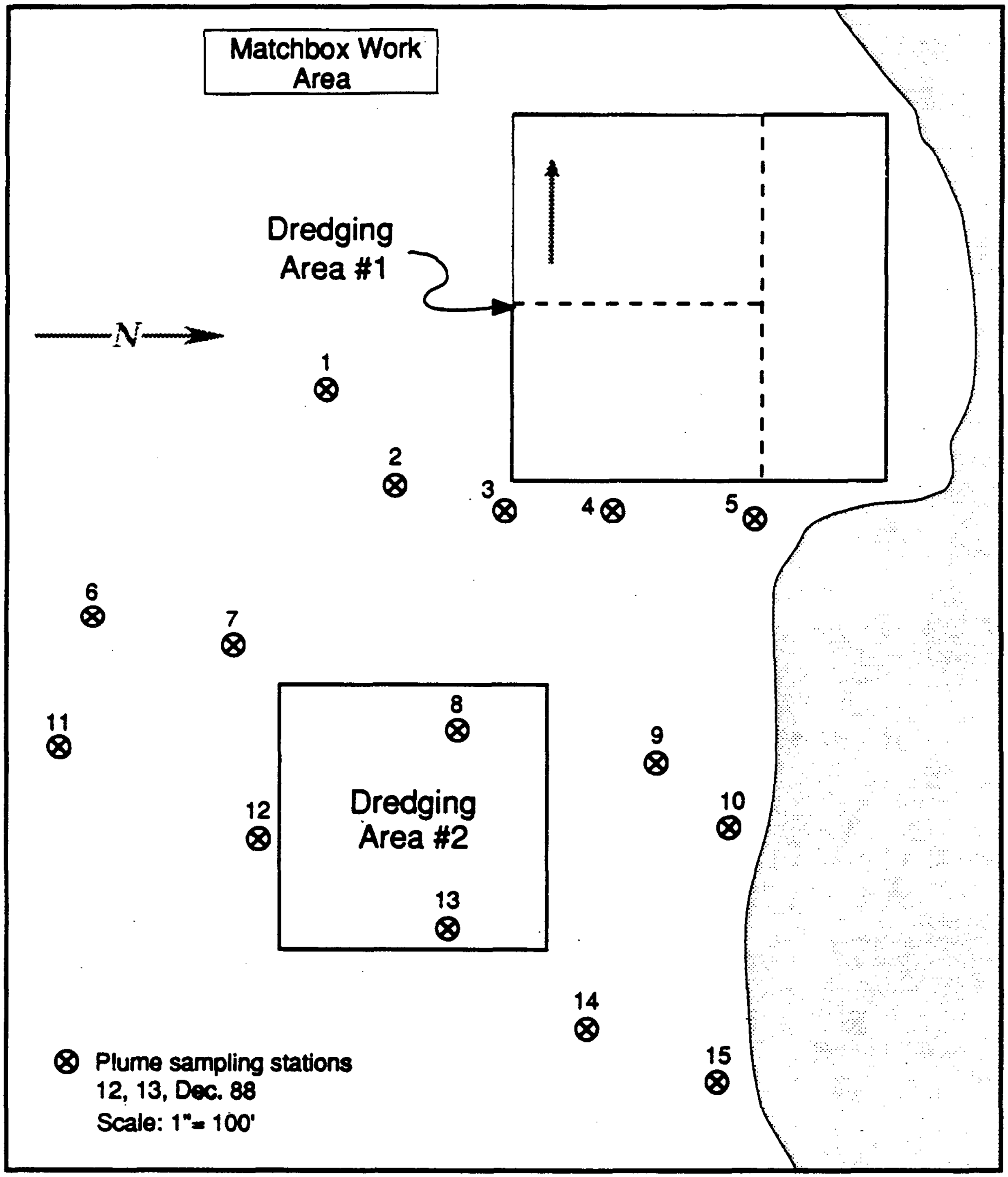


Figure 1-14 Plume Sample Locations - Matchbox Work Area

Table 1

Resuspension Rate - Cutterhead Dredge
November 21

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0654	3.9	10.1	0.53	151.6	305.1	46.3
0709	3.9	10.1	0.53	151.6	175.8	26.7
0726	3.7	9.6	0.53	144.1	114.4	16.5
0748	3.5	9.1	0.53	136.6	87.6	12.0
0755	3.3	8.6	0.53	129.1	97.3	12.6
0813	3.1	8.1	0.53	121.6	97.2	11.8
AVG.						21.0

November 23

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0710	4.7	12.2	0.58	200.5	37.3	7.5
0719	4.7	12.2	0.58	200.5	55.6	11.1
0732	4.7	12.2	0.58	200.5	54.7	11.0
0748	4.6	12.0	0.58	197.2	45.8	9.0
0804	4.5	11.7	0.58	192.2	45.5	8.7
0819	4.1	10.7	0.58	175.8	40.9	7.2
0842	3.9	10.1	0.58	165.9	31.4	5.2
0848	3.9	10.1	0.58	165.9	38.7	6.4
0903	3.4	8.8	0.58	144.6	61.1	8.8
0928	2.8	7.3	0.58	119.9	102.2	12.3
0933	2.8	7.3	0.58	119.9	59.2	7.1
0948	2.5	6.5	0.58	106.8	68.7	7.3
AVG						8.5

November 25

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0730	3.9	10.1	0.55	157.4	65.7	10.3
0741	4.1	10.7	0.55	166.7	46.5	7.8
0752	4.1	10.7	0.55	166.7	87.5	14.6
0817	4.3	11.2	0.55	174.5	59.9	10.5
0856	4.4	11.4	0.55	177.6	54.1	9.6
0925	4.3	11.2	0.55	174.5	40.7	7.1
0941	4.2	10.9	0.55	169.8	18.7	3.2
0953	4.1	10.7	0.55	166.7	17.8	3.0
1008	4.1	10.7	0.55	166.7	65.3	10.9
1023	4.0	10.4	0.55	162.0	134.5	21.8
1039	3.8	9.9	0.55	154.2	104.2	16.1
1056	3.5	9.1	0.55	141.8	60.0	8.5
1108	3.5	9.1	0.55	141.8	40.7	5.8
1123	3.1	8.1	0.55	126.2	58.3	7.4
AVG						9.8

1) tide height x length of dredgehead (2.6 ft)

Table 1

Resuspension Rate - Cutterhead Dredge (continued)
December 17

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1430	3.73	9.7	0.34	93.4	127.7	11.9
1445	3.88	10.1	0.34	97.3	176.0	17.1
1500	4.13	10.8	0.34	104.0	64.1	6.7
1515	4.14	10.8	0.34	104.0	86.1	9.0
1530	3.95	10.3	0.34	99.2	64.6	6.4
1545	3.80	9.9	0.34	95.4	100.4	9.6
1600	3.66	9.5	0.34	91.5	131.7	12.1
1615	3.45	9.0	0.34	86.7	163.7	14.2
1630	3.26	8.5	0.34	81.9	556.3	45.6
AVG						14.7

January 8

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0848	4.81	12.5	0.42	148.7	422.9	62.9
0900	4.62	12.0	0.55	187.0	527.2	98.6
0915	4.51	11.7	0.49	162.4	401.8	65.3
0930	4.81	12.5	0.49	173.5	454.2	78.8
0945	5.04	13.1	0.49	181.8	427.6	77.7
1005	4.92	12.8	0.49	177.7	272.5	48.4
1025	4.46	11.6	0.49	161.0	215.8	34.7
1034	4.46	11.6	0.51	167.6	350.5	58.7
1055	4.09	10.6	0.49	147.1	249.3	36.7
1150	2.85	7.4	0.49	102.7	418.2	42.9
AVG						60.5

(1) tide height x length of dredgehead (2.6 ft)

Table 2
Dredgehead Samples - PCB Analysis (Cutterhead Dredge)

Date	Sample No.	Time	TSS (mg/l)	PCB (ppb)	
11-21	519121	0730	56.0	5.430	WWC
	519122	0730		18.000	FWC
	519122	0730		0.530	WFC
	519123	0730		3.760	WWC
11-22	519321	0742	88.0	6.870	WWC
	519322	0742		0.556	FWC
	519322	0742		0.512	WFC
11-23	519521	0741	46.0	3.590	WWC
	519522	0903	61.0	3.480	WWC
	519523	0903		0.501	WFC
	519523	0903		3.160	FWC
12-16	520921			22.600	WWC
	520923			14.300	WWC
	520922			66.700	FWC
	520922			1.590	WFC
12-17	521950	1420		32.800	FWC
	521950	1420		0.986	WFC
	521951	1520	76.0	3.200	WWC
	521952	1620	388.0	3.390	WWC
1-8	526222	1120	216.0	4.970	WWC
	526223	1120		12.400	FWC
	526223	1120		0.675	WFC

WWC - Whole Water Composite (Total PCB)
FWC - Filtered Water Component (Particulate)
WFC - Water Filter Component (Dissolved)
21 November - Dredging from 0645-0745
22 November - Dredging from 0635-0820
23 November - Dredging from 0650-1010
16 December - Dredging from 1345-1535
17 December - Dredging from 1320-1645
8 January - Dredging from 0715-1155

Table 3
Plume Sampling Stations
PCB Analysis

Cutterhead Dredge

Date	Sample No.	Time	Stations	TSS (mg/l)	PCB (ppb)	
11/21	513151	0745-0815	6-10	37.0	1.410	WWC
	513153	0745-0815	11-15	4.0	1.410	WWC
11/22	513251	0840-0855	6-10	16.0	1.650	WWC
	513252		6-10		1.880	WWC
	513253		6-10		0.658	FWC
11/23	513351	0745-0800	1-5	5.0	0.618	WWC
	513353	0945-1000	11-15	5.0	0.539	WWC

21 November - Dredging began at 0645 and continued for 1 hour

22 November - Dredging from 0635-0820

23 November - Dredging from 0650-1010

WWC - Whole Water Composite (Total)
FWC - Filtered Water Component (Particulate)
WFC - Water Filter Component (Dissolved)

Table 4
Plume Samples PCBs (ppb) Total

Cutterhead Dredge

Station	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
1-5	0.6	-	-	-	-	1
6-10	1.5	0.2	11.1	1.4	1.7	2
11-15	1.1	0.6	56.7	0.5	1.9	4

Mudcat Dredge

Station	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
1-5	1.5	0.7	45.2	0.6	2.2	4
6-10	1.4	0.6	40.1	0.7	1.9	4
11-15	1.9	-	-	-	-	1

Matchbox

Station	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
1-5	10.8	9.6	199.0	0.9	49.4	5
6-10	1.6	2.4	147.7	0.2	5.1	4
11-15	1.1	0.1	5.2	1.1	1.1	2

Table 5
Dredgehead Samples PCBs (ppb)

TOTAL:

Dredge	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
Cutterhead	7.0	7.3	104.3	1.6	26.6	11
Mudcat	54.9	45.7	83.2	12.6	133.0	9
Matchbox	2.6	2.2	87.2	0.2	4.5	4

DISSOLVED:

Dredge	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
Cutterhead	0.6	0.2	32.1	0.5	1.0	5
Mudcat	10.1	9.2	90.8	1.0	22.9	4
Matchbox	0.5	0.1	25.0	0.3	0.6	4

PARTICULATE:

Dredge	Mean	Std. Dev.	Coef. Var.	Min.	Max.	Number
Cutterhead	22.3	24.6	110.7	0.6	66.7	6
Mudcat	200.3	199.8	99.8	18.2	382.0	4
Matchbox	56.9	76.4	134.2	6.7	205.0	7

Table 6
Standard Elutriate Test PCBs (ppb)

Description	Dissolved	Suspended	Total
Area 1	0.06	0.46	0.52
Site Water	0.19	0.17	0.36
	0.14	0.37	0.51
Elutriate	7.98	92.10	100.08
	10.10	99.10	109.20
	10.10	82.70	92.80
Area 2	0.35	0.22	0.57
Site Water	0.20	0.88	1.08
	0.26	0.57	0.33
Elutriate	3.36	30.70	34.06
	6.23	60.80	67.03
	4.61	35.50	40.11

Table 7
Dredgehead and Plume Sampling
Cutterhead Dredge - Total Suspended Solids (mg/l)

Plume Sampling
November 21

Dredging on ebb tide. High water @ 0520, began dredging 0700. Sampling began approximately 10 minutes later, samples taken at 45 minute intervals. Dredging stopped after 45 minutes

STATION	EVENT 1 0700-0720	EVENT 2 0745-0815
6	1.78	9.88
7	2.86	24.26
8	4.02	15.00
9	3.04	80.04
10	4.24	56.98
11	4.86	4.58
12	5.92	1.98
13	6.94	3.98
14	7.10	
15	7.34	

Dredgehead Sampling
November 21

Samples taken approximately every 15 minutes. Sampling ports situated on both sides of the dredgehead at 3 different elevations. Ports 1 and 4, 2 and 5, and 3 and 6 are at the same elevation.

	Ports						
Time	1	2	3	4	5	6	
0726	65.68			46.28			P-S
0741	33.76			7.60			S-P

P-S - dredgehead moving port to starboard
S-P - dredgehead moving starboard to port

Table 8
Dredgehead and Plume Sampling
Cutterhead Dredge - Total Suspended Solids (mg/l)

Plume Sampling
November 22

Dredging on ebb tide. High water at 0612, began dredging at 0635, sampling began approximately 20 minutes later, samples taken at 45 minute intervals. Dredging for 1 hour, 45 minutes.

	Sampling Event				
Station	0645-0700	0730-0745	0810-0825	0840-0855	
	1	2	3	4	5
6	2.86	7.24	8.26	16.18	4.92
7	7.76	5.84	7.54	22.90	12.98
8	2.70	6.22	6.72	13.18	7.08
9	12.06	7.32	5.44	17.14	4.38
10	9.44	4.16	9.36	12.62	9.14
11	7.56	6.38	16.38	14.08	6.48
12	6.34	4.12	5.58	7.62	13.74
13	4.26	5.80	10.62	40.94	16.10
14	5.44	5.28	24.34	8.88	28.02
15	5.02	5.42	8.84	7.90	7.12

Dredgehead Sampling
November 22

Time	Port						
	1	2	3	4	5	6	
0654	236.84	443.52	109.12	591.92	221.48	227.64	S-P
0709	208.72	176.96	126.20	224.64	252.96	65.56	P-S
0726	213.56	209.92	49.12	50.60	98.08	65.44	P-S
0743(C)	122.08	26.92	184.80	47.16	56.96		S-P
0755	111.80	169.20		77.00	30.96		S-P
0813	47.60	103.96	68.32		168.68		S-P

P-S - dredgehead moving port to starboard
S-P - dredgehead moving starboard to port

Table 9
Dredgehead and Plume Sampling
Cutterhead Dredge - Total Suspended Solids (mg/l)

Plume Sampling
November 23

Dredging began just prior to high tide. Initial plume sample taken 10 minutes after the start of dredging. Plume samples taken at 45 minute intervals. Dredging continued for 3 hours and 20 minutes.

