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SDMS DocID 63935

New Bedford Harbor Superfund Pilot Study

Evaluation of Dredging and Dredged Material Disposal

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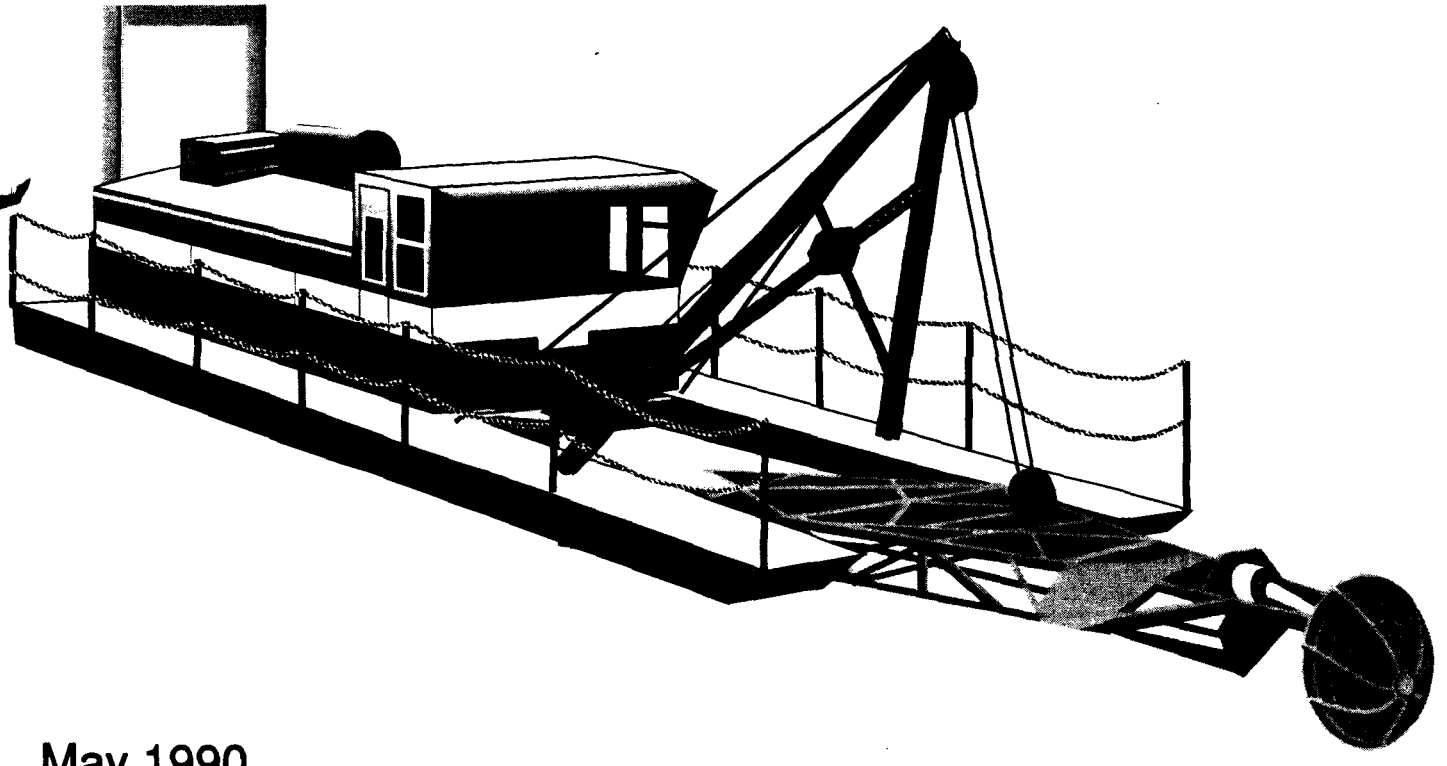

May 1990

US Army Corps
of Engineers
New England Division

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 dredged 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 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, a horizontal auger and a Matchbox dredge. The dredges were evaluated on their ability to remove the contaminated sediments while minimizing sediment resuspension, contaminant release, and impacts to water quality. 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 report details the design procedures and construction techniques used for both the CDF and CAD. It also provides a detailed assessment of the three hydraulic dredges which includes the results of their performance, their suitability for removing contaminated materials in New Bedford Harbor and recommended procedures for their 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.

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 and contaminant release was also minimized with no identifiable plume of resuspended material moving away from the dredging area and no measured elevated levels of contaminants 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 sediment 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 placed in both disposal sites. Monitoring for any leaching of contaminants at the CDF and contaminant migration into the cap covering the CAD cell will continue.

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 from 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 activities were conducted between May 1988 and February 1989.

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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:

USACE, Omaha District, coordination and management support.
USACE, St. Paul District, operation of the Matchbox Dredge.
USACE, Waterways Experiment Station, photographic and videographic services.
USACE, NED's Material and Water Quality Laboratory, field sampling.
USACE, NED's Project Operations Branch, site construction.
USACE, Waterways Experiment Station, Geotechnical Laboratory, Dr. Jack Fowler - Dike Design.
USEPA, Environmental Research Laboratory, Narragansett, Rhode Island, environmental sampling and analyses.
Ebasco Services Incorporated - air monitoring.
Zoppo Construction Company - CDF construction.
AGM Marine Contractors, Inc. - operation of the Cutterhead and Horizontal Auger Dredges.
Bean Dredging - fabrication of the Matchbox Dredgehead.

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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. Chemical stability, non-flammability, and a number of other desirable characteristics made PCBs ideal for many industrial uses. Unfortunately, these 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.

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.