Station	Sampling Event 0700-0715 1	0745-0800 2	0830-0840 3	0915-0925 4	0945-1000 5
1	2.84	4.56			
2	-	3.02			
3	2.64	7.00			
4	3.40	7.38			
5	6.34	5.40			
6	5.42	10.08	2.82	3.86	4.56
7	6.48	12.12	6.58	5.74	7.02
8	5.48	4.06	5.12	4.20	8.40
9	5.54	4.24	9.16	2.22	5.20
10	3.12	5.46	3.98	3.42	3.96
11			4.70	4.64	3.98
12			4.72	10.42	5.10
13			2.66	3.66	3.44
14			4.18	6.42	4.40
15			3.88	5.26	7.46

Dredgehead Sampling
November 23

Time	Port 1	2	3	4	5	6	
0710	16.44	68.84	26.36	15.84	34.00	62.56	P-S
0719	69.84	29.72	19.96	82.32	92.56	39.00	S-P
0732	26.16	79.48	96.24	36.32	70.80	19.04	P-S
0748	38.64	77.40	40.76	41.12	51.52	25.92	S-P
0804	34.76	46.12	47.40	39.56	70.56	34.24	S-P
0819	38.16	55.08	37.00	25.04	35.88	54.16	P-S
0842	32.56	46.32	39.96	23.92	22.88	22.48	S-P
0848	28.60	79.04		13.76	33.40		P-S
0903(C)	79.04	56.60		67.08	41.72		S-P
0928	83.08	162.52		121.56	41.68		P-S
0933	67.64	74.28		50.80	44.12		S-P
0948	71.20	129.88		30.32	43.68		S-P
0741							P-S

P-S - dredgehead moving port to starboard
S-P - dredgehead moving starboard to port

Table 10
Resuspension Rate - Horizontal Auger Dredge

December 2

Time	Tide Ht. (ft)	Area (1) (ft2)	Rate of Advance (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1345	2.3	20.7	0.48	281.5	771	217
1350	2.3	20.7	0.56	328.4	2781	913
1425	2.4	21.6	0.50	305.9	2063	631
1430	2.4	21.6	0.68	416.1	1215	505
1438	2.4	21.6	0.46	281.5	1939	546
1535	2.3	20.7	0.48	281.5	4037	1136
1555	2.3	20.7	0.49	287.3	2363	679
1602	2.3	20.7	0.48	281.5	3407	959
1620	2.2	19.8	0.45	252.4	2487	628
AVG						690

December 3

Time	Tide Ht. (ft)	Area (1) (ft2)	Rate of Advance (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1630	3.0	27.0	0.23	175.9	692	122
1637	2.9	26.1	0.21	155.3	528	82
1640	2.9	26.1	0.24	177.4	3050	541
1720	2.8	25.2	0.21	149.9	1302	195
1755	2.4	21.6	0.20	122.4	634	78
1815	2.3	20.7	0.22	129.0	803	104
AVG						187

December 4

Time	Tide Ht. (ft)	Area (1) (ft2)	Rate of Advance (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1555	2.1	18.9	0.26	139.2	1630	227
1615	2.1	18.9	0.35	187.4	935	175
1640	2.1	18.9	0.35	187.4	1230	231
1715	2.1	18.9	0.26	139.2	2630	366
1735	2.1	18.9	0.35	187.4	1205	226
1750	2.0	18.0	0.26	132.6	5154	680
AVG						245

(1) tide height x width of dredgehead (9 feet)

Table 10
Resuspension Rate - Horizontal Auger Dredge (continued)

January 15

Time	Tide Ht. (ft)	Area (1) (ft2)	Rate of Advance (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1105	0.94	8.46	0.13	31.2	975.4	30.4
1135	0.99	8.91	0.21	53.0	169.9	9.0
1205	0.91	8.19	0.28	65.0	245.4	16.0
1220	0.97	8.73	0.31	76.7	512.1	39.3
1235	1.03	9.27	0.33	86.7	1174.0	101.8
1250	1.10	9.90	0.30	84.1	712.4	59.9
1335	1.87	16.83	0.28	133.5	934.1	124.7
1350	2.10	18.90	0.37	198.1	399.2	79.1
1400	2.27	20.43	0.21	578.8	1600.6	926.4
1415	2.50	22.50	0.22	140.2	401.5	56.3
1455	3.03	27.27	0.25	193.1	337.5	65.2
1505	3.03	27.27	0.20	154.5	781.7	120.8
1515	3.03	27.27	0.26	200.9	844.6	169.7
1525	3.09	27.81	0.22	173.3	2788.8	483.3
1535	3.09	27.81	0.20	157.6	2862.3	451.1
1545	3.09	27.81	0.23	181.2	977.8	177.2
1555	2.95	26.55	0.22	165.5	416.8	69.0
1635	2.88	25.92	0.21	154.2	3991.4	615.5
1645	2.77	24.93	0.23	162.4	2795.8	454.0
1655	2.44	21.96	0.22	136.9	2020.4	276.6
1705	2.44	21.96	0.22	136.9	1806.7	247.3
AVG						213

(1) tide height x width of dredgehead (9 feet)

Table 11
Dredgehead Samples - PCB Analysis

Horizontal Auger Dredge:

Date	Sample No.	Time	TSS (mg/l)	PCB (ppb)	
12-2	519922	1535		364.0	FWC
	519922	1535		22.9	WFC
	519923	1535	4037.00	133.0	WWC
12-3	520122	1755	634.00	19.90	WWC
	520122	1755		18.20	FWC
	520122	1755		8.79	WFC
	520123	1755		29.10	WWC
12-4	520323	1630	1083.00	29.60	WWC
	520323	1630		12.60	WWC
	520323	1630		36.80	FWC
	520323	1630		7.81	WFC
1-15	527421	1220		16.20	WWC
	527422	1220	2207.40	1.020	WFC
	527422	1220		382.0	FWC
	527423	1400	1757.24	98.6	WWC
	527424	1525	2133.00	108.0	WWC
	527425	1635	1665.20	47.4	WWC

2 December - Dredging from 1300-1630
3 December - Dredging from 1300-1830
4 December - Dredging from 1615-1900

WWC - Whole Water Composite (Total)
FWC - Filtered Water Composite (Particulate)
WFC - Water Filter Component (Dissolved)

Table 12
Dredgehead and Plume Sampling
Horizontal Auger Dredge - Total Suspended Solids (mg/l)

Plume Sampling
December 2:

Dredge began operating 1 hour prior to high tide, operated over 3.5 hour period.

Station	Event 1430-1440 1	1515-1545 2	1610-1615 3	1628-1638 4
1	7.46	11.06		
2	6.58	14.48		
3	4.22	12.14		
4	30.62	4.90		
5	10.72	16.18		
6	11.02	11.98	4.48	16.26
7	6.52	6.10	6.06	8.62
8	7.82	8.94	10.02	7.46
9	5.40	8.74	7.64	7.34
10	8.54	12.24	11.00	7.34
11			11.54	10.76
12			8.90	6.66
13			6.70	9.14
14			5.24	5.74
15			11.40	6.16

Dredgehead Sampling
December 2:

Time	Port 1	2	3	4	5	6	
1345	596.44	1011.72	1894.76	615.52	360.72	147.04	F
1350	2942.32	5020.08		4715.60	953.68	273.60	R
1425	1286.96	2840.24					F
1430	1693.52	1221.68	729.60				R
1438	2616.13	1751.87	1450.40				F
1535(C)	6162.20	1329.60	4619.60				F
1555	1811.80	4141.20	1138.20				R
1602	4354.40	2820.40	3046.80				F
1620	2197.40	2149.80	3115.00				R

F - Dredge moving forward
R - Dredge moving in reverse

Table 13
Dredgehead and Plume Sampling
Horizontal Auger Dredge - Total Suspended Solids (mg/l)

Plume Sampling
December 3

Dredge began operating approximately 2 1/2 hours prior to high tide and worked for over a 5 1/2 hour period.

Station	**Event** 1345-1400 1	1430-1440 2	1515-1600 3	1600-1645 4	5
1	9.38	17.46	21.50		
2	6.80	7.46			
3	6.84	6.44			
4	17.64	2.82	4.80		
5	5.00	9.60	13.18		
6	2.68	2.06	21.32	3.78	3.68
7	2.94	3.82	36.50	1.78	1.86
8	2.06	1.50	34.24	2.82	1.54
9	4.90	4.78	36.38	2.44	3.00
10	6.40	12.60	41.34	12.20	8.36
11				9.00	2.52
12				1.80	1.52
13				0.86	0.68
14				0.34	3.52
15				1.42	4.70

Dredgehead Sampling
December 3

Time	**Port** 1	2	3	4	5	6	
1630	131.60	1185.84	971.00	1149.28	355.64	358.16	R
1637	416.48	1564.48	912.00	162.48	63.16	53.20	F
1640	257.96	2340.16	6552.80				R
1720	2077.60	1276.72	551.12				F
1755	726.88	1853.76	604.24	267.92	140.92	209.48	F
1815	1007.28	721.68	679.52				R

Table 14
Dredgehead and Plume Sampling
Horizontal Auger Dredge - Total Suspended Solids (mg/l)

Plume Sampling
December 4

Dredge began operating just prior to high tide and operated over a 3.1 hour period.

	Event		
	1615-1630	1645-1700	1730-1745
Station	1	2	3
1	8.08	6.04	
2	13.06	15.50	
3	28.50	66.76	
4	11.08	9.60	
5	16.02	18.64	
6	12.10	15.56	9.22
7	12.76	9.12	10.70
8	9.18	4.72	7.82
9	6.68	7.58	11.30
10	10.78	9.08	9.10
11			13.14
12			9.12
13			7.42
14			8.60
15			11.16

Dredgehead Sampling
December 4

	Port			
Time	1	2	3	
1555	1799.32	1460.32		F
1615	401.08	2055.40	349.40	R
1640	1913.20	1422.60	355.60	R
1715	1331.20	2552.60	4007.60	F
1735	539.80	2602.80	473.60	R
1750	7378.80	4833.80	3248.40	F

F - Dredge moving forward
R - Dredge moving in reverse

Table 15
Plume Sampling Stations
PCB Analysis

Horizontal Auger Dredge

Date	Sample No.	Time	Stations	TSS (mg/l)	PCB (ppb)	
12-2	513451	1515-1545	1-5	7.0	1.450	WWC
	513452	1610-1615	6-10		1.250	FWC
	513453	1610-1615	6-10	8.0	0.713	WWC
12-3	513551	1515-1600	1-5	13.0	1.740	WWC
	513552	1515-1600	6-10		1.920	FWC
	513553	1645-1700	11-15	3.0	1.850	WWC
12-4	513651	1700-1715	1-5	24.0	2.190	WWC
	513652	1700-1745	1-5		0.588	FWC
	513653	1730-1745	6-10	10.0	1.900	WWC

2 December - Dredging from 1300-1630
3 December - Dredging from 1300-1830
4 December - Dredging from 1615-1900

WWC - Whole Water Composite (Total)
FWC - Filtered Water Component (Particulate)
WFC - Water Filter Component (Dissolved)

Table 16
Resuspension Rate - Matchbox Dredge

January 9

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0855	3.74	22.44	0.23	146.2	309.8	45.3
0919	3.85	23.10	0.23	150.5	1363.0	205.1
0930	3.82	22.92	0.23	149.3	802.9	119.9
1105	4.08	24.48	0.23	159.5	353.5	56.4
1111	3.98	23.88	0.23	155.6	174.9	27.2
1121	3.80	22.80	0.23	148.6	110.4	16.4
AVG						78.4

January 10

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0900	2.78	16.68	0.26	122.9	481.4	59.2
0915	3.02	18.12	0.26	133.5	53.4	7.1
0925	3.24	19.44	0.26	143.2	61.7	8.8
0946	3.44	20.64	0.26	152.0	62.4	9.5
0953	3.61	21.66	0.26	159.5	99.9	15.9
1003	3.61	21.66	0.31	190.2	79.5	15.1
1052	3.87	23.22	0.28	184.2	438.8	80.8
1103	3.87	23.22	0.22	144.7	679.6	98.3
1111	3.79	22.74	0.20	128.8	481.5	62.0
1125	3.81	22.86	0.29	187.8	590.0	110.8
1141	3.73	22.38	0.24	164.8	179.1	29.5
1146	3.73	22.38	0.26	164.8	241.6	39.8
1158	3.43	20.58	0.26	151.6	226.9	34.4
1200	3.43	20.58	0.27	157.4	431.2	67.9
AVG						45.7

January 11

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
0845	2.40	14.4	0.30	122.4	240.0	29.4
0900	2.64	15.8	0.29	129.8	41.0	5.3
0912	2.85	17.1	0.29	140.5	40.6	5.7
0918	2.85	17.1	0.27	130.8	31.8	4.2
0935	3.13	18.8	0.29	154.4	61.1	9.4
1135	3.34	20.0	0.29	164.3	300.0	49.3
1142	3.05	18.3	0.29	150.3	156.1	23.5
1155	2.76	16.6	0.30	141.1	118.3	16.7
1205	2.76	16.6	0.29	136.4	170.1	23.2
1229	2.45	14.7	0.29	120.8	1368.5	165.3
1230	2.10	12.6	0.29	103.5	1285.6	133.1

(1) tide height x length of dredgehead (6 feet)

Table 16
Resuspension Rate - Matchbox Dredge
(continued)

January 12

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1008	2.40	14.4	0.27	110.1	185.3	20.4
1030	2.89	17.3	0.28	137.2	369.2	50.7
1037	3.00	18.0	0.32	163.2	230.4	37.6
1045	3.12	18.7	0.35	185.4	296.8	55.0
1050	3.15	18.9	0.32	171.3	237.3	40.6
1100	3.25	19.5	0.32	176.8	201.1	35.6
1105	3.31	19.9	0.32	180.4	321.7	58.0
1110	3.37	20.2	0.32	183.1	208.3	38.1
1115	3.43	20.6	0.32	186.7	246.3	46.0
1120	3.51	21.1	0.34	203.3	262.5	53.3
1125	3.60	21.6	0.32	195.8	241.8	47.3
1130	3.69	22.1	0.32	200.3	199.4	39.9
1200	3.84	23.0	0.32	208.5	218.3	45.5
1220	3.87	23.2	0.37	243.2	225.8	54.9
1330	3.59	21.5	0.32	194.9	251.5	49.0
1350	3.34	20.0	0.32	181.3	190.7	34.6
1400	3.19	19.1	0.32	173.1	213.9	37.0
1410	3.07	18.4	0.32	166.8	694.7	115.9
AVG						47.7

January 13

Time	Tide Ht. (ft)	Area (1) (ft2)	Swing Speed (ft/sec)	Volume (l)	Avg TSS (mg/l)	Resuspension Rate (g/sec)
1015	1.9	11.4	0.26	84.0	263	22.1
1025	2.1	12.6	0.26	92.8	92	8.5
1035	2.1	12.6	0.29	103.5	350	36.2
1040	2.1	12.6	0.23	82.1	1170	96.1
1053	2.2	13.2	0.27	101.0	227	22.9
1100	2.3	13.8	0.26	101.6	21	2.1
1115	2.4	14.4	0.26	106.1	86	9.1
1125	2.5	15.0	0.26	110.5	116	12.8
AVG						26.2

(1) tide height x length of dredgehead (6 feet).

Table 17
Dredgehead Samples - PCB Analysis

Matchbox Dredge:

Date	Sample No.	Time	TSS (mg/l)	PCB (ppb)	
12-12	520521	1252	76	4.540	WWC
	520522	1252		17.100	FWC
	520522	1252		0.590	WFC
	520523	1252		4.390	WWC
1-9	526322	1119	111	119.000	FWC
	526322	1119		0.524	WFC
1-10	526522	0942	62	205.000	FWC
	526522	0942		1.120	WWC
1-11	526722	1230	582	0.190	WWC
1-12	526923	1100	214	7.470	FWC
	526923	1100		0.336	WFC
	526924	1220	201	12.600	FWC
	526924	1220		0.385	WFC
	526925	1220	121	30.400	FWC
1-13	527924	1125	68	6.720	FWC

WWC - Whole Water Composite (Total)
FWC - Filtered Water Component (Particulate)
WFC - Water Filter Component (Dissolved)

Table 18
Dredgehead and Plume Sampling
Matchbox Dredge - Total Suspended Solids (mg/l)

Plume Sampling
December 12

Sampling Event

Station	1210-1220	1230-1240	1305-1315
1		12.2	
2		3.7	
3		5.8	
4		6.0	
5		11.4	
6	8.2	14.3	36.6
7	9.2	13.9	53.1
8	8.5	10.0	9.5
9	8.1	5.0	6.4
10	20.3	19.7	13.9
11	8.9		17.1
12	16.4		13.6
13	7.0		8.7
14	4.1		3.7
15	4.7		9.6

Dredgehead Sampling
December 12

Time	Port 1	2	3	4	5	6	
1220	67.9			44.7	33.3		S-P
1230	246.3			44.5	51.3		P-S
1235	58.5			45.0	38.4		S-P
1243	20.0				110.4		P-S
1252	111.7			38.5			S-P
1257	87.0			89.3			P-S
1301	126.7			135.7			S-P

Samples taken from boat due to frozen lines

S-P - Dredgehead moving from starboard to port
P-S - Dredgehead moving from port to starboard

Table 19
Dredgehead and Plume Sampling
Matchbox Dredge - Total Suspended Solids (mg/l)

Dredgehead Sampling
December 13

Time	Port 1	2	3	4	5	6	
0945	293.0	46.8	62.8	34.8	49.2	35.2	P-S
0950	85.1	26.4	20.0				S-P
0955				17.1	22.9	26.6	P-S
1000	18.8	21.2	24.6	25.2	21.9	30.4	S-P
1005	46.0	18.1	18.9				S-P
1010				36.7	7.2		P-S
1025	43.2	30.9	53.0	39.1	63.0		P-S
1035	27.8	23.1	23.8	1148.6	25.2	20.8	S-P

Samples taken from a boat due to frozen lines.

P-S - Dredgehead moving from port to starboard
S-P - Dredgehead moving from starboard to port

Plume Sampling
December 13

Station	Sampling Event 0938-0948	1033-1040	1205-1215
1	41.4	18.8	13.4
2		38.7	
3	5.6		7.3
4		44.9	
5	17.9		19.8
6		45.5	
7	66.1		45.0
8		12.4	
9	10.4		40.5
10		12.7	
11	9.3		12.9
12		8.5	
13	2.9		10.2
14	10.5	8.8	18.6
15	14.0	16.1	10.2

Table 20 Plume Sampling Stations PCB Analysis

Matchbox Dredge

Date	Sample No.	Time	TSS Stations	(mg/l)	PCB (ppb)	
12-10	513751	0850-0900	1-5		1.050	WWC
	513752	1055-1105	6-10		0.807	FWC
	513752	1055-1105	6-10		0.208	WWC
	513753	1055-1105	11-15		1.050	WWC
12-12	513851	1210-1220	1-5	8	1.640	WWC
	513852	1305-1315	6-10	24	5.130	FWC
	513852	1305-1315	6-10		0.264	WWC
	513853	1305-1315	11-15	11	1.130	WWC
12-13	513952	1205-1215	1-5		0.856	FWC
	513952	1205-1215	1-5	32	49.400	WWC
	513953	1205-1215	1-5		1.230	WWC

10 December - Dredging from 0615-1000

12 December - Dredging from 1130-1315

13 December - Dredging from 0915-1045

WWC - Whole Water Composite (Total)
FWC - Filtered Water Composite (Particulate)
WFC - Water Filter Component (Dissolved)

Table 21

Ellicott Series 370 Specifications

General:		
Overall Length (With Ladder)	17.5 m	57.5 feet
Overall Width	3.7 m	12 feet
Hull Depth	1.2 m	4 feet
Mean Draft (With Fuel)	0.8 m	2.75 feet
Spud Length (Each)	8.4 m	27.5 feet
Spud Weight (Each)	839 kg	1,850 lbs
Total Dredge Dry Weight	22,680 kg	50,000 lbs
Operating Conditions:		
Digging Depth:		
Minimum	1.0 m	3 feet
Maximum	6.0 m	20 feet
Maximum Cut of Dredge		
@ Minimum Digging Depth	22.3 m	73 feet
@ Maximum Digging Depth	18.3 m	60 feet
Minimum Channel Width	9.3 m	30.5 feet

Table 21
Ellicott Series 370 Specifications
(continued)

Prime Mover:		
Caterpillar 3406 Diesel Engine (Radiator Cooled)		
Intermittent Rating @ 1800 RPM	268 kw	360 SHP
Continuous Rating @ 1800 RPM	230 kw	308 SHP
Cutter Module:		
Cutting Force	1,742 kg	3,840 lbs
Cutting Force per Linear Inch of Blade	35 kg/cm	195 lbs
Cutter Diameter	800 mm	31.5 inches
Shaft Diameter (Average)	89 mm	3.5 inches
Cutter Rating @ 40 RPM	30 kw	40 SHP
Cutter Speed (Variable)	0-40 RPM	0-40 RPM
Swing Winches:		
Line Pull	3,629 kg	8,000 lbs
Line Speed (1st layer)	23 m/min	75 ft/min
Wire Size	12.7 mm	0.50 inch
Drum Capacity	61.0 m	200 feet
Ladder Hoist Cylinder:		
Extending Force	4,452 kg	9,815 lbs
Retracting Force	18,235 kg	40,200 lbs
Lowering Speed	5.5 m/min	18 ft/min
Hoisting Speed	7 m/min	22 ft/min
Spud Hoist Cylinders:		
Lifting Force (@ Spud)	2,545 kg	5,610 lbs
Lowering Speed	Free-Fall	Free-Fall
Hoisting Speed	41.5 m/min	136 ft/min
Electrical System:		
Battery (24 VDC)	220 amp-hr	220 amp-hr
Capacities:		
Fuel		
Port Fuel Comparment	1,325 liters	350 gal
Starboard Fuel Compartment	1,325 liters	350 gal
Hydraulic Oil	1,136 liters	300 gal

Optional Equipment:

Air Conditioning	Anchors
Heating	Booster Pumps
AC Electrical System	Pipeline
Production Measuring Equipment	Pipeline Components
Dredge Lifting Ring	Additional Components Upon Request

Table 22
Mudcat Machine Specifications (Model SP-915)

General: Length -39'5 1/2"
Width -9'0"
Height -O.A. 8'8"
Draft -21"
Floating Clearance -6'9"
Fuel Capacity -360 gallons

Floatation: Pontoons-Two 36" x 32" x 33'0"
10 gauge H.R. steel with internal bulkheads and stiffeners; formed for rigidity; polyurethane foam filled

Cutter Auge rAssembly:
Diameter -13 5/8"
Pitch -11"
Flighting -3/8"
Speed -Up to 100 RPM
Cutter Knives -Detachable Heat-Treated Blades
Auger Torque -16,500 in. lbs.

Mud Shield: 19" x 9' Hydraulically Adjustable

Working Capacity:
Cut 9' wide x 18" maximum depth
Operating Depth 15' maximum

Engine: Detroit Diesel 6-71 RC
175 BHP @ 1800 RPM

Pump: Centrifugal Recessed Impeller
Impeller Diameter 18"
Suction Diameter 8"
Discharge Diameter 6"
Capacity-2000 GPM @ 1180 against 124' Head (water)

Hydraulic Auger and Accessory DriveSystem: Dual Pumps
Capacity Total-30.5 GPM @ 1800 RPM
Resevoir-47 gallons
Circuit One-Auger Drive
Circuit Two-Boom, Mud Shield, and Winch
Relief Valve Setting: Auger-3000 PSI, Others-1500 PSI
Main Pump Drive
Single Pump
Variable Displacement Hydraulic Pump
Fixed Displacement Hydraulic Motor
Capacity-78 GPM @ 1800 RPM (Engine Speed)
Resevoir-30 Gallon
Relief Valve Setting: 5000 PSI

Table 22
Mudcat Machine Specifications (Model SP-915)
(continued)

Propulsion: Capstan Type Hydraulic Winch
Traverse Speed-50 FPM Maximum Forward and Reverse
Average Cutting Speed 8 to 12 FPM

Electrical System: Voltage-12V
Alt. Output-65 Ampere
Batteries-12V, 205 Ampere Hour, Parallel Wired
Circuits-2 Wire System Full Ground

Finish: Polyurethane finish coat on corrosion inhibitive epoxy primer

Colors: Standard Colors-Green and White

Table 23
Matchbox Dredge "Bean-Sweep"

General Overall Length (Ladder Up): 65'-0"
Hull Length: 50'-0"
Overall Beam: 23'-0"
Depth: 6'-0"
Ladder Length: 35'-0"
Fuel Capacity: 11,500 gals.
Approximate Weight: 100,000 lbs.

Hull Single Piece Welded Construction
Center 30'0" x 10'-0" x 5'0"
Sponsons 50'-0" x 3'-0" x 6'0"

Floatation Hull is divided into 8 watertight sections

Leverroom Leverroom provides 360 degree visibility and is removable for transportation.

Ladder Channel, Angel and Plate construction (heavy duty) for cutting hard materials.

Spuds 16 inch diameter pipe - 45 ft. long.

Cutter Assembly Cutter: Mobile Pulley - Left Hand - 6 Blade 32" I.D.
Assembly: Rotary Cutterhead

Table 23
Matchbox Dredge "Bean-Sweep"
(continued)

Renewable Edges

Engine Main Power - Pump
Twin-D-342 Caterpillar Engines
Horsepower = + 750

Dredge Pump Ammco - 10" x 12" diameter of intake and discharge. Pump is complete with cleanout box

Service Goulds 2 x 3x 8
Water Belt Driven for High Efficiency

Swing Braden Hydraulic Winches
Winches Winches equipped with various speed transmissions for smooth steady operation

Ladder Winch Braden Hydraulic Winch

Spud Rams Spuds operate with 4 part line for speed

APPENDIX 2

Confined Disposal Facility

June 1989

Interim Report

APPENDIX 2 CONFINED DISPOSAL FACILITY

The confined disposal facility (CDF) is a diked retention basin constructed to contain dredged material. The facility used during the pilot study was constructed on a parcel of city-owned property located on the New Bedford shoreline. Approximately half of the CDF facility was constructed below the high water line. This appendix discusses the operation of the facility and the monitoring of the two contaminant release pathways: effluent discharged from the facility and seepage/leachate escaping through the bottom of the site and through the dikes. Appendix 6 covers the design and construction of the in-water portion of the CDF dike.

CDF Design: Design requirements for storage of the dredged material and retention of solids generally control the sizing of CDFs. Procedures for calculating the requirements for volumetric storage, minimum surface area, effluent suspended solids, and weir length are described in EM 1110-2-5027 (12). Design data for applying these procedures include: sediment physical characteristics, dredge production rates and laboratory settling test data.

This design procedure was reversed for the pilot study. Only a limited area was available to construct the CDF and it was necessary to determine how much sediment could be contained in the available CDF volume and the optimum sequence of dredging and disposal operations to utilize this available volume. Settling data for the EFS composite sample was used along with estimated dredge production rates to determine that 10,000 cubic yards of sediment could be placed in the facility while minimizing the suspended sediment load in the effluent.

The CDF is shown in Figures 2-1 and 2-2 and the physical dimensions are listed below:

- Linear feet of dike 1775
- Initial elevation of in-water dike +15 MLW
- Top elevation of land dike +12 MLW
- Capacity - primary cell to elevation +10 MLW 26,500 c.y.

  secondary cell to elevation +10 MLW 4,400 c.y.
- Surface area at elevation +10 Mean Low Water (MLW)

  primary cell 142,400 s.f.

  secondary cell 26,750 s.f.

CDF Operation: The CDF was divided into a primary and secondary cell as shown in the figures. The dredged material entered the primary cell in a slurry that reached a solids content of 40% when dredging cap material. The slurry was discharged both with and without a diffuser attached to the pipeline. The majority of solids settled out in the primary chamber with the water flowing over a weir constructed in the sheetpile wall separating the two cells. At this weir a cationic polymer emulsion (Magnifloc 1596C) was sprayed into the water. The chemically enhanced settling took place in the secondary cell prior to the water being discharged back into the estuary. Contaminated sediment was initially pumped into the CDF followed by clean sediment which was placed to cap the facility. The following table summarizes operations:

Type of Material	Quantity(c.y.)	Days	Hours	Period
Contaminated	2200	23	59.7	21 Nov - 19 Dec
Clean	3920	11	51.5	20 Dec - 4 Jan

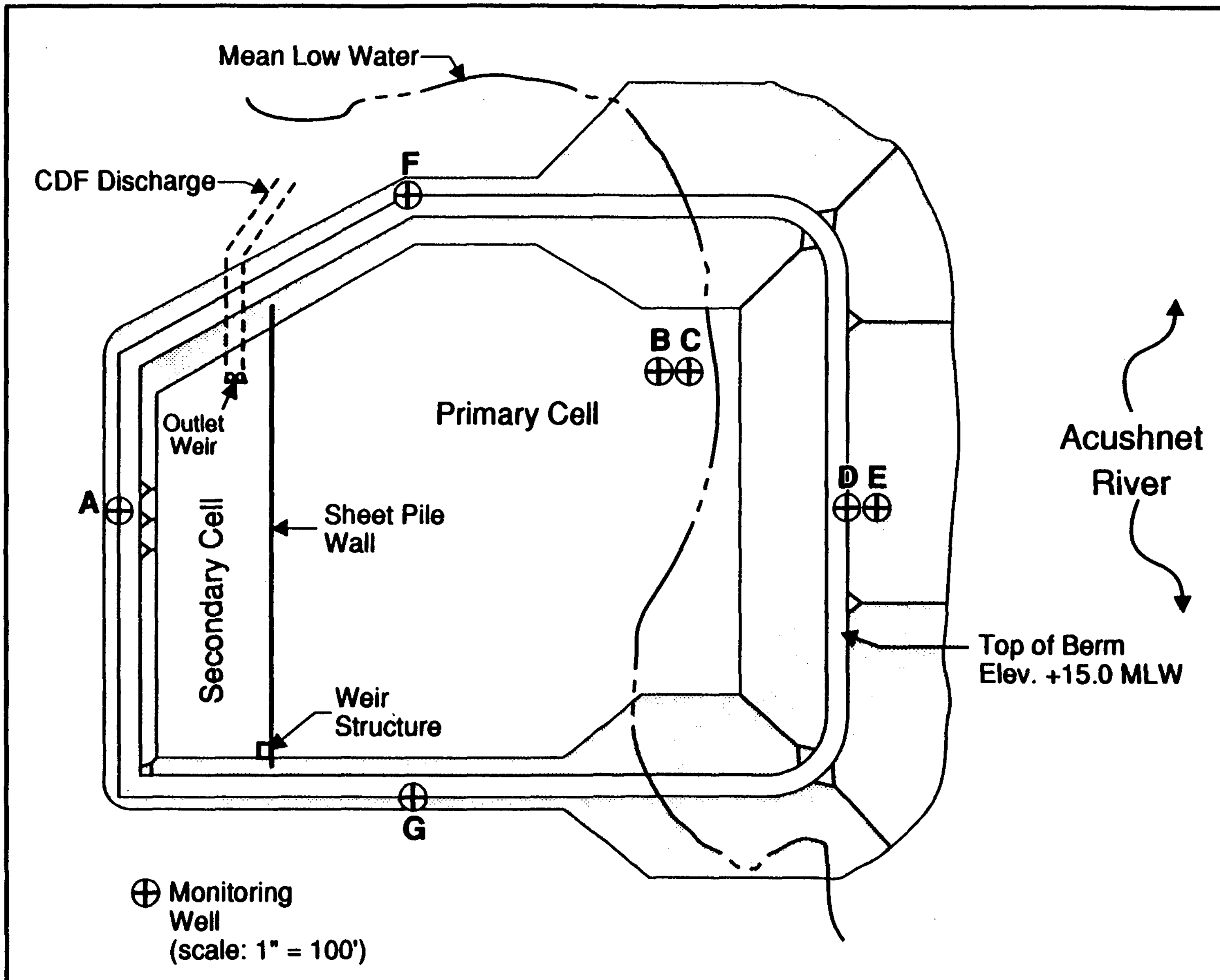


Figure 2-1 Confined Disposal Facility

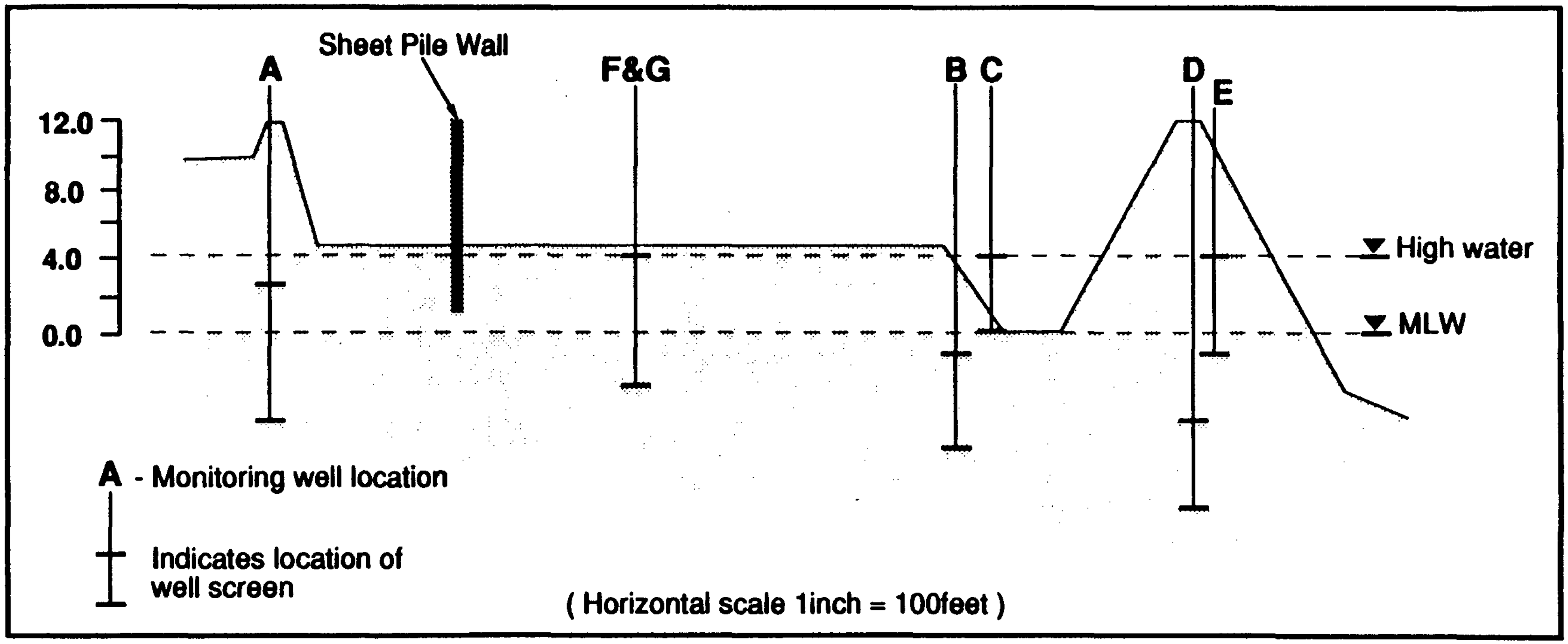


Figure 2-2 Confined Disposal Facility

The boards in the weir between the primary and secondary cell were set to elevation +8.0 MLW at the start of dredging and were not lowered. Water flowed through the weir and leaked through the sheet pile wall during the early stages of dredging and was subsequently discharged from the facility. The water level within the CDF increased as material built up within the facility and dredging periods increased in length. Water began flowing over the weir at elevation +8.0 MLW on 23 December. Additional weir boards were added until the water reached the design elevation at +10 MLW on 3 January.

The system adding polymer to the water flowing over/through the weir between the primary and secondary cells operated for 96.7 hours over a six day period while clean material was being discharged into the CDF. The polymer was mixed with water and sprayed into the flow at the weir at a rate of 2 GPM. The mix of polymer to mixing water was approximately 1 to 1000.