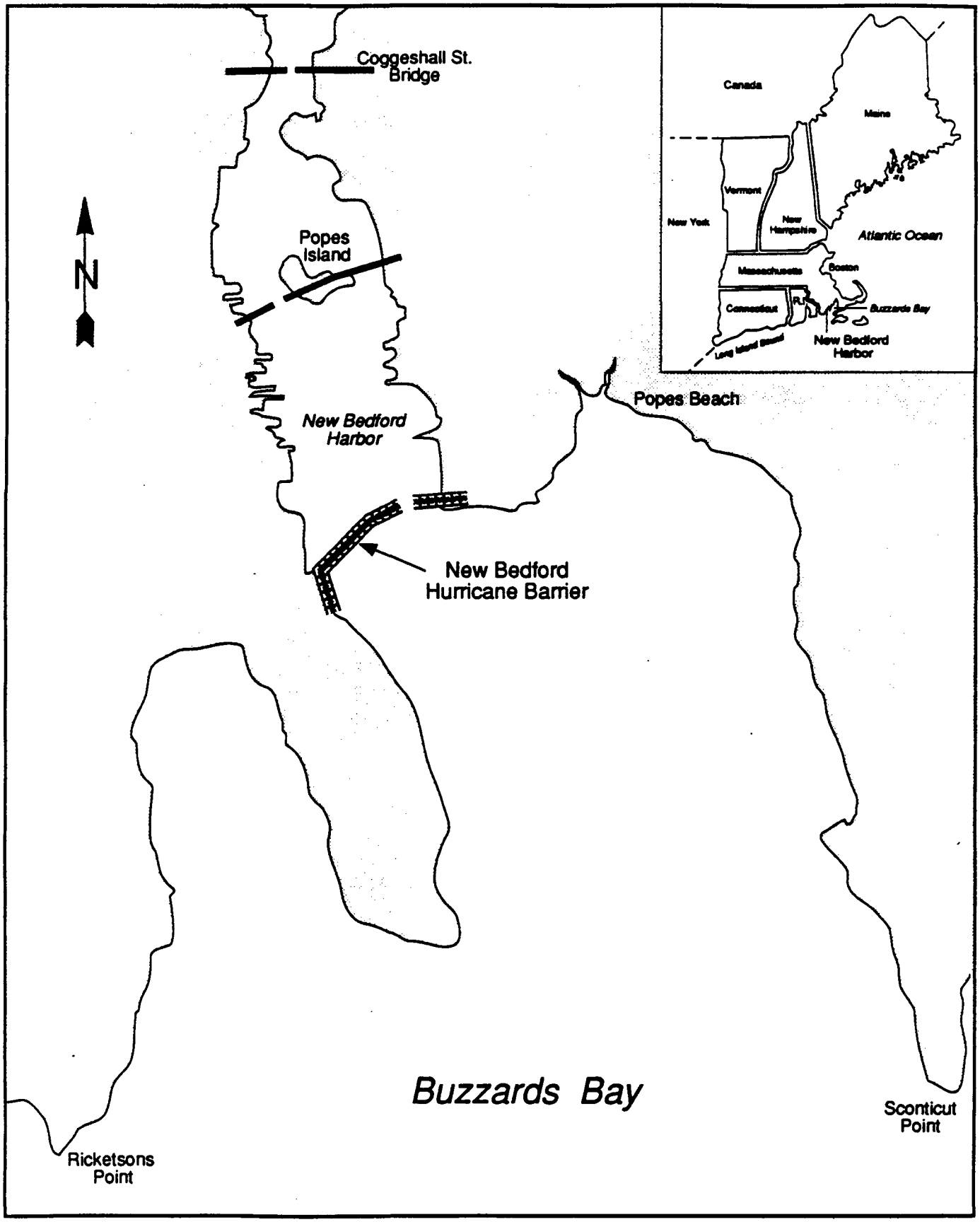

Figure 1 New Bedford Harbor

Figure 2 Acushnet River Estuary

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), the decision was made 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 removed by conventional and/or specially designed dredging equipment without triggering unacceptable releases of contaminants.

The pilot study achieved and/or evaluated the following specific technical objectives:

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

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

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

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

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

- Evaluated contaminant release out of the upper harbor.

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 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 in 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 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 deep-

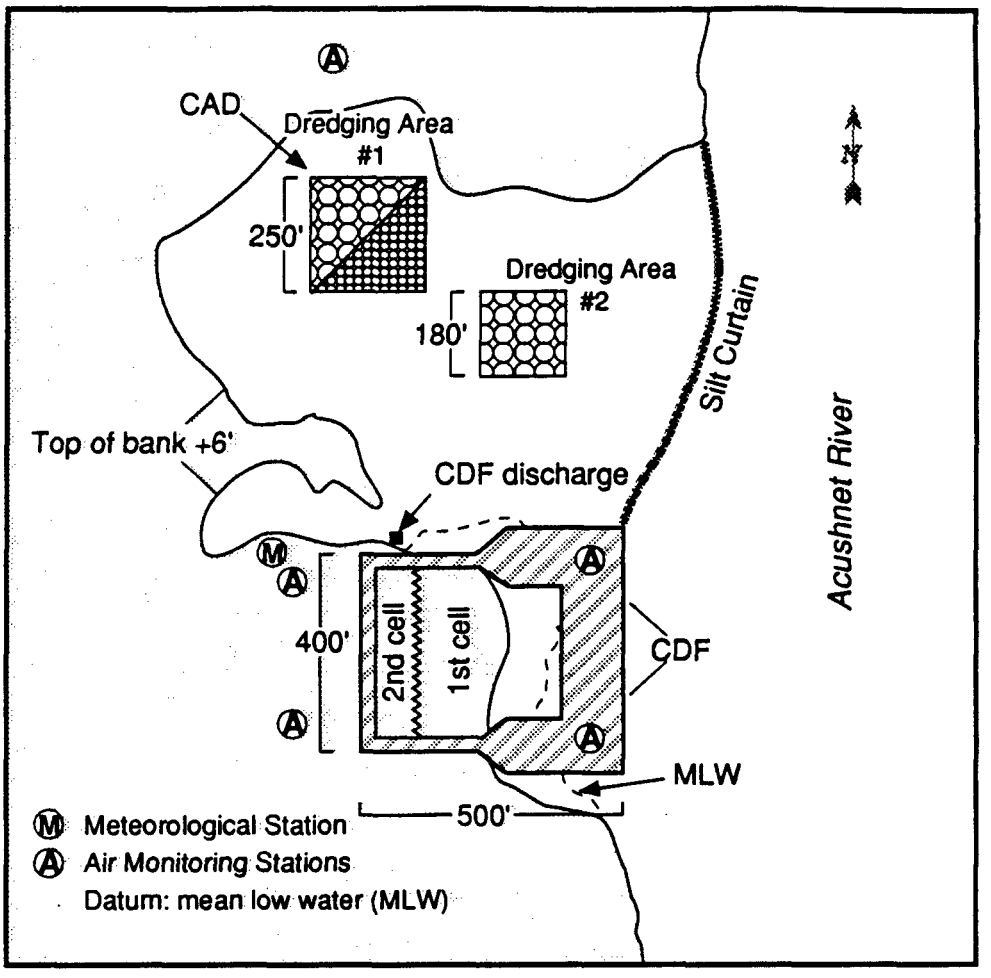

Figure 3 Pilot Study Site

ened 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: It was necessary to construct a portion of the dike below the mean high water line to accommodate the CDF and its attendant space requirements on the Sawyer Street site. 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. 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 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 the 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 minimized impacts to 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 top 6 inches of sediment 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 noncontaminated 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 Dredging Division. The EPA Environmental Research Laboratory in Narragansett, Rhode Island (ERLN) played a significant role in the design of the 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). 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 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 pilot study.

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"Engineering Feasibility Study," 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 New England Division operated three hydraulic dredges in the upper Acushnet River estuary. All major aspects of the study were conducted under close supervision and were extensively monitored. 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 along 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 six technical appendices:

Appendix 1 contains data on the dredges utilized for the project and discusses production rates, contaminant removal, 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 throughout the harbor and describes the 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 and chemical characteristics of the dredged material.

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.

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, 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 selecting 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 method of moving through an area while dredging. These operational characteristics are detailed in Part III of the main report and in Appendix 1.

Other Equipment Considered: 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 considered 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 considered, it was determined that 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 design parameters were developed during the EFS 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): 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 from the top two feet of sediment from dredging area 1 and was then capped with clean material taken from the 2-6 foot layer of dredging area 1.

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 that is generally 10 to 20 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. Water flowing over this 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 prior to discharging the water back into the estuary. 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.

Contained Aquatic Disposal (CAD): Contained aquatic disposal (CAD) involves the dredging of the contaminated sediments, placement in an 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 5.

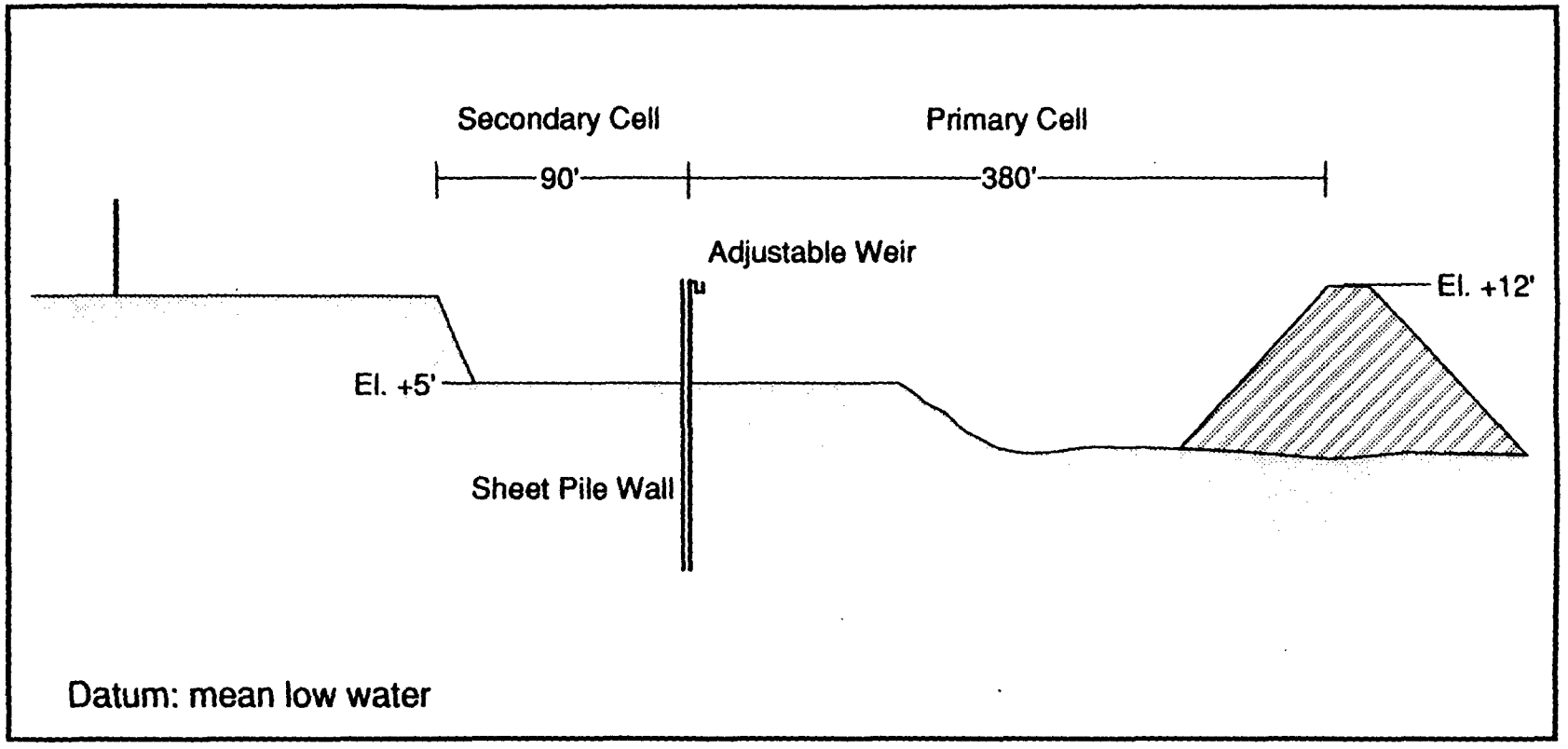

Figure 4 Typical cross section
Confined Disposal Facility (CDF)