Effluent Suspended Solids: Laboratory settling column data for the EFS composite sample were used in the procedure outlined by Palermo (13) to estimate the effluent suspended solids at the weir between the primary and secondary cells. Results from bench scale jar tests performed for the EFS indicated that more than 82% additional suspended solids reduction could be achieved in the secondary cell following polymer flocculation. These estimates indicated that an effluent suspended solids concentration of 70 mg per liter could be attained.

Sampling was conducted at the weir dividing the cells on 19 days. Samples were taken hourly over varying daily periods with the hourly samples combined into a daily composite. Sampling at the CDF discharge was conducted over a 16 day period following the same procedure. The hourly samples were analyzed to determine the amount of suspended solids. This data is shown on table 1 for both locations. Table 2 shows the daily averages for suspended solids.

The results indicate that our estimate of 70 mg per liter was accurate. The polymer had a significant effect on suspended solids levels during the later stages of the project. During this period, suspended solids levels were high (800 mg per liter) at the primary weir and the polymer significantly reduced these levels prior to discharge from the site. The polymer appeared to have only minimal impacts when suspended solids levels were in the 100 mg per liter range at the primary weir.

Effluent Contaminant Levels: Contaminant release from the CDF discharge is calculated directly from suspended sediment contaminant concentrations and dissolved contaminant concentrations observed in the modified elutriate test. The results of this test on pilot study sediment are contained in appendix 4 and summarized in table 3. Tables 4 and 5 contain the PCB concentrations found in the CDF effluent composite samples. The results are summarized in the following table and indicate that the modified elutriate test provides a conservative estimate of the contaminant loading in the CDF effluent.

	Mean	Std. Dev.	Range	Number	Modified Elutriate Test
Dissolved PCB (ppb)					
Weir	1.9	0.91	0.63 - 4.3	12	8.2
Discharge	1.4	0.63	0.30 - 2.9	11	8.2
Particulate PCB (ppb)					
Weir	9.1	3.10	5.2 - 15.9	12	65.6
Discharge	10.7	3.57	5.0 - 19.2	11	65.6

* This table summarizes data from the period when contaminated sediment was being discharged into the CDF.

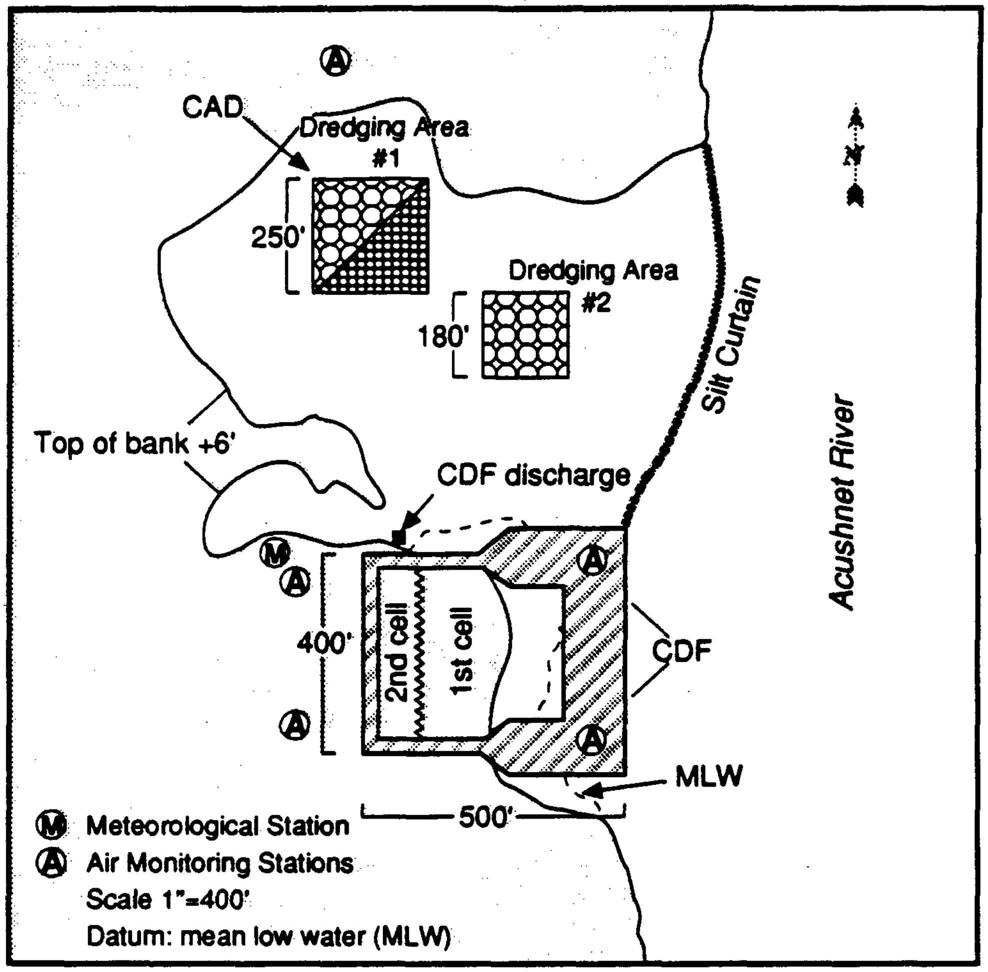


Figure 2-3 Confined Disposal Facility (CDF) and Contained Aquatic Disposal Area (CAD) in the upper Acushnet River Estuary

Leachate: Leachate from the CDF is produced by three potential sources: pore water from the dredged material placed in the site, net precipitation percolating through the dredged material, and ground water or estuary water contacting the dredged material as a result of tidal pumping. The time frame during and immediately after CDF filling represents the greatest potential for leachate flow because it occurs during the maximum head above the CDF bottom and when the dredged material permeability is greatest. As the dredged material consolidates, water is expelled from the dredged material and the permeability of the fine grained sediment is reduced. Not all consolidation pore water expulsion produces leachate. Some of this water is expelled at the surface and evaporates or is drained from the site as CDF effluent. Once the final state of consolidation is reached, net precipitation becomes the primary source of leachate from the site (9).

Seven monitoring wells were installed in and around the CDF to monitor for leachate that may be escaping from the site. The location of the wells are shown in Figures 2-2 and 2-3. Figure 2-4 provides a cross-sectional view of a typical well. The wells were sampled three times prior to the start of CDF filling then three times per week over the six week period that the CDF was filled. They were then sampled weekly for the next three weeks and will be sampled quarterly for the next two years.

No samples have been analyzed to date.

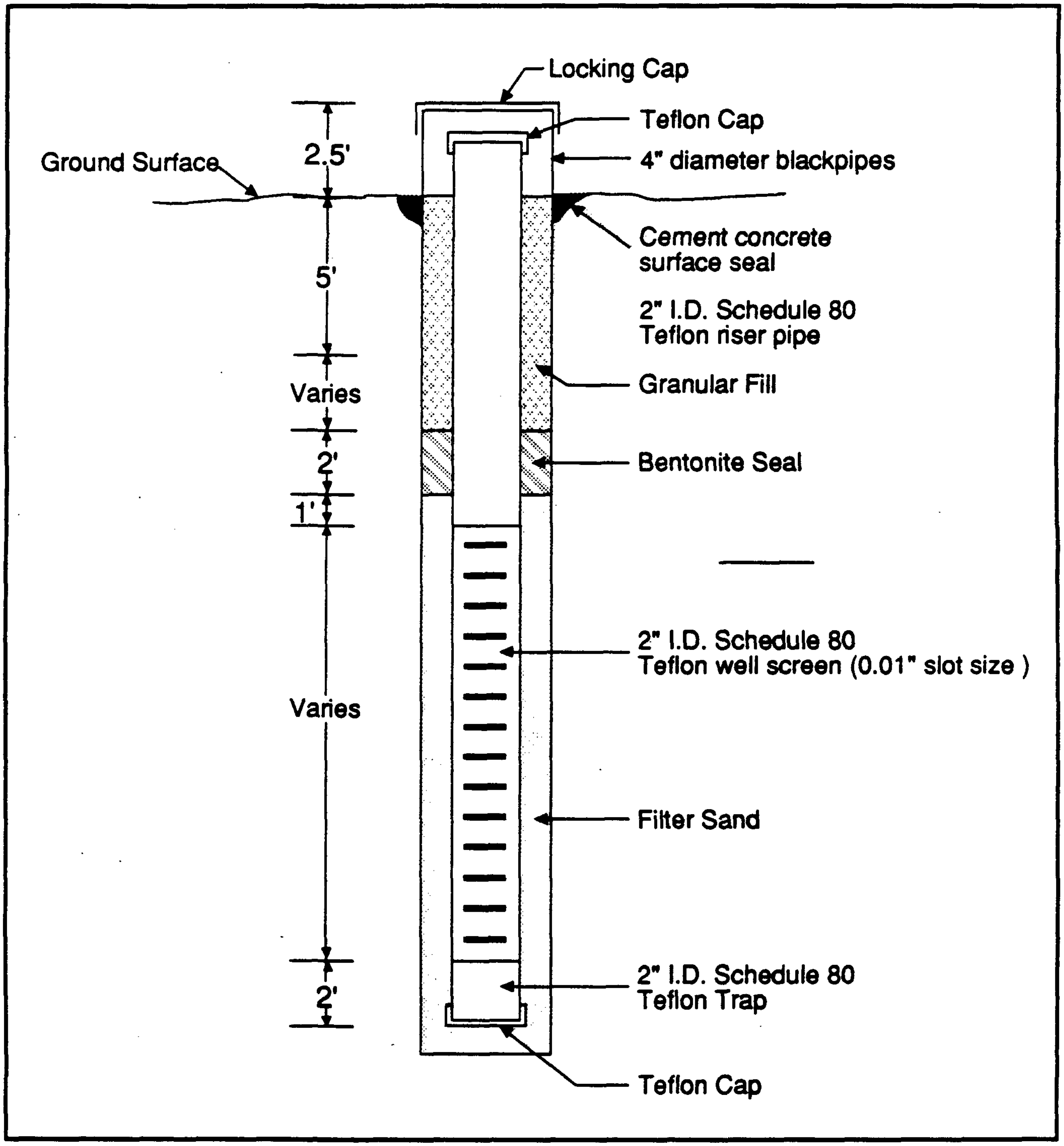


Figure 2-4 Typical Monitoring Well, Confined Disposal Facility

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)

December 2
Dredging for 1.9 hours beginning at 1300 hours

Time	Weir	CDF Discharge
1430 D	60	
1530 D	46	
1630 D	39	
1730	68	
1830	72	
1930	49	
2030	46	
2130	44	
2230	37	
2330	25	
2430	33	

December 3
. Dredging for 4.3 hours beginning at 1300 hours

1330 D	71	
1430 D	103	
1530 D	91	
1630 D	115	
1730 D	133	
1830 D	150	
1930	144	
2030	193	
2130	150	
2230	174	

December 4
Dredging for 1.6 hours beginning at 1615 hours

1630 D	101	
1700 D	102	
1730 D	96	
1800 D	108	
1830 D	102	
1900 D	103	
1930	112	
2000	120	
2030	104	
2100	101	

D- Indicates dredging period

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 5
Dredging began at 1445 - Dredge operating for 3.4 hours

Time	Weir	CDF Discharge
1600 D	19.60	
1700 D	2800	
1800 D	34.40	
1900 D	37.72	
2000 D	38.08	
2100	42.28	
2200	38.76	
2300	3612	
2400	38.28	
0100	57.40	

December 10
Dredging began at 0615 - Dredge operated for 3 hours

Time	Weir	CDF Discharge
0800 D	90.4	124.6
0900 D	91.5	106.0
1000 D	79.2	
1100	91.0	101.6
1200	83.6	101.8
1300	98.4	85.7
1400	14.6	32.8
1500	12.7	32.5
1600	26.6	36.1
1700	20.7	26.0
1800	76.5	32.2
1900	13.5	33.1
2000	20.3	33.6
2100	25.6	33.4
2200	81.7	27.2
2300	79.4	81.8
2400	80.4	82.7
0100	77.4	80.3
0200	80.0	76.8
0300	77.8	84.2
0400	77.2	74.9
0500	80.2	76.3
0600	84.8	80.2

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

Time	Weir	CDF Discharge
December 11		
Dredge operated for only 20 minutes in morning		
0700	20.5	23.0
0800	9.9	10.1
0900	13.2	20.1
1000	20.4	16.3
1100	9.9	12.4
1200	14.8	16.0
1300	44.2	18.0
1400	79.0	8.5
December 12		
Dredge operated for 1.5 hours beginning at 1130 hours		
0700	40.6	26.0
0800	21.4	19.2
0900	19.4	14.7
1000	108.1	48.6
December 13		
Dredge began at 0915. Dredge operated for 2.3 hours		
0800	96.9	94.1
0900	99.4	101.9
1000 D	95.3	100.2
1100 D	64.0	128.0
1200	125.8	123.0
1300	125.8	189.8
1400	208.6	-
1500	-	224.9
1600	216.2	199.4
1700	195.7	205.0
December 16		
Dredge began at 1345. Dredge operated for 2.3 hours		
1400 D	104.6	86.9
1500 D	97.5	84.7
1600 D	83.9	93.7
1700	79.7	71.9
1800	86.4	94.6
1900	25.3	34.7
2000	17.1	32.2
2100	19.7	29.9
2200	14.5	31.8
2300	21.6	30.8
2400	15.6	24.4

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 17

Dredge began at 1320 and operated for 3.7 hours.

Time	Weir	CDF Discharge
1000	22.0	29.0
0200	24.3	26.8
0300	21.7	28.6
0400	19.5	28.7
0500		
0600	38.6	---
0700	64.7	87.7
0800	80.0	92.1
0900	85.3	87.5
1000	91.7	88.8
1100	87.6	99.2
1200	85.2	90.4
1300	90.7	84.0
1400 D	82.2	87.3
1500 D	86.7	88.1
1600 D	38.8	104.6
1700 D	26.3	72.6
1800	27.9	54.8
1900	30.1	45.6
2000	23.5	49.0
2100	26.6	46.1
2200	22.2	48.0
2300	23.2	48.2
2400	15.9	49.9

December 18

Dredging began at 1400 and operated for 3.83 hours.

Time	Weir	CDF Discharge
0100	77.8	122.1
0200	24.2	42.6
0300	21.6	42.8
0400	33.9	45.2
0500	29.8	101.4
0600	28.8	44.6
0700	38.5	43.6
0800	35.6	43.2
0900	32.3	31.0
1000	31.3	30.7
1100	31.4	29.3
1200	29.3	29.1
1300	32.6	31.0
1400	33.3	37.8
1500	26.7 D	30.9
1600	28.3 D	35.9
1700	37.7 D	42.6
1800	41.0 D	68.5
1900	45.1 D	136.4

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 18 (cont'd)

Time	Weir	CDF Discharge
2000	43.6	67.0
2100	38.4	82.3
2200	30.8	85.8
2300	34.0	75.1
2400	41.5	69.8

December 19
Dredging began at 1515 and operated for 3 hours

0100	46.0	64.6
0200	135.5	63.2
0300	59.9	54.7
0400	132.3	59.8
0500	46.6	61.2
0600	63.9	44.7
0700	50.8	44.2
0800	34.3	32.5
0900	23.0	29.1
1000	27.4	22.2
1100	23.1	36.7
1200	24.7	34.2
1300	22.2	30.3
1400	20.6	25.0
1500	25.6 D	32.5
1600	26.5 D	25.8
1700	52.7 D	111.8
1800	54.2 D	84.2
1900	47.8 D	87.4
2000	68.3 D	87.9
2100	95.4 D	83.0
2200	88.1	87.4
2300	85.0	82.7
2400	72.9	91.5

December 20
Dredging began at 1615 and operated for 3.3 hours.
First day dredging cap material

0100	51.1	73.5
0200	61.7	77.6
0300	63.2	82.0
0400	61.7	48.9
0500	88.4	142.2
0600	245.8	240.3
0700	215.1	212.3
0800	192.5	193.8
0900	206.5	228.9
1000	189.1	183.1
1100	213.4	200.2
1200	204.2	191.9
1300	198.6	197.4

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 20 (cont'd)

Time	Weir		CDF Discharge	
1400	201.9		184.1	
1500	202.2		193.7	
1600	197.7	D	211.0	
1700	43.7	D	47.0	
1800	41.5	D	46.1	
1900	52.6	D	49.3	
2000	102.4	D	52.5	
2100	84.2	D	56.0	
2200	84.2		60.4	
2300	59.6		54.7	
2400	74.5		55.3	

December 21
Dredging Began at 0515. Dredge operated for 4+ hours.
Polymer system started at 0920.