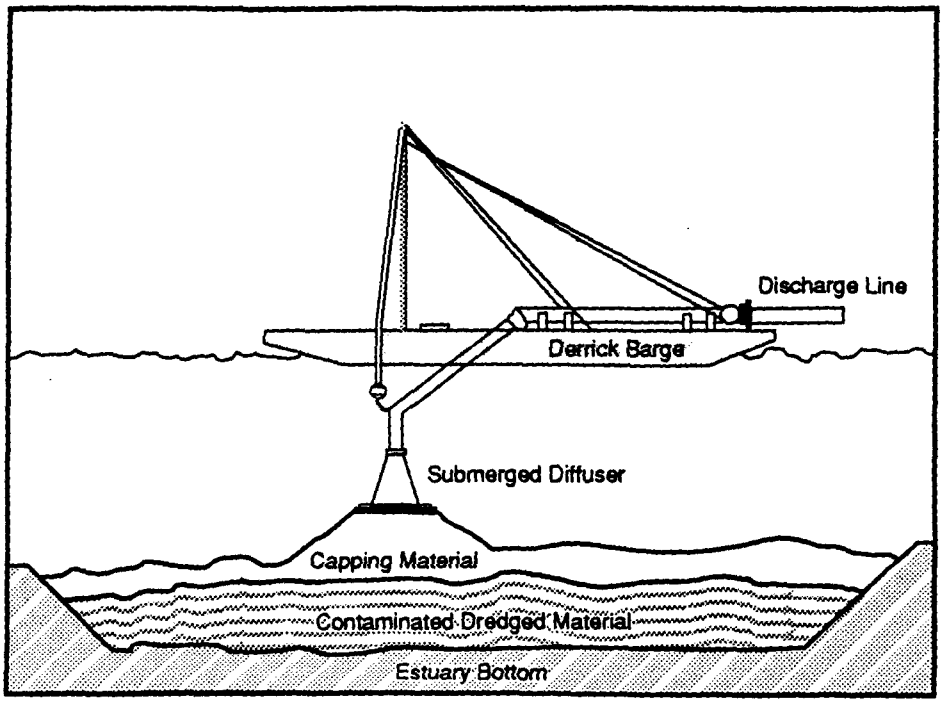

Figure 5 Contained Aquatic Disposal (CAD)

The CAD cell was created as a result of the dredging in area 1. Contaminated sediment from dredging area 2 was deposited in the cell using the submerged diffuser which was positioned approximately 2 feet off the bottom. The diffuser 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 indicated 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. Report 6 of the EFS (10) contains a complete discussion of the laboratory testing on cap effectiveness.

ENVIRONMENTAL MONITORING PROGRAM

The environmental monitoring program was designed by personnel from NED, WES, and EPA's Environmental Research Laboratory in Narragansett, Rhode Island (ERLN), with input from other federal agencies and the State of Massachusetts. 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 dredging and disposal;

- 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, 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 construction and dredging operations. These five major tasks consisted of:

- Performance of preliminary sampling to determine background (conditions in the absence of construction/dredging activities) characterization of water quality and sediment.

- Evaluation of the CDF by determining effluent and leachate water quality over time.

- Evaluation of CAD by determining water quality impacts 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.

- 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 to be implemented if conditions indicated the need:

- 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.

- The amount of scheduled down time between dredging periods could be extended, should restricting the dredging and/or CAD operation prove ineffective. The dredge operating parameters, i.e.: depth of cut, swing speed, rate of advance, etc. were experimented with over the course of the study. If other control options proved ineffective or inadequate, these parameters could be reduced or modified to further minimize sediment resuspension.

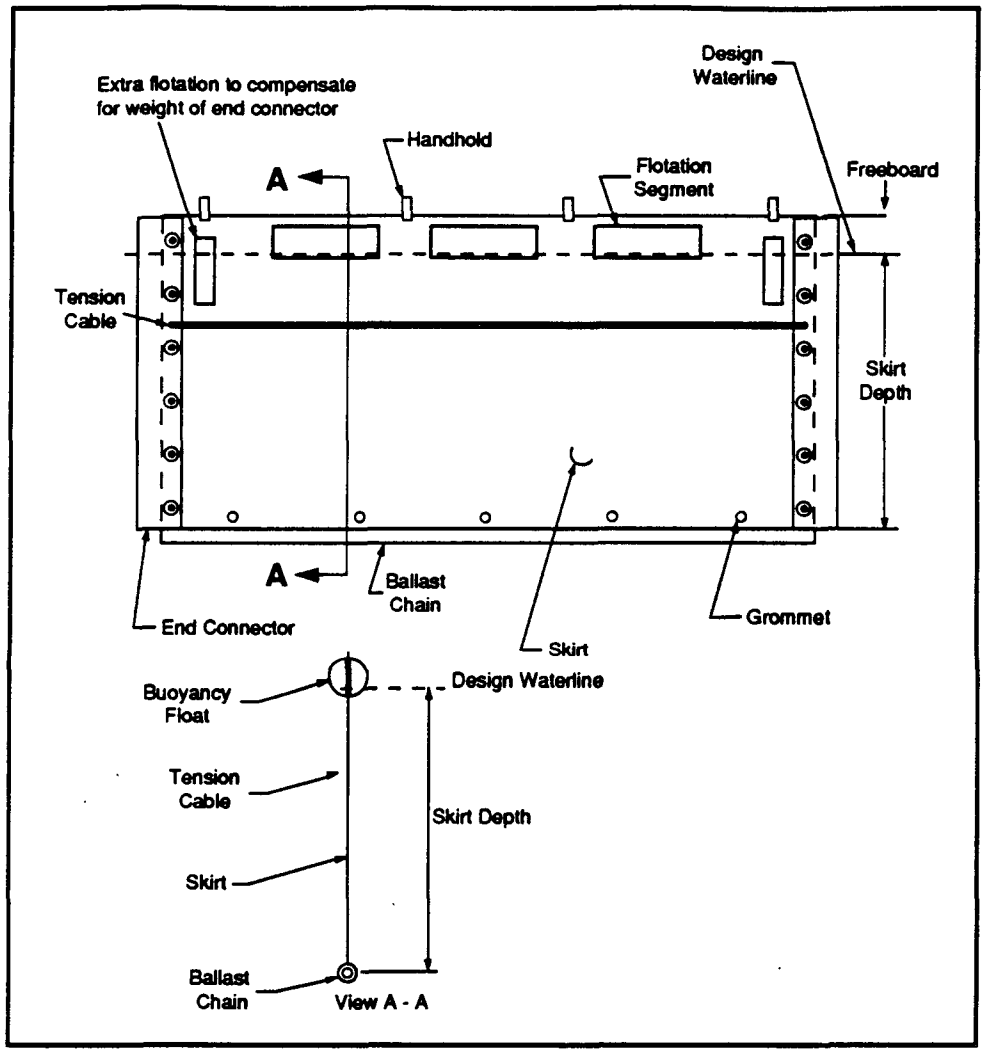

Figure 6 Typical silt curtain section

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 dredging and CAD operation a silt curtain and oil boom were to be deployed across the mouth of the cove.

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

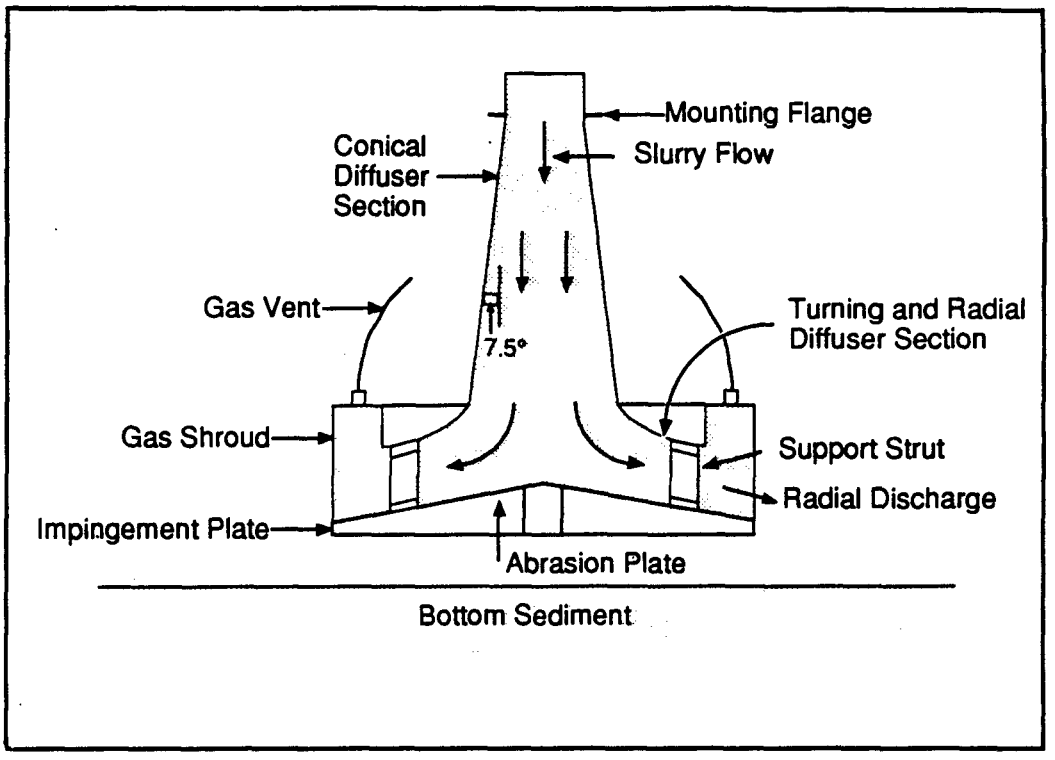

Figure 7 Submerged Diffuser

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 6). 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 had 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 to be 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 curtain deployed during pilot study dredging sustained substantial damage as a result of severe weather conditions on 20 November and was not redeployed until CAD operations were underway. The elevated suspended solids levels generated at the point of dredging returned rapidly to background levels, indicating a silt curtain was not needed during this phase of the project. CAD operations resulted in significantly higher suspended solids levels both at the discharge point and up to 1,000 feet away. As a result of these conditions the curtain was re-deployed during the placement of cap material in the CAD cell. It was visually apparent that the curtain aided in reducing the turbidity

levels during this period. 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.

Diffuser: A submerged diffuser is used to reduce sediment resuspension 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 7. 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 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 overdredging while maximizing the removal of contaminated sediment,
- to develop and refine the operating procedures to achieve the first two objectives while still maintaining effective production rates,
- to develop and refine operating procedures to minimize the operating and support personnel's 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. 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 8 and the specifications for the dredge used at New Bedford are shown in Appendix 1, Table 14.

The operating procedures that were adjusted at the start of the operation included swing speed, cutterhead rotation, cutterhead location and advance per swing. The following procedures were established and used when removing contaminated sediment.

swing speed: This represents the side to side movement of the dredge and was measured at the swing winch. It was kept steady and as slow as possible, averaging 40% of the dredge's capability.
cutterhead rotation: 50% of maximum (approximately 20 RPM)
cutterhead location: 2 feet below sediment/water interface
advance per swing: 2 feet
width of cut: 60 feet
dredge pump: run at maximum RPM

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 only skim the surface and removed very little additional sediment.

The major operational problem 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 sediment 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.