Time	Weir		CDF Discharge	
0100	53.6		68.4	
0200	63.6		52.1	
0300	64.9		53.8	
0400	61.0		60.0	
0500	69.6	D	53.8	
0600	102.0	D	99.0	
0700	127.4	D	110.5	
0800	215.4	D	183.9	
0900	144.3	D	142.6	P
1000	91.9		143.8	P
1100	252.2		211.9	P
1200	245.1		161.4	P
1300	228.3		46.0	P
1400	100.6		40.6	P
1500	241.0		125.3	P
1600	202.1		158.2	P
1700	58.6		30.0	P
1800	63.1		53.8	P
1900	56.7		39.4	P
2000	76.0		37.0	P
2100	62.0		35.7	P
2200	54.5		33.4	P
2300	59.7		33.3	P
2400	56.6		33.0	P

P - Indicates that polymer system was operating

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 22
Dredge began at 0540. Dredge operated for 3.7 hours

Time	Weir		CDF Discharge	
0100	56.6		38.1	P
0200	54.8		36.0	P
0300	51.1		28.1	P
0400	44.8		19.1	P
0500	35.1	D	34.7	P
0600	90.8	D	31.2	P
0700	120.2	D	74.6	P
0800	136.5	D	115.5	P
0900	178.4	D	168.2	P
1000	140.9		93.2	P
1100	102.8		67.0	P
1200	100.2		68.6	P
1300	48.5		68.6	P
1400	51.6		56.9	P
1500	24.6		45.4	P
1600	28.3		48.1	P
1700	40.7		42.4	P
1800	60.8		56.6	P
1900	65.0		41.0	P
2000	57.4		41.8	P
2100	72.2		41.0	P
2200	48.9		32.4	P
2300	187.4		51.9	P
2400	54.4		32.9	P

December 23
Dredging began at 0600. Dredge operated for 4.4 hours

0100	44.5	44.0	P
0200	33.2	29.2	P
0300	60.4	42.9	P
0400	37.6	25.4	P
0500	42.7	27.1	P

No Dredging on 12/24, 12/25, & 12/26

27 Dec. Dredge operated for 4.2 hours between 0900-1300

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 28
Dredging began at 0800. Dredge operated for 5.8 hours
Polymer system turned on at 0915

Time	Weir	CDF Discharge
0600	212.2	209.0
0700	171.2	181.0
0800	171.7 D	180.1
0900	314.5 D	73.7 P
1000	376.5 D	71.9 P
1100	681.4 D	107.7 P
1200	812.1 D	257.7 P
1300	630.5 D	203.6
1400	895.4 D	165.2 P
1500	785.9	264.7 P
1600	280.3	70.6 P
1700	170.5	83.5 P
1800	169.5	186.0 P
1900	134.4	94.7 P
2000	178.9	77.4 P
2100	123.6	78.0
2200	131.4	68.6
2300	212.6	52.6 P
2400	85.8	49.9 P

December 29
Dredging began at 0800. Dredge operated for 5 hours

Time	Weir	CDF Discharge
0100	62.3	59.8 P
0200	183.0	93.4 P
0300	110.8	57.4 P
0400	77.6	47.6 P
0500	66.8	47.6 P
0600	211.5	172.6 P
0700	206.5	147.5 P
0800	192.4 D	152.1 P
0900	506.5 D	155.1 P
1000	687.8 D	159.4 P
1100	637.9 D	577.4 P
1200	695.4 D	181.0 P
1300	812.4 D	152.6 P
1400	689.4 D	149.0 P
1500	424.8	58.6 P
1600	394.9	153.7 P
1700	152.9	85.7 P
1800	109.4	50.2 P
1900	78.9	48.7 P
2000	86.5	63.9 P
2100	35.9	40.0 P
2200	62.2	47.6 P
2300	62.6	49.2 P
2400	55.1	42.9 P

Table 1
Confined Disposal Facility
Effluent Suspended Solids (mg/l)
(continued)

December 30

Time	Weir	CDF Discharge
0100	71.0	135.2 P
0200	58.2	50.8 P
0300	56.6	33.0 P
0400	58.6	119.0 P
0500	60.2	39.1 P

Table 2
Confined Disposal Facility Effluent Suspended Solids (mg/l) Daily Averages

Date	Weir	Discharge	Number of Samples
December 2	47		11
December 3	132		10
December 4	105		10
December 5	37		10
December 10	50	61	17
December 11	49	48	14
December 12	47	27	4
December 13	136	152	9
December 16	51	56	11
December 17	47	64	24
December 18	35	57	24
December 19	55	59	24
December 20	131	128	24
December 21	115	84 P(1)	24
December 22	77	56 P	24
December 23	44	34 P	5
December 28	344	130 P	19
December 29	276	97 P	24
December 30	61	75 P	5

1) P indicates that polymer system was operating

Table 3
Modified Elutriate Test Dredge Area I

Sample No.	Description	Suspended Solids (mg/l)	Total PCB's (ppb)
3532	E (F)		6.24
3533	E (F)		8.85
3534	E (F)		9.38
3535	E (U)	129	70.30
3536	E (U)	167	87.20
3537	E (U)		63.90
3514	SW (F)		0.06
3515	SW (F)		0.19
3516	SW (F)		0.14
3517	SW (U)		0.52
3518	SW (U)		0.36
3519	SW (U)		0.51

E - Modified Elutriate
SW - Site Water
F - Filtered (dissolved)
U - Unfiltered (total)

Comparison

	Dissolved PCB	Particulate PCB (ppb)	Total PCB (ppb)
Site Water	0.06	0.46	0.52
	0.19	0.17	0.36
	0.14	0.37	0.51
Avg.	0.13	0.33	0.46
Modified Elutriate	6.24	64.10	70.30
	8.85	78.30	87.20
	9.38	54.50	63.90
Avg.	8.16	65.63	73.80

Table 4
Confined Disposal Facility Effluent PCB Levels
Primary Weir

Date	Sample No.	TSS (mg/l)(1)	PCB (ppb)
Dec. 2	514025	47	5.2 FWC
	514025		1.3 WFC
Dec. 3	514050	132	8.5 FWC
	514050		2.4 WFC
Dec. 4	514075	105	6.4 FWC
	514075		2.4 WFC
Dec. 5	514100	37	8.2 FWC
	514100		2.0 WFC
Dec. 10	514150	58	6.6 FWC
	514150		1.9 WFC
Dec 11	514175	49	8.7 FWC
	514175		2.4 WFC
Dec. 12	514125	47	7.2 FWC
	514125		1.8 WFC
Dec. 13	514200	136	12.9 FWC
	514200		4.3 WFC
Dec. 16	514275	51	6.4 FWC
	514275		1.4 WFC
Dec. 17	514300	47	12.4 FWC
	514300		1.3 WFC
Dec. 18	514325	35	15.9 FWC
	514325		1.0 WFC
Dec. 19	514350	55	10.8 FWC
	514350		0.6 WFC
Dec. 20	514375	131	5.3 FWC
	514375		0.8 WFC
Dec. 21	514400	115	1.2 FWC
	514400		0.2 WFC
Dec. 22	514425	77	0.9 FWC
Dec. 28	514450	344	0.4 FWC
	514450		0.5 WWC
Dec. 29	514475	276	2.1 FWC
	514475		1.8 WWC

(1) These values represent the average of the hourly samples analyzed on that day.

WWC = Whole Water Composite (total)
FWC = Filtered Water Component (particulate)
WFC = Water Filter Component (dissolved)

Table 5
Confined Disposal Facility Effluent PCB Levels Discharge
Discharge

Date	Sample No.	TSS (mg/l)(1)	PCB (ppb)
Dec. 9	515125		7.2 FWC
	515125		2.9 WFC
Dec. 10	515150	61	10.8 FWC
	515150		1.5 WFC
Dec. 11	515175	48	9.0 FWC
	515175		1.7 WFC
Dec. 12	515100	27	9.2 FWC
	515100		1.3 WFC
Dec. 13	515200	152	19.2 FWC
	515200		1.7 WFC
	515225		5.0 FWC
	515225		1.8 WFC
Dec. 15	515250		13.9 FWC
	515250		1.0 WFC
Dec. 16	515275	56	10.2 FWC
	515275		8.3 WFC
	515275		0.9 WFC
Dec. 17	515300	64	10.5 FWC
	515300		1.2 WFC
Dec. 18	515325	57	13.3 FWC
	515325		1.0 WFC
Dec. 19	515350	59	11.7 FWC
	515350		0.3 WFC
Dec. 20	515375	128	7.4 FWC
	515375		0.8 WFC
Dec. 21	515400	84	2.2 FWC
	515400		0.5 WFC
	515400		0.1 FWC
Dec. 22	515425	56	0.6 WFC
	515425		0.2 FWC
Dec. 28	515450	130	0.3 FWC
	515450		0.2 WWC
Dec. 29	515475	97	0.5 FWC
	515475		0.3 WWC

(1) These values represent the average of the hourly samples analyzed on that day.

WWC = Whole Water Composite (total)
FWC = Filtered Water Component (particulate)
WFC = Water Filter Component (dissolved)

APPENDIX 3

Contained Aquatic Disposal

June 1989

Interim Report

APPENDIX 3
CONTAINED AQUATIC DISPOSAL

Contained aquatic disposal (CAD) involves the dredging of the contaminated sediment, placement in a pre excavated subaqueous pit, and capping with clean sediment. It is similar to level bottom capping but with the additional provision of some form of lateral confinement to minimize the spread of material (9). The dredged material slurry is discharged through a submerged diffuser to control the placement of material and minimize contaminant release during placement. The concept is illustrated in Figure 3-1.

Physical Dimensions: The CAD cell was created in dredge area 1 while removing clean material to cap the confined disposal facility. It is approximately 180 feet by 140 feet in size. The bottom elevation of the excavated cell is generally at -6.0 feet MLW with a 50 foot by 50 foot section at -8.0 MLW. Two typical cross sections of the cell are shown in Figure 3-2.

Dredging and Disposal Operations: All three dredges were used to move contaminated material from dredge area 2 to the CAD cell. The following table summarizes operations.

DATE	DREDGE *	OPERATING HOURS
1-7	CH	0.67
1-8	CH	4.25
1-9	MB	1.48
1-10	MB	3.70
1-11	MB	4.00
1-12	MB	4.17
1-13	MB	1.30
1-14	HA	0.75
1-15	HA	5.67
1-18	CH	3.50
1-19	CH	3.25
1-20	CH	3.00

* CH - Cutterhead Dredge
MB - Matchbox
HA - Horizontal Auger

Totals:
- Days: 12
- Hours: 35.7
- Material: 719 cubic yards
  - Cutterhead Dredge: 233 cubic yards
  - Matchbox Dredge: 359 cubic yards
  - Horizontal Auger Dredge: 127 cubic yards

A typical cross section of the CAD cell after filling with contaminated sediment is shown in Figure 3-3.

The Cutterhead dredge was used to cap the CAD cell. It operated over an 18 day period for a total of 64 hours. The cap material came from the section of dredge area 2 from which contaminated material had been removed.

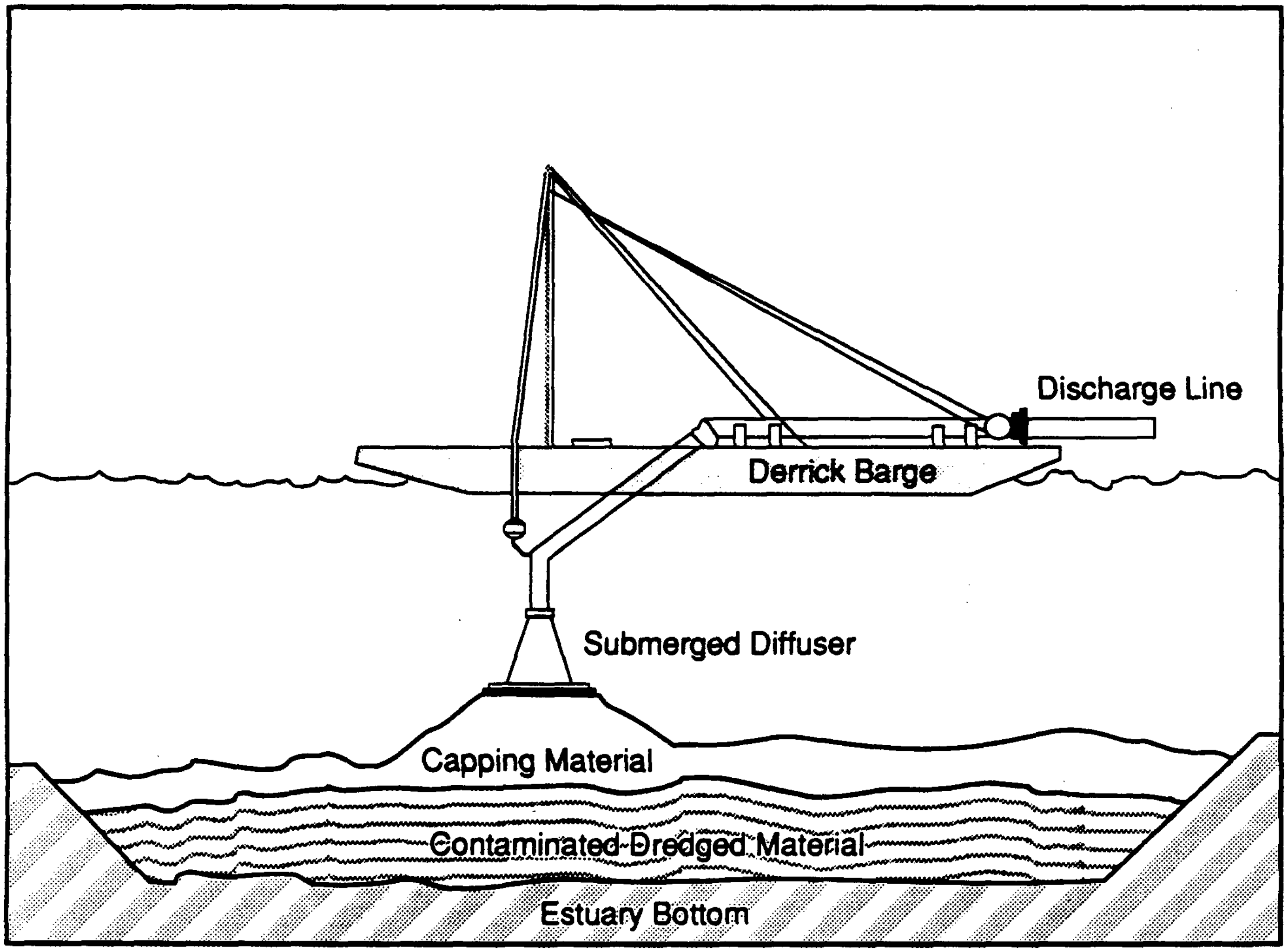


Figure 3-1 Contained Aquatic Disposal (CAD) Cell Filling with a Submerged Diffuser

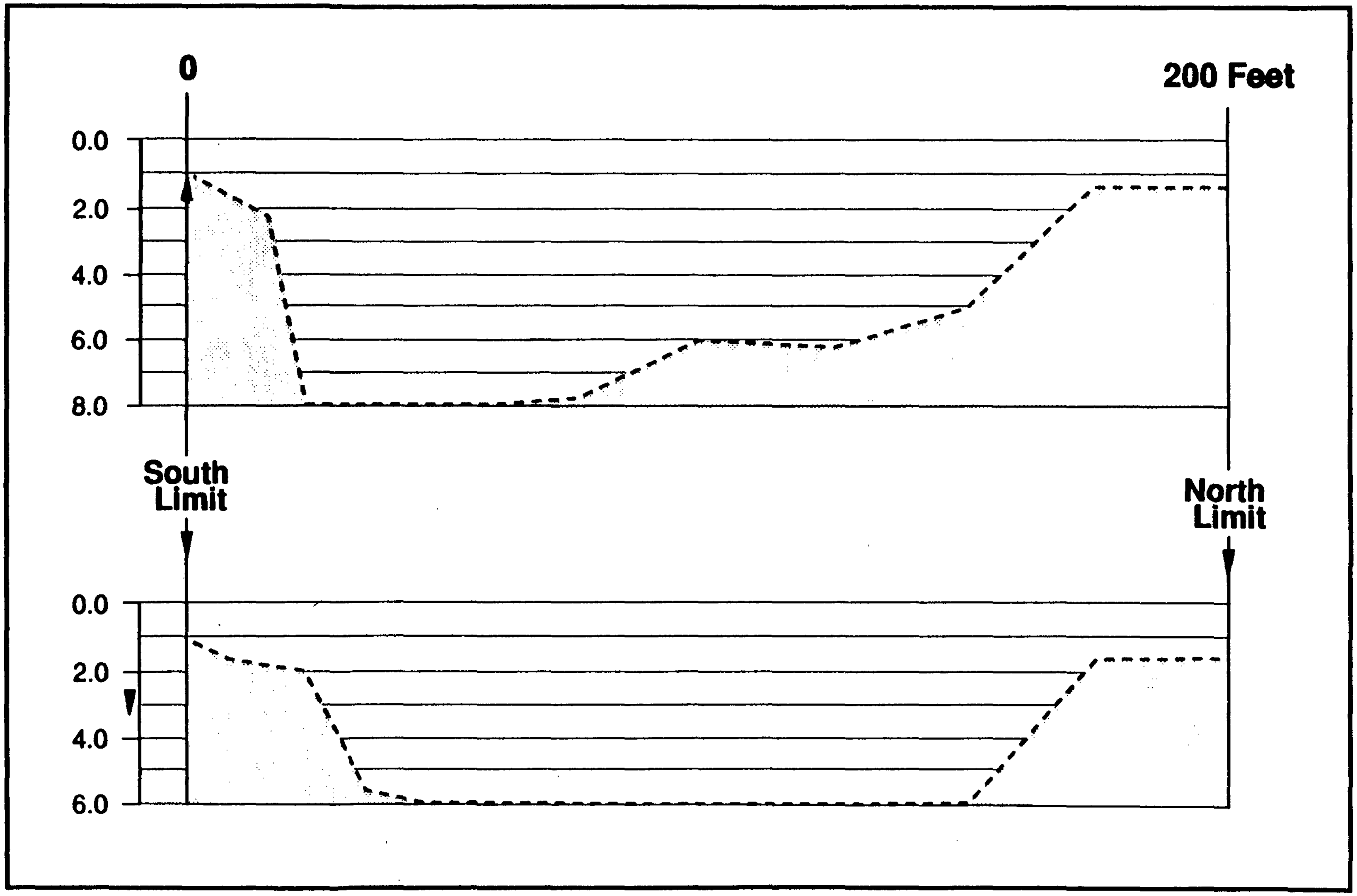


Figure 3-2 Contained Aquatic Disposal Cell

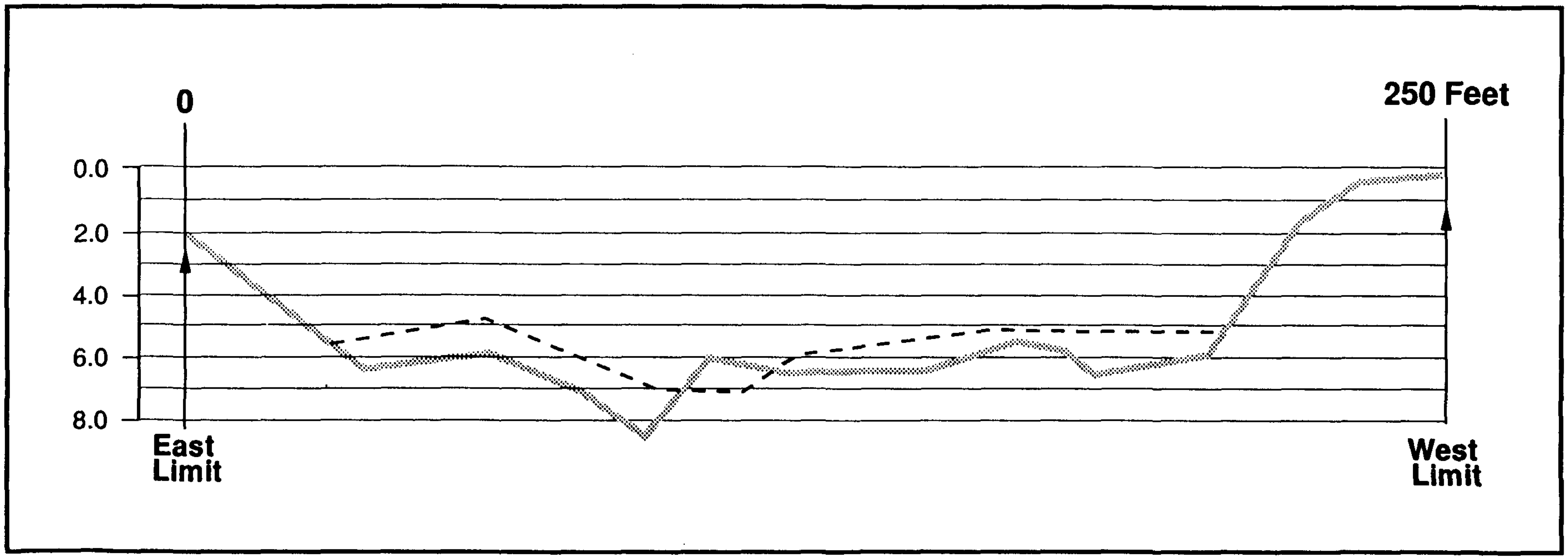


Figure 3-3 Contained Aquatic Disposal Cell
(after filling with contaminated sediment)

Sediment Resuspension: A predictive test for estimating the mass of suspended sediment release in the CAD cell during filling has not been developed. In Report 11 of the EFS a sediment release rate of 1 percent of the dredging rate was used in making estimates of contaminant release. This percentage was arrived at using column settling test data and other studies of sediment loss during open water disposal of dredged material. Based on the solids content of the dredged material slurry measured while pumping into the CDF, the effluent total suspended solids content at the discharge point would be 40 grams per liter.

An array of stations was established around the CAD cell and these stations were sampled hourly during the filling operation. Figures 3-4 and 3-5 show the location of these stations and the position of the discharge within the CAD cell. Tables 1 and 2 contain suspended solids data from the various stations on the first four days of CAD filling. Background levels in the cove are generally less than 10 mg/l. During CAD filling levels were elevated above background and increased as the length of the dredging period increased. The data indicated that a plume of resuspended sediment was moving away from the CAD cell.

Sampling carried out at monitoring station 7 (NBH7) during the CAD operation also detected elevated levels of suspended solids. Station 7 is located at the mouth of the cove, approximately 800 feet from the point of disposal. The following table shown the average suspended solids level of five hourly samples taken on the ebb tide at station 7 while CAD was taking place.

Date	Average TSS (mg/l)
7 January	11
8 January	37
9 January	29
10 January	40
12 January	33
14 January	26
18 January	54

Average ebb tide suspended solids levels detected during earlier phases of the pilot study averaged 5.0 mg/l and ranged from 1.7 to 16.0 mg/l.

Contaminate Release: The suspended and soluble PCB concentrations from the standard elutriate test are used with the sediment release rate to estimate the flux of PCBs away from the discharge point within the cell. Composite samples were formed from a combination of samples taken at the individual stations (example: station 1-5, hour 3). These samples were analyzed for PCBs with the results shown on Table 3.

CAD was predicted to release the largest quantity of PCBs when compared to the other pilot study operations. PCB levels detected were elevated above background and also exceeded levels detected during the earlier phases of the study. The data shown in Table 3 is summarized below:

Total PCB (ppb)

Station	Mean	Std. Dev.	Minimum	Maximum	Number
1-5	13.4	10.76	2.5	31.8	5
6-10	6.8	5.13	1.5	15.3	4

PCB levels detected at monitoring station 2 and station 7 during CAD are compared with background conditions and other phases of the pilot study in Table 4. The PCB levels detected at the Coggeshall Street Bridge did not represent a statistically significant increase above background conditions.

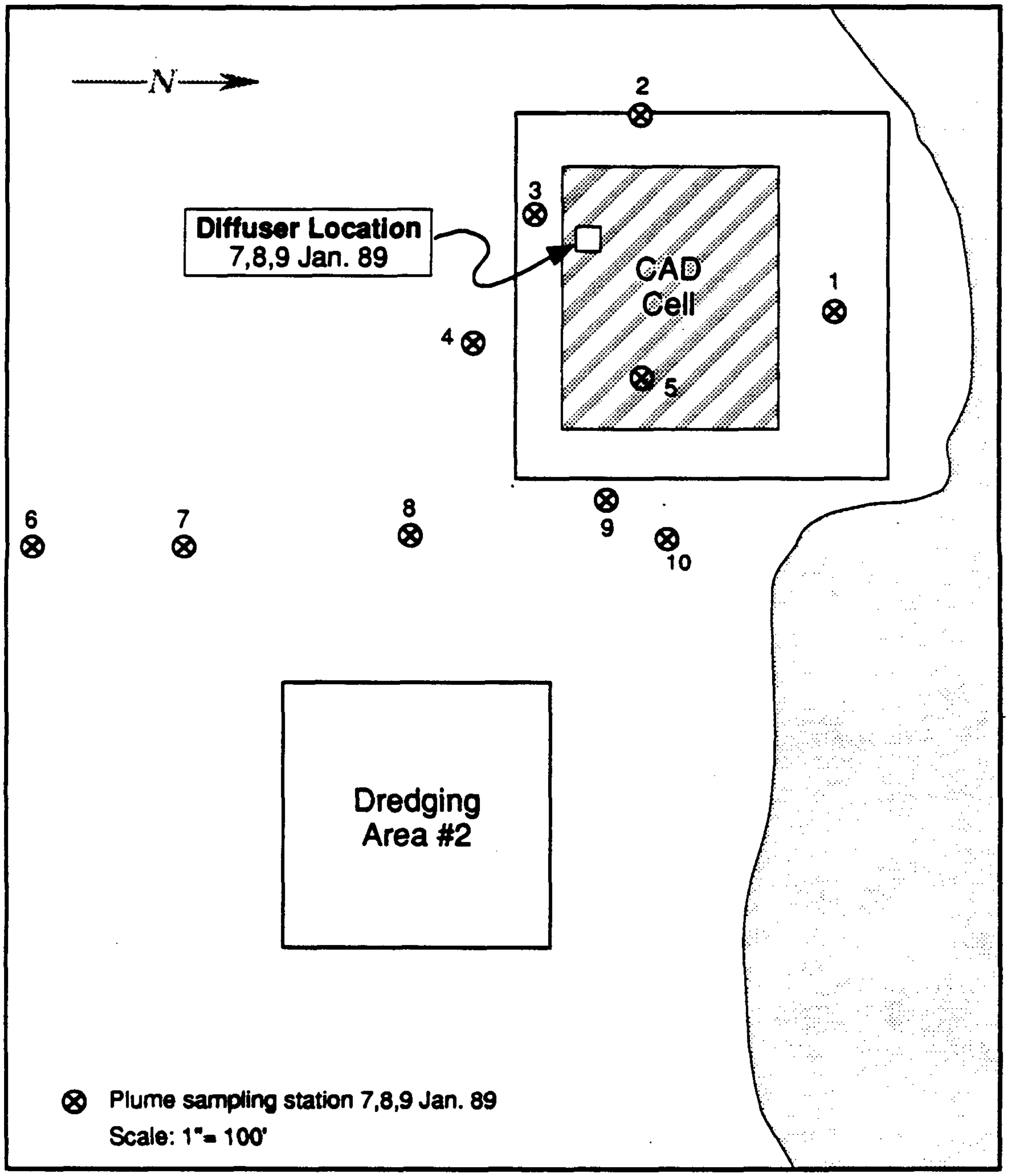


Figure 3-4 Plume Sample and Diffuser Locations

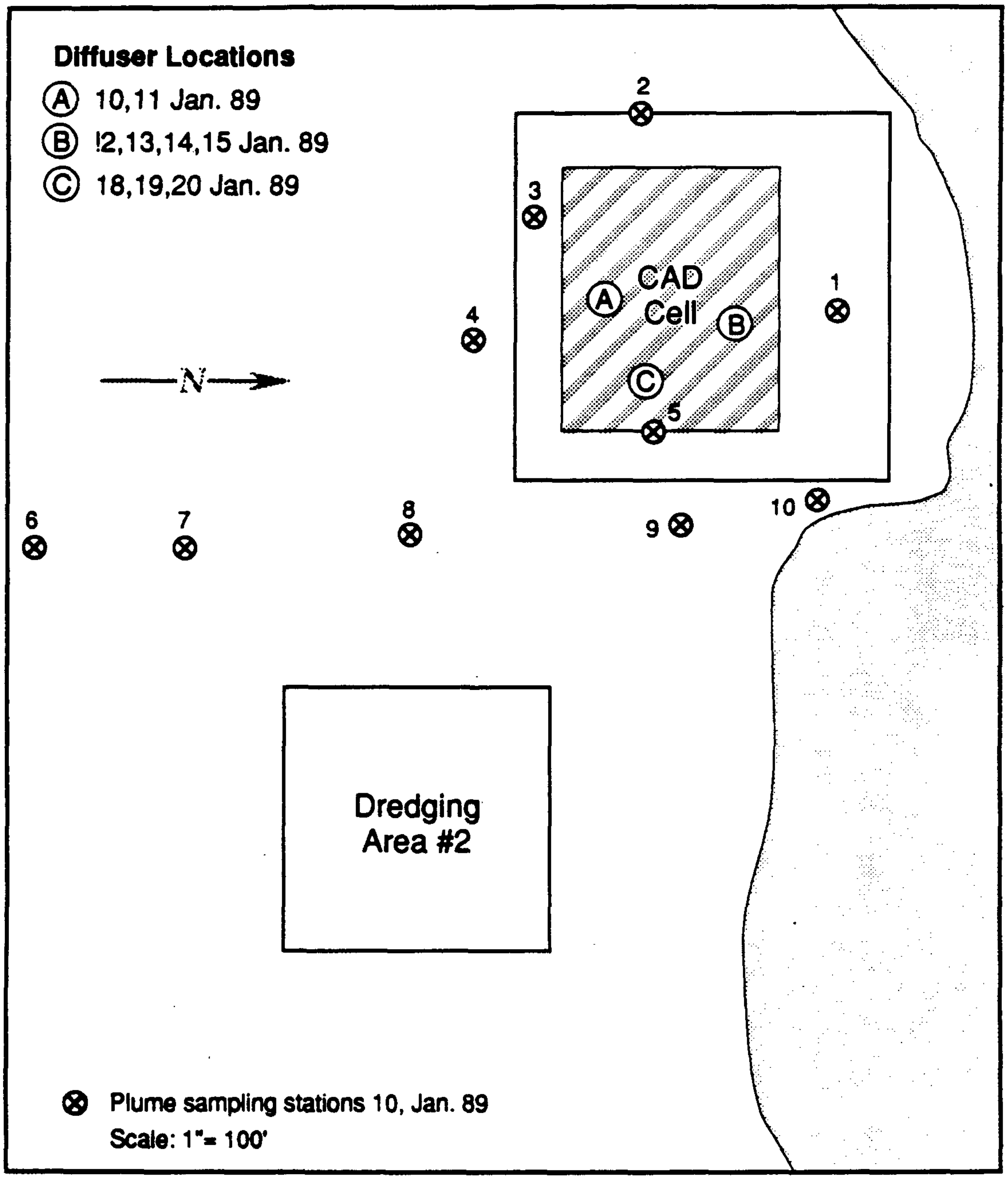


Figure 3-5 Plume Sample and Diffuser Locations

Control Measures: The following types of control measures were applied in an effort to maximize the amount of contaminated material removed while minimizing the resuspension of these materials:

- Diffuser: As mentioned earlier, a diffuser was attached to the discharge end of the pipeline to reduce the exit velocity of the dredge slurry. It appeared to be effective in reducing sediment resuspension and in controlling the placement of contaminated and cap material. It was most effective when situated approximately two feet above the bottom.

- Silt Curtain: A curtain was not in place during most of the CAD operation. The elevated levels of suspended solids detected indicate that a curtain deployed around the disposal point may reduce dispersion of suspended solids.

Capping Effectiveness: An estimated 2-3 foot cap of clean sediment was placed over the 6-12 inch layer of contaminated sediment. The area will be surveyed and a typical cross section of the CAD cell after capping will be shown. Sediment cores will also be taken within the CAD cell. These cores will be divided into 6 inch horizons and analyzed for PCBs. Toxicity testing will also be performed using the *Ampelisca abdita*. This sediment sampling effort will be carried out on two occasions. The initial samples will be taken in June 89 to determine if contaminants were mixed with the clean sediment during the capping operation. The second effort will be carried out in mid-1990 to determine if contaminants are migrating up into the cap material. This appendix and section of the main report will be updated when these results become available.

Table 1
Plume Sampling During CAD (TSS mg/l)

January 7
Cutterhead Dredge

Station	Sampling Event 1040-1052	1112-1120
1	138.8	131.9
2	29.9	100.2
3	19.8	44.9
4	16.4	143.0
5	18.6	96.1
6	12.6	
7	57.8	15.8
8	11.2	15.9
9	22.4	38.6
10	80.3	83.7

Dredge operating from 1020-1100.

January 8
Cutterhead Dredge

Station	Sampling Event 0745-0755	0845-0855	0945-0955	1045-1055	1138-1148
1	10.3	9.6	12.8	18.0	81.8
2	13.6	12.9	30.5	29.8	197.3
3	25.8	75.8	85.3	263.9	917.6
4	16.9	10.5	25.6	61.2	54.7
5	11.1	7.9	70.3	131.6	16.8
6	13.0	13.3	42.8	26.8	10.5
7	15.8	12.6	16.0	58.5	1407.8
8	71.9	14.8	25.4	28.4	171.3
9	79.4	17.0	19.2	49.6	38.6
10	12.6	7.6	11.5	95.0	

Dredge operating from 0715-1155

Table 2
Plume Sampling During CAD

January 9
Matchbox Dredge

Plume Sampling (TSS mg/l)

Station	Sampling Event 0905-0912	1105-1112	1128-1135
1	18.7	39.0	54.0
2	25.4	150.2	461.2
3	163.6	57.6	723.1
4	21.2	96.5	114.8
5	19.3	53.7	59.2
6	18.8	44.6	47.7
7	18.0	52.4	63.3
8	16.8	49.9	55.9
9	20.6	46.8	69.8
10	12.8	13.6	59.5

Dredge operating for 1.5 hours between 0900 and 1145.