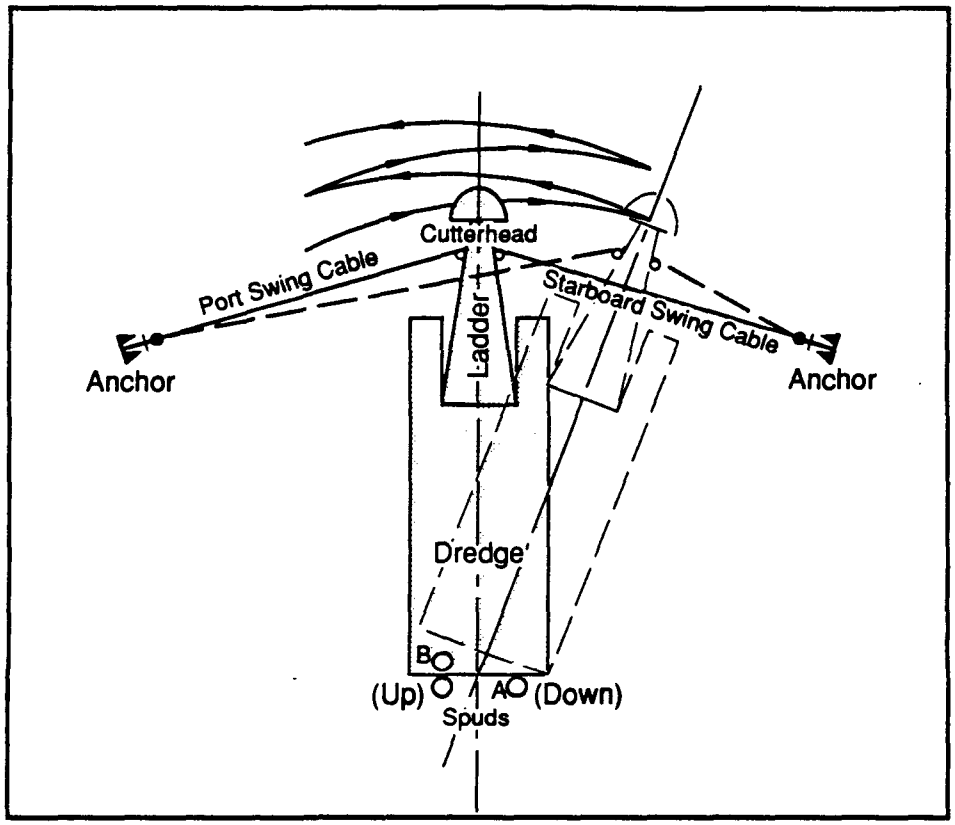

Figure 8 Operation of a Cutterhead & Matchbox Dredge (view from above)

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 effective operating 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 effective operating time by necessitating a longer warm-up period for the dredge's 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 of sediment was removed per operating hour. 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 90^0pipe 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 removed 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 solids concentration in the dredging slurry 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: The dredge made one pass over area 1 and removed a 1.5 foot layer of sediment on average. The average PCB level in the remaining sediment was 80.5 ppm. In area 2 the dredge made a second or sweep pass over the area. A 1.1 foot layer of sediment was removed on average, and the average PCB level in the remaining sediment was 8.6 ppm. The substantial difference in the PCB level remaining after dredging clearly displays the benefits gained by making a second pass over the area. The cutterhead dredge was able to remove less than a two foot lift of material while achieving a significant reduction in the level of contamination.

Sediment Resuspension and Contaminant Release: The EFS estimated sediment resuspension rates at the dredgehead to be 40 grams per second. This estimate was based on limited information from other projects and field data from a sediment sampling effort in New Bedford. One of the pilot study's critical objectives was to develop data in this area and to improve the accuracy of contaminant release estimates.

A sampling device (Figure 1-7) was installed at the dredgehead and sampling was conducted on five days while the dredge operated in contaminated sediments. These samples were analyzed for total suspended solids, and this data was used to develop a suspended solids level for the water column adjacent to the operating dredgehead. This value was then used with the dredge swing speed and the water depth to develop the sediment resuspension rate. The rates computed ranged from 3.0-46.3 grams per second and averaged 12.1 grams per second. The cutterhead dredge proved to be the most effective in minimizing resuspension.

Contaminant release estimates are made by using the sediment resuspension rate and total and soluble contaminant concentrations from elutriate tests. Composite samples taken from the dredgehead sampler were analyzed for PCBs and metals. This data is summarized in Table 1 and allows for a comparison between the elutriate test results and the actual contaminant levels found in the water column adjacent to the operating dredgehead. These results indicate that the use of the standard elutruate test results in a conservative estimate of contaminant release.

Sediment and Contaminant Transport: An array of fifteen stations located around the dredge (Figure 1-8) were sampled during the first three days of dredge operation. This effort was carried out to detect a plume of suspended material and/or contaminants moving away from the point of dredging. A well defined plume of suspended material never developed however, with only minor increases above background detected 400 feet from the operating dredge. Background levels of suspended material were generally less than 10 mg/l, and the highest level detected by this sampling effort in the last row of stations was 41 mg/l at station 13.

Composite samples were prepared from samples taken at the individual stations in each row (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals, and the results are summarized in Table 2. They show a considerable reduction from the contaminant levels at the dredgehead and are within the range that occurs in this area in the absence of dredging, indicating that movement of contaminants away from the point of dredging was limited at this location.

TABLE 1
Dredgehead Sampling
Cutterhead Dredge

PCB(ppb)	Mean	Standard Deviation	Minimum	Maximum	Number
Total	7.0	7.3	1.6	26.6	11
Dissolved	0.6	0.2	0.5	1.0	5
Particulate	22.3	24.6	0.6	66.7	6
Copper (ppb)					
Total	138.0	95.2	90.0	281.0	4
Dissolved	2.0		2.0	2.0	2
Particulate	415.0	241.0	228.0	687.0	3
Cadmium (ppb)					
Total	4.3	3.9	2.0	10.0	4
Dissolved	0.2		0.2	0.3	2
Particulate	13.3	10.2	6.0	25.0	3
Lead (ppb)					
Total	55.5	43.1	31.0	120.0	4
Dissolved	0.5		0.4	0.5	2
Particulate	128.0	67.8	71.0	2.3	3

TABLE 2
Plume Sampling
Cutterhead Dredge

TOTAL PCB (ppb)

Stations*	Mean	Minimum	Maximum	Number
1-5	1.0	0.6	1.4	2
6-10	1.2	0.7	1.7	2
11-15	1.0	0.5	1.4	2

* Refer to Figure 1-6 for the station locations. Composite sample formed from 5 individual samples from each group.

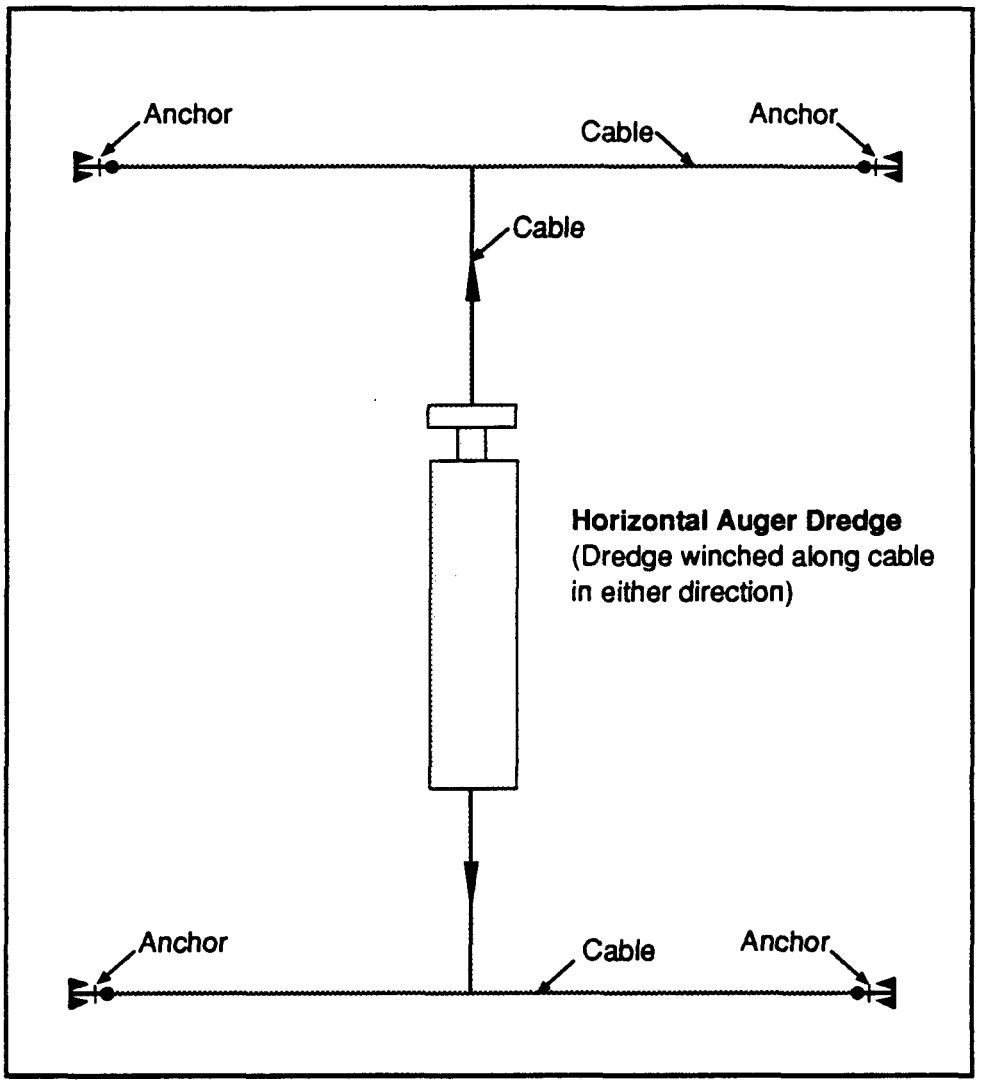

Figure 9 Horizontal Auger Dredge operation

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 15. The Mudcat required workboats for it to be moved into position and to be hooked up to its cable system, as shown in Figure 9. The Mudcat advances by winching itself along a single cable line and is capable of digging while 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, various operating procedures were adjusted at the start of the operation. The following procedures were established and used when removing contaminated sediment.

average rate of advance: 13 feet per minute
auger rotation: maximum - approximately 100 RPM

auger location: 6 inches below sediment/water interface
passes per cut: 4 (2 forward, 2 reverse)
dredge pump: maximum RPM
mudshield: raised when moving forward, lowered when moving in reverse

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; however, the operation still averaged only 4 hours per day. Production time was 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 were also lower than originally estimated. In dredging area 1, production averaged 41 cubic yards of sediment removed per hour of operation with an average dredge slurry flowrate of 1709 GPM. The suspended solids concentration in the dredged material slurry averaged 45 grams per liter.

Removal Efficiency: The Mudcat made 4 passes over the dredging areas which resulted in the removal of a 1.5 foot layer of sediment on average in area 1 and a 1.2 foot layer of sediment in area 2. In area 1, the PCB level in the remaining sediment averaged 66.4 ppm.

Sediment Resuspension and Contaminant Release: A sampling device (Figure 1-11) was installed at the dredgehead, and sampling was carried out on four days while the dredge operated in contaminated sediment. These samples were analyzed for total suspended solids, and this information was used along with the water depth and the dredge's rate of advance to develop a sediment resuspension rate. The rates computed for the horizontal auger dredge ranged from 9-1136 grams per second and averaged 329 grams per second. This resuspension rate was significantly higher than those for the other dredges. Composite samples taken from the dredgehead sampler were analyzed for PCBs and metals, and the results are summarized in Table 3. These results are much higher than those obtained for the cutterhead and the Matchbox dredges and indicate that the horizontal auger dredge is much less effective in reducing sediment resuspension and contaminant release at the point of dredging.