January 10
Matchbox Dredge

Station	Sampling Event 0850-0900	0950-1000	1050-1100	1145-1155	1245-1255
1	--	94.1	48.6	83.8	343.6
2	26.8	80.0	84.6	151.8	233.7
3	30.3	28.7	44.1	125.2	145.2
4	50.3	13.2	31.4	65.1	75.0
5	17.6	60.7	34.3	108.2	98.0
6	10.5	11.7	14.5	18.0	31.3
7	15.0	15.8	27.6	38.0	44.8
8	12.0	28.5	32.8	120.6	110.9
9	14.0	48.7	48.7	133.9	279.1
10	79.2	181.0	73.7	--	--

Dredge operating for 3.8 hours between 0830 and 1230

Table 3
Plume Sampling Stations PCB Analysis Contained Aquatic Disposal

Date	Sample No.	Time	Station	TSS (mg/l)	PCB(ppb)	Dredge
1-7	516051	-	1-5	67	2.50WWC	CH
	516052	-	6-10		2.56 FWC	CH
	516052	-	6-10		0.50 WFC	CH
	516053	-	6-10	39	5.80 WWC	CH
1-8	516151	1138-1148	1-5		6.23 WWC	CH
	516152	1138-1148	6-10		3.13 FWC	CH
	516152	1138-1148	6-10		4.66 WWC	CH
1-9	516251	1105-1112	1-5	80	19.10 WWC	M
	516252	1128-1135	6-10		4.01 FWC	M
	516253	1128-1135	1-5	59	31.80 WWC	M
	516254	1128-1135	6-10		5.45 FWC	M
1-10	516351	1245-1255	1-5	179	7.29 WWC	M
	516352	1145-1155	6-10		40.80 FWC	M
	516352	1145-1155	6-10	78	1.53 WWC	M
	516353	1245-1255	6-10	117	15.30 WWC	M
1-12	516552	--	#3		3.09 FWC	M
1-13	516652	--	#3		4.45 FWC	M

CH - Cutterhead dredge
M - Matchbox dredge

Table 4
Contained Aquatic Disposal Monitoring Stations 2 & 7 EBB Tide PCB Analysis

Station	Date	Total PCB (ppb)
2	7 January	0.61
7		0.92
2	8 January	0.69
7		3.12
2	9 January	1.50
7		5.42
2	10 January	1.04
2	11 January	0.86
7		3.70
2	12 January	0.74
7		1.50
2	14 January	0.74
7		0.87

Average EBB Tide

Station	Period(1)	PCB Level (ppb)	Range
2	1	0.60	0.3 - 1.2
2	2	0.57	0.26 - 0.97
2	3	0.88	0.61 - 1.50
7	2	1.05	0.31 - 1.94
7	3	2.59	0.87 - 5.42

(1) Period 1 - Preoperational - prior to the start of CDF construction
Period 2 - Days when dredge operated for more than 1 hour with disposal in CDF
Period 3 - Dredging with CAD

APPENDIX 4

Environmental Monitoring Program

June 1989 Interim Report

Appendix 4 Environmental Monitoring Program

INTRODUCTION

The high levels of pollution in the sediments and the extensive regulatory controls over toxic substances greatly restricted the monitoring protocol on this experimental project. The limited availability of field toxicological testing procedures with short turn around time, ERLN ongoing extensive efforts in designing standard testing protocols for waste water discharges (15), and the regulatory directives to insure no increased environmental degradation during this experiment further reduced the options of environmental effects monitoring protocols. The focus of this monitoring effort was to present the results in the minimum amount of time to allow for changes in the ongoing construction activities. This would insure that the dredging would continue in a timely fashion without an increase in the degradation of the harbor. The physical configuration of the harbor, along with the numerous discharges into it make the hydrodynamics very complex. It was assumed that several structures which restrict the flow to narrow channels control circulation in the harbor. Water leaving the upper estuary is restricted to the narrow channel under the Coggeshall Street bridge and water leaving the harbor passes through the 150 foot wide channel at the hurricane barrier. Release of contaminants past these points would be unacceptable to those regulating the project. It was also assumed, that existing contaminant releases would not influence pilot study monitoring results or their interpretation.

This monitoring program was designed by personnel from ERLN, EPA Region I , and the Corps of Engineers, with the following objectives:

- evaluation of dredging and disposal effectiveness
- water quality prediction for full-scale operations
- assessment of monitoring protocol, operation regulation, and environmental protection

The following summarizes the results of the physical, chemical, and biological monitoring that was conducted during the pre-construction, construction, and post-construction periods, with the primary focus on sampling at the Coggeshell Street Bridge. Presently post-contruction monitoring data is unavailable and will be released at a later date. The physical data includes: currents, tides, temperature, salinity, and suspended solids measurements. The chemical data included water column levels for: polychlorinated biphenyl (PCBs), cadmium (Cd), copper (Cu), and lead (Pb). Five (5) biological testing protocol were used: *Arbacia punctulata* (sea urchin) sperm cell fertilization, *Champia parvula* (red alga) number of cystocarps developed, *Cyprinodon variegatus* larval (sheepshead minnow) survival and growth, *Mysidopsis bahia* (mysid) survival and growth, and *Mytilus edulis* (blue mussel) scope for growth (SFG) measurements and increased shell length.

These monitoring protocols were chosen from numerous other chemical and biological assay methods for the following reasons; existing toxicity testing protocol that had been previously developed and evaluated, existing indepth knowledge of tests by ERLN personnel, test organisms previously used in assay work, which were easily maintained and cultured in the laboratory; levels of toxicity known for each test organism, demonstrated screening and sensitivity abilities; reproducible results, acceptability to local regulatory agencies, short turn around time for results; and, with some, procedural flexibilities. All physical and chemical testing protocols were in the water column and followed Standard Methods (15). The following paragraph presents a brief background on the selected biological monitoring procedures.

A two week *C. parvula* toxicity test method has been evaluated with arsenite and arsenate (16) and 10 different organic compounds (17). These tests indicate that sexual reproduction is generally the most sensitive and practical endpoint to use for *C. parvula* as a test organism. The *A. punctulata* sperm cell toxicity test has been employed in the marine complex effluent testing program at ERLN since 1983 (18). Dinnel has demonstrated that *A. punctulata* gametes are sensitive to a wide range of toxicants including metals and complex effluents from industrial wastewater. The 28 day life-cycle *M. bahia* test has been used for several metals (19, 20, 21) and pesticides (22). These have extensive use and demonstrate that reproduction is a sensitive indicator of sublethal toxic effects on mysids. A 7 day modification of this test was undertaken during this monitoring program. Fish mortality from toxic effects often occurs in the first 2 weeks post-hatch period (23, 24). Complete and partial life cycle toxicity tests have demonstrated that early life stage tests have been reasonable predictors of chronically safe environmental concentrations of toxicants and that the embryonic and larval fish stages are often the most sensitive life stages (25, 26). Because the *C. variegatus* test uses both larval growth and survival as endpoints, it can reliably predict the chronic toxicity. The test used for this monitoring program was an adaptation of the procedure for the *Pimephales promelas* test (27). *M. edulis* SFG and shell growth increases have been used throughout the world and are currently employed in numerous marine pollution trend studies. These *M. edulis* results may be compared and contrasted with other studies.

The use of biological testing to monitor human-induced changes is well documented in the literature (28, 29). Physiological changes in marine biological organisms have been used to demonstrate effects of pollutants for decades. There presently exist numerous biological testing organisms which have proven to be very accurate indicators of potential environment problems associated with contaminant removal. Many of these other organisms and assay methods may be more appropriate to assess contaminated sediment dredging and disposal effects. Community changes have also been used, and, in some situations makes a better prediction (30). Log-normal plots (30a), expected species (31, 32) and canonical correlation analysis (33), among other methods, have been used for years to detect pollutant impacts along gradients at the community level. All of these assessment methods have their specific uses for the monitoring of pollution effects. A variety of testing protocols may be more appropriate during a full scale clean-up effort in the New Bedford Harbor.

Pre-construction monitoring was undertaken by ERLN during July and September 1987 and May and June 1988 to collect existing water quality data and adjust monitoring methods. These same personnel undertook monitoring during construction activities and will undertake post-construction monitoring activities. The monitoring of the pilot study took place from July 1988 to February 1989. A detailed summary of the daily monitoring results are presented elsewhere. Only specific physical, chemical, and biological results are presented in this appendix.

METHODS

Field:

Water samples were collected, using hand-operated pumps, at 4 stations in the harbor (Figure 4-1). All 4 stations were located within the harbor based on the assumption that physical restrictive water passage points control circulation and release of contaminants past these points during construction activities would be unacceptable. At stations 1, 2, 4, and 7 daily ebb and flood tide composite samples (5/day) were collected by pumping 2 l. aliquots each from the surface (-0.5m), mid-water depth, and bottom (.5m off the sediment) at each of five hourly intervals during both tides. Samples were not collected during the hours of slack low and high tides. At station 2, composite samples were collected at 2 locations (Figure 4-2). These locations were positioned approximately 1/3 and 2/3 of the total distance across the bridge span. Current speed data were used to determine the volume of sample collected at each sample location that was incorporated into the station 2 hourly composite sample. The current meter measurements were made using an electromagnetic meter (InterOceans S-4) equipped with temperature and salinity probes. Tide measurements were made with a Fisher Porter punched tape level recorder (type 1550). Water samples (1000 ml.) for toxicity testing were collected at each spatial location and then composited. Additional water samples were collected at station 2 to determine spatial variability using chemical, suspended solids, and sperm cell tests.

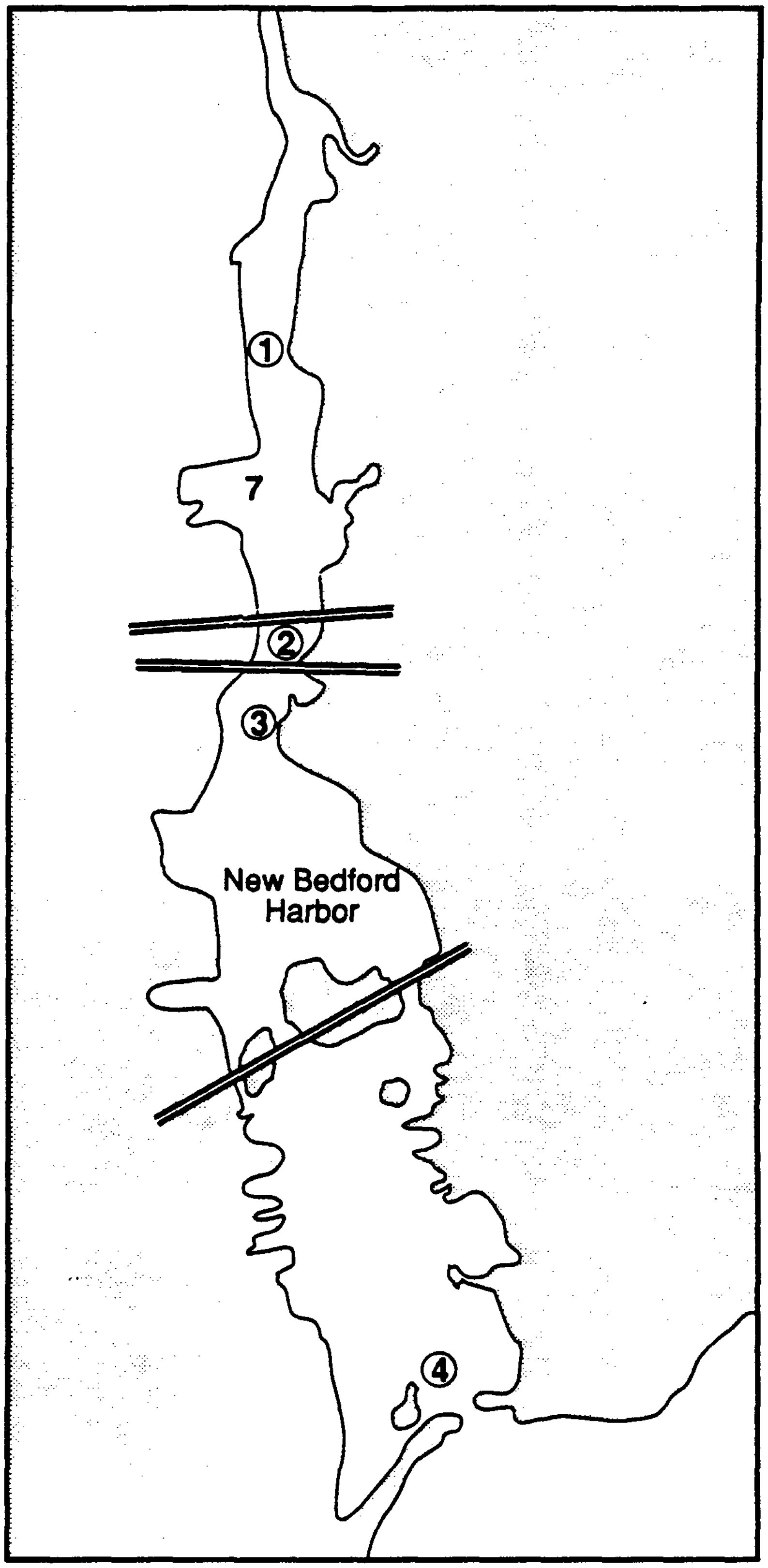


Figure 4-1 Locations of ERLN Operational Monitoring Stations

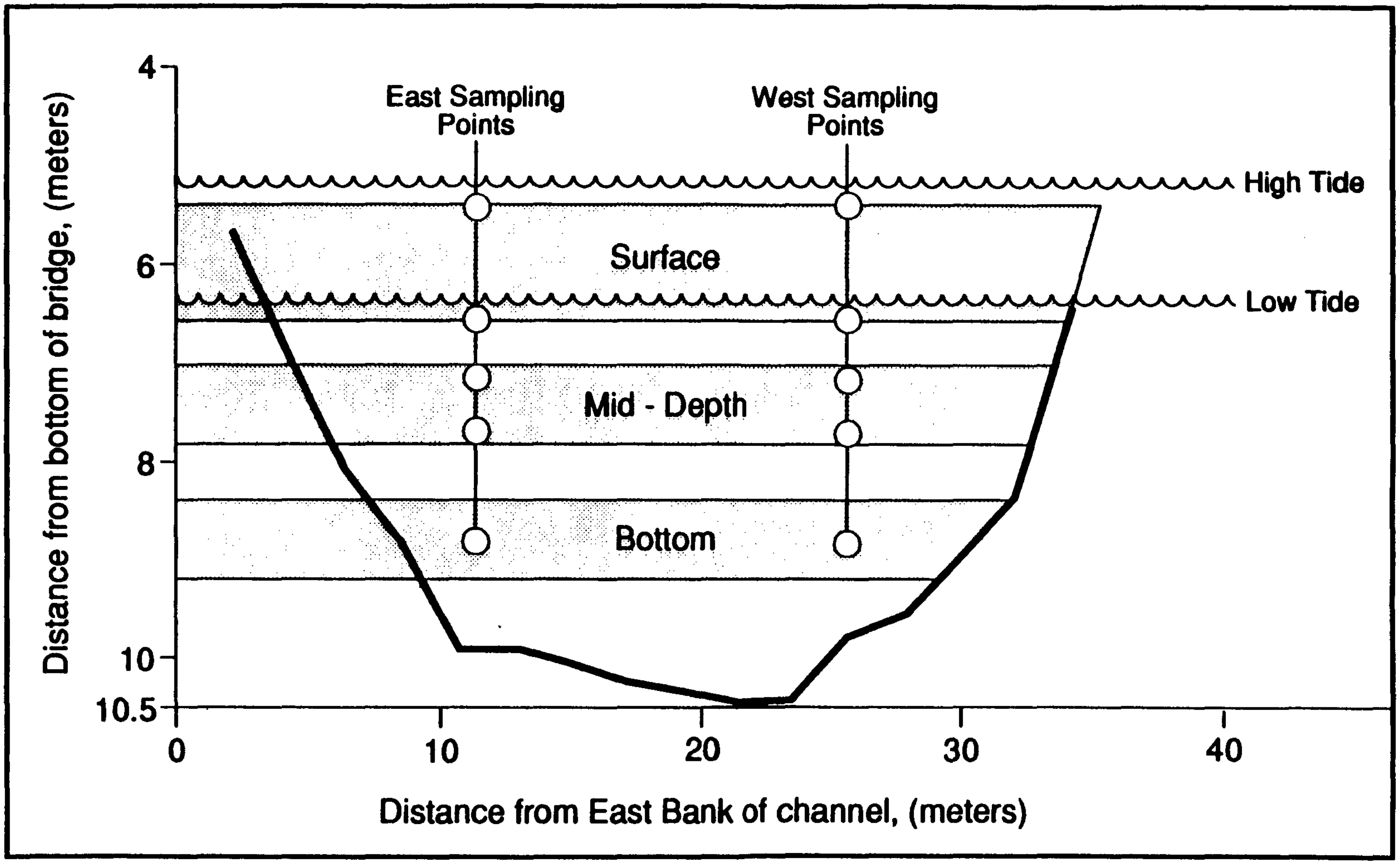


Figure 4-2 Channel Bottom Profile, (Coggeshall Street Bridge) at ERLN Station 2 with approximate sampling locations

Samples taken at the plume stations and dredge head stations for chemistry analyses used 1 or 2 l. plastic bottles. Both TSS and chemistry water samples were taken at these stations. The plume stations were located in the cove in 3 arrays around the dredging activities. All samples were taken at mid water depth. The dredge head station consisted of 6 suction ports at 3 water depths on both sides of the dredge head. The TSS samples were taken by Niskin sampler for determination of TSS settling time and by water pump to 250 ml plastic bottles for dredge head TSS samples. The location of the plume stations were based on a dye study undertaken during August and September, 1988 to show normal sediment movement in the water column. The results of this cursory effort showed a clear trend of the dye leaving the cove in a direct line to the Coggeshell Street Bridge. With these results the plume stations were place in an array to record elevated levels in metals, PCBs, and TSS coming from the dredge. The array of sampling ports on the different dredge heads were located to give results of spacial differences in concentrations (water column depth and side movement).

For M. edulis (mussel) deployments, organisms were collected from a reference population, appropriately characterized chemically and deployed at stations 2, 4, and a reference site outside of the harbor. The water for the other biological testing was collected at the same time as the chemistry and transported to ERLN laboratory where all of these toxicity tests were run.

Laboratory:

The daily water samples were used in the 7 day static renewal bioassays on C. variegatus (fish) and M. bahia (mysid). Individual tests using the daily water samples were performed on the remaining species. Water samples collected from sites at West Island (Buzzards Bay) and central Narragansett Bay were used as reference and control treatments for the toxicity tests. The laboratory methods (chemical and biological testing) are described in Standard Methods (15), except for the mysid test which will be published in the next edition.

All receiving water test results were analyzed using one-way analysis of variance (ANOVA) and t-test. M. bahia and C.variegatus survival data, M. bahia females with eggs data, and A. punctulata data were transformed using arcsine square root. All data are presented as significant toxic effect relative to their respective test controls. ERLN staff is presently in the process of publishing these testing results elsewhere (S. Nelson, personal communication). Only a brief summary is presented here. The water chemistry and TSS measurements were analyzed using Scheffé unplanned comparison test. No data transformation was needed based on normality testing.

Due to the experimental nature, the procedural complexities, and the publication schedule of this report, only preliminary results of the monitoring efforts can be presented at this time. It is felt that the collection of post construction monitoring data and additional data reduction and analyses will reinforce the preliminary opinions and results expressed in this report.

RESULTS

Physical measurements: Details of results of the hydrographic measurements discussed in this section are available in computer format at NED. During the sampling period temperature varied between 18° and 24° C. with very minor differences between depths. The salinity ranged from 24 to 33 o/oo. Mean temperature increased with distance from the harbor mouth, while salinity decreased. Current speeds varied between 0 and >90 cm/sec. The tidal fluctuation averaged approximately 1.6 m. Although the physical measurements suggest fairly constant patterns, there were significant differences at several stations due to wind and water circulation. These data indicate the complexity of the hydrodynamics of the harbor. Mean total suspended solids (TSS) concentrations ranged from a low of 4 to 15 mg/l over the study area. The values at station 2 were from 6 to 11 mg/l. The trend in these data was that the ebb tide concentrations were lower then the flood tide concentrations.

The following table presents a statistical summary of the TSS data generated during the dredging activities. The trends seen during this monitoring effort showed that the horizontal auger dredge produced the highest levels of turbidity, followed by the cutterhead dredge and Matchbox dredge. All dredge generated TSS reached background levels by the first array of plume stations, even during CAD operations. Releases of TSS from the CDF did not seem to effect the monitoring station results. The monitoring stations during these 9 days (22, 23 November 1988; 2, 3, 4 December 1988; 7, 8, 9, 10 January 1989) of sampling did not have a statistically significant difference between them. The monitoing stations closest to the dredging activities tended to have the greatest statistical difference. No statistically significant difference was recorded using these testing protocols between horizontal auger dredging days (2, 3, 4 December, 1988).

Table 1

Total Suspended Solids (TSS) Analyses by dredge day

DATE	Dredge/Station	Test value (p)	Significance
12-2	HA vs. PL	5.282	HA>PL P <0.05
12-2	HA vs. NBH-7	3.502	HA>NBH-7P <0.05
12-2	HA vs. NBH-2	4.056	HA>NBH-2P <0.05
12-2	HA vs. CH	4.944	HA>CH P <0.05
12-2	HA vs. MB	5.246	HA>MB P <0.05
12-3	HA vs. PL	1.153	HA>PL P <0.05
12-3	HA vs. NBH-7	1.309	HA>NBH-7P <0.05
12-3	HA vs. NBH-2	0.989	HA>NBH-2P <0.05
12-3	HA vs. CH	3.045	HA>CH P <0.05
12-3	HA vs. MB	3.752	HA>MB P <0.05
12-4	HA vs. PL	3.018	HA>PL P <0.05
12-4	HA vs. NBH-7	4.148	HA>NBH-7P <0.05
12-4	HA vs. NBH-2	3.653	HA>NBH-2P <0.05
12-4	HA vs. CH	2.043	HA>CH P <0.05
12-4	HA vs. MB	2.292	HA>MB P <0.05

Note: HA = horizontal auger dredge; CH = cutter head dredge; MB = match box dredge; NBH = harbor sample stations; DH = dredge head stations; PL = plume stations. Scheffé comparison analysis by dredging day. Some test values shown are averaged.

The particle size analysis (PSA) over time results are presented in Figure 4-3. These data indicate that the settling times of the suspended particles would allow for the TSS levels generated at the dredgehead to reach background before the first plume sampling stations. This is an important consideration for those pollutants with high sediment binding coefficients. They too should settle out within a relatively short distance from the dredge head. These data graphed in Figure 4-3 show that samples taken at the dredge head settle much faster and start at a much higher level. This indicates that heavier particles are in suspension for shorter periods of time while lighter and more numerous particles are found in the plume stations. This figure also shows a trend towards background within 24 hours at the dredge area.

Chemical measurements: The pre-operational temporal mean water values for PCB concentrations showed a distinct trend of the highest at the inner harbor stations decreasing towards the harbor mouth. These values indicated an increase as the tide ebbed to slack low tide and decreased as the flood tide approached slack high tide. Mean water concentrations for the metals (Cd, Pb, Cu) indicated no consistent trends for the ebb and flood tide samples. Station 4 (closest to the hurricane barrier) consistently had the lowest levels. The results for *M. edulis* (mussel) PCB tissue residues showed levels reaching a 100 fold increases at day 7 and 200 fold increase at day 28.

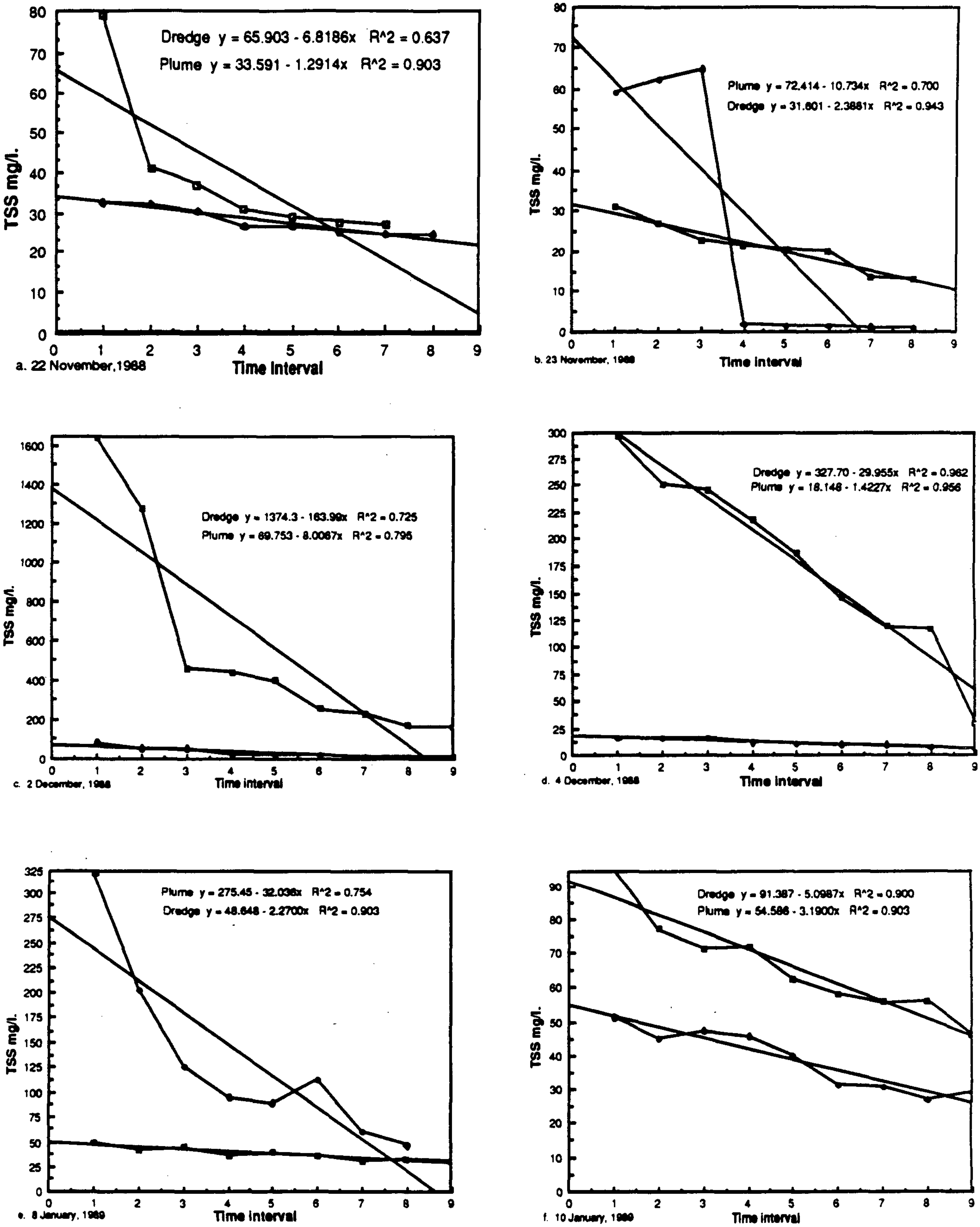


Figure 4-3 Particle Size Analyses by Settling Time

The following table summarizes the PCB data collected on dredging days (22, 23 November, 1988 2, 3, 4 December 1988, and 7, 8, 9, 10 January, 1989) comparing the different dredges by stations. These data indicate that there did not exist a significant difference between all sampling locations for the Matchbox dredge. The samples collected at the dredge head for the cutter head dredge indicated no significant difference at the near field stations, but a significant reduction in the far field stations. The samples collected during the horizontal auger operation indicated a significant difference at both the near and far field stations. There were differences recorded at the NBH stations. NBH-7 showed no difference between dredges and no dredging, except for the Matchbox dredge. The PCB levels were significantly higher for the Matchbox dredge when comparisons were made with no dredging samples and horizontal auger dredging samples. NBH-2 showed levels recorded during no dredging activities were higher then all three dredges and both the Matchbox and cutterhead dredges were significantly higher then the horizontal auger. NBH-1 showed that the cutterhead dredge levels were significantly higher then the horizontal auger. The cutterhead dredgehead sample were significantly higher for harbor stations (NBH-7,-2,-1). The horizontal auger dredge head samples were significantly higher for plume stations (6-10 and 11-15) and harbor stations (NBH-7,-2,-1). It should be noted that these monitoring days included CAD disposal into the cove. These results indicate that CAD disposal did not effect the results of monitoring. The stations closest to discharge were close to background levels when compared to dredge head samples.

Table 2
A statistical comparison of total PCB (whole water) values by station for each dredge
Scheffe Comparison Analysis

Station	Dredge	Test#	Significance
NBH-7	MB vs. ND	0.744	p<0.05 MB > ND
NBH-7	MB vs. HA	0.379	p<0.05 MB > HA
NBH-2	ND vs. HA	0.968	p<0.05 ND > HA
NBH-2	ND vs. CH	0.257	p<0.05 ND > CH
NBH-2	ND vs. MB	0.125	p<0.05 ND > MB
NBH-2	MB vs. HA	0.590	p<0.05 MB > HA
NBH-2	CH vs. HA	0.377	p<0.05 CH > HA
NBH-1	CH vs. HA	0.198	p<0.05 CH > HA
DH1-6	HA vs. CH	7.383	p<0.05 HA > CH
DH1-6	HA vs. MB	5.117	p<0.05 HA > MB
PL1-5	MB vs. HA	0.724	p<0.05 MB > HA
PL1-5	MB vs. CH	0.739	p<0.05 MB > CH
PL6-10	CH vs. HA	0.826	p<0.05 CH > HA
PL6-10	CH vs. MB	0.100	p<0.05 CH > MB
PL11-15	MB vs. CH	0.669	p<0.05 MB > CH
PL11-15	CH vs. HA	0.567	p<0.05 CH > HA
CHDH	vs. 11-15	2.501	p<0.05 CHDH > PL11-15
HADH	vs. 1-5	3.488	p<0.05 HADH > PL1-5

Note: MB = match box dredge; ND = not dredging; HA = horizontal auger dredge; CH = cutter head dredge; NBH = harbor sample stations; DH = dredge head stations; PL = plume stations. CHDH = cutterhead dredge head; HADH = horizontal auger dredge head

The CDF discharge was monitored for PCBs and TSS during the dredging operations. The PCB values for filtered water component (particulate) ranged from 0.1 to 19.2 mg/l. with an average of 6.4 (sd. 5.7). The TSS averaged 80.1 (sd. 63.4), with a maximum value of 577.4 and a minimum value of 8.48. These discharges did not effect the determinations made here relative to dredging operations.

Biological measurements: No toxic effects were detected by the A. punctulata (sea urchin) sperm cell test, including no significant spatial or temporal variation among individually examined samples at station 2. No toxic effects were detected by the *C. parvula* (red alga) reproduction test, except at station NBH-7 on 4 December 1988. The tests for *C. variegatus* (fish) survival and growth (except for 1-7 December 1988 and 7-14 January 1989) and *M. bahia* (mysid) reproduction and growth tests showed no toxicological effects. During the pre-operational monitoring period there was determined to be a significant difference among stations in shell growth after 28 days of exposure and were inversely correlated with PCB tissue concentrations in *M. edulis*. Scope for growth (SFG) and shell growth were lowest and PCB levels highest at station 2. SFG and shell growth were highest and PCB levels lowest at the hurricane barrier and control site. There were no significant mortalities among stations during this exposure period. During the operational phases, no toxicity was recorded using these testing protocols which related to the dredging or disposal activities.

Table 3
Summary of Biological Testing Data During Construction And Monitoring Activities

Test	Dates	Results
C. parvula	4 Dec.88	sign. effect at NBH-7
A. punctulata		ns. effect at any station
M. bahia		ns. effect at any station
C. variegatus	1-7 Dec.88	sign. effect at NBH-2 & 1 growth
	7-14Jan.89	sign. effect at NBH-7 & 4 growth
M. edulis		ns. effect at any station

Note: These data only reflect those dates when total dredging activities were being monitored. These are statistically significant differences.

The three instances of statistically significant toxicological effects based on these tests may not necessarily reflect the dredging activities. The effect seen on 4 December,1988 may have be the result of storm run-off through the Coggeshell Street combined sewage outfall (at that time NBH-7 was directly opposite it). The effect seen for *C. variegatus* both times may have been related to other events occurring in the harbor. The fact that station NBH-1 also was significant indicates that an event may have taken place up-stream of the dredging activities. The fact that station NBH-4 was significant indicates that again storm run-off may have been a factor.

DISCUSSION

Physical: The average tide range during these dredging activities was 1.42 m. with a extreme low of 0.43 m. and high of 1.54 m. The currents at the Coggeshell Street Bridge averaged 0.34 m/ sec. These water depths varied during the study due to weather conditions and location within the upper estuary. On several days dredging start time was delayed, or dredging was terminated early due to lack of water in the cove. The physical measurements taken during this study re-enforce the earlier opinions about the complexity of the hydrodynamics of this harbor.

Chemical: The chemical monitoring results indicate that samples collected at the dredge head for the cutter head dredge indicated no significant difference at the near field stations, but a significant reduction in the far field stations. The samples collected during the horizontal auger operation indicated a significant difference at both the near and far field stations. There were differences recorded at the NBH stations. NBH-7 showed no difference between dredges and no dredging, except for the Matchbox dredge. The PCB levels were significantly higher for the Matchbox dredge when comparisons were made with no dredging samples and horizontal auger dredging samples. NBH-2 showed levels recorded during no dredging activities were higher then all three dredges and both the Matchbox and cutterhead dredges were significantly higher then the horizontal auger. NBH-1 showed that the cutterhead dredge levels were significantly higher then the horizontal auger. The metals data is presently not available and will be incorporated into this report after the post construction data becomes available.

Biological: The biological monitoring results within their limitations appeared adequate to predict and protect existing environmental conditions in the harbor during this pilot study. The data generated during the pilot study indicate that contamination levels in the vicinity of the stations sampled was sufficient to produce only sporadic low-level toxicity. No biologically significant increase in water toxicity, with the species tested, could be directly attributed to these construction activities. Future analyses of all data generated should support these finding. This monitoring program was very useful in adjusting the day to day operational activities, which in turn produced low level exposure potential.