Sediment and Contaminant Transport: Despite the higher resuspension rates, sampling of the 15 stations located around the dredge (Figure 1-12) did not detect a well defined plume of suspended sediment. Only minor increases above background were found 500 feet from the point of dredging. Composite samples were again prepared from samples taken at the individual stations in each row (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals, and the results are summarized in Table 4. As with the cutterhead dredge, they show a considerable reduction from the contaminant levels at the dredgehead and are within the range that occurs in this area in the absence of dredging. This data is a further indication that sediment and contaminant movement away from the point of dredging is limited.

TABLE 3
Dredgehead Sampling
Horizontal Auger Dredge

	Mean	Standard Deviation	Min.	Max.	Number
PCBs (ppb)					
Total	54.9	45.7	12.6	133.0	9
Dissolved	10.1	9.2	1.0	22.9	4
Particulate	200.3	199.8	18.2	382.0	4
Metals (ppb)					
Total					
Copper	2397.0	1152.0	1188.0	3932.0	5
Cadmium	99.6	58.5	27.0	163.0	5
Lead	1220.0	489.0	608.0	1707.0	5
Dissolved					
Copper	4.0	1.0	3.0	5.0	2
Cadmium	0.3	0.2	0.1	0.5	2
Lead	11.5	0.6	1.0	2.2	2
Particulate					
Copper	3232.0	1706.0	832.0	4644.0	3
Cadmium	85.3	47.4	23.0	138.0	3
Lead	1082.0	490.0	392.0	1483.0	3

TABLE 4
Plume Sampling
Horizontal Auger Dredge

Station	Mean	Standard Deviation	Min.	Max.	Number
PCBs (Total) ppb					
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
Metals (Total) ppb					
6-10 Cu	13.0	3.3	9.7	16.2	2
Cd	0.74		0.74	0.74	2
Pb	6.2	1.9	4.3	8.1	2
11-15 Cu	24.9				1
Cd	0.84				1
Pb	10.4				1

MATCHBOX DREDGE

Operating Procedure: The Matchbox dredge operates in the same manner as the cutterhead dredge and as shown in Figure 8. The dredge's specifications are shown in Appendix 1, Table 16.

The Matchbox dredgehead was designed to remove an 18 inch layer of sediment per swing. This depth of cut was initially attempted, but the presence of debris hampered operations significantly. The depth of cut was reduced to 12 inches; however, numerous shutdowns still 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 this dredge in area 1 was limited.

In area 2 the operating procedures were further adjusted to minimize problems with clogging of the dredgehead with the following procedures being used.

swing speed: This represents the side to side movement of the dredge and was measured at the swing winch. It was kept steady and as slow as possible. It averaged 0.28 feet per second.
depth of cut: 6 inches per swing, two swings per advance
width of cut: 60 feet
dredge pump: run at maximum RPM
passes: 2

Operationally, the same problems with the swing anchors that effected the cutterhead dredge also impacted the Matchbox. The corrective measures 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 the material was removed in 6-inch lifts. These measures were for the most part successful, enabling an effective operating time of 91 percent to be achieved in dredging area 2. 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 or 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.

Production: The Matchbox dredge, with a draft of 3 feet, could operate only 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 averaged 24.5 cubic yards of sediment removed per hour of operation. 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 2410 GPM with a solids concentration of 24.4 g/liter. These rates were achieved when the dredge was removing material in 12-inch lifts per swing.

Removal Efficiency: The dredge made two passes over dredging area 2 which resulted in the removal of a 1.5 foot layer of sediment. PCB levels in the remaining sediment averaged 5.4 ppm.

Sediment Resuspension and Contaminant Release: A sampling device (Figure 1-16) was installed at the dredgehead and sampling was conducted on five days while the dredge operated in contaminated sediment. These samples were analyzed for total suspended solids and were used with the dredge swing speed and the water depth to develop a sediment 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.

Composite samples taken from the dredgehead sampler were analyzed for PCBs and metals, and the results are summarized in Table 5. The results are similar to those obtained from the cutterhead dredge and are a further indication that the standard elutriate test provides a "worst case" estimate of the contaminant levels in the water column adjacent to the operating dredgehead.

Sediment and Contaminant Transport: Sampling of the 15 stations located around the dredge (Figure 1-17) produced results similar to those of the other dredges. A well defined plume of suspended sediment did not develop and only minor increases in the suspended solids level were detected 400 feet from the point of dredging. Composite samples were again prepared from samples taken at the individual stations in each row (example: composite of stations 6-10, hour 3). These samples were analyzed for PCBs and metals, and the results are summarized in Table 6. As with the other dredges, the results show a reduction from the contaminant levels at the dredgehead and provide further indication that sediment and contaminant movement away from the point of dredging is limited.

TABLE 5
Dregehead Sampling
Matchbox Dredge

	Mean	Standard Deviation	Min.	Max.	Number
PCBs (ppb)					
Total	2.6	2.2	0.2	4.5	4
Dissolved	0.5	0.1	0.3	0.6	4
Particulate	56.9	76.4	6.7	205.0	7
Metals (ppb)					
Total					
Copper	102.0	--.--	--.--	--.--	1
Cadmium	3.0	--.--	--.--	--.--	1
Lead	39.0	--.--	--.--	--.--	1
Dissolved					
Copper	3.0	--.--	--.--	--.--	1
Cadmium	0.5	--.--	--.--	--.--	1
Lead	2.0	--.--	--.--	--.--	1
Particulate					
Copper	85.0	14.0	71.0	99.0	2
Cadmium	2.5	0.5	2.0	3.0	2
Lead	30.0	2.0	28.0	32.0	2

TABLE 6
Plume Sampling
Matchbox Dredge

PCBs (Total) ppb

Station	Mean	Standard Deviation	Min	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

Metals (Total) ppb

1-5	Cu	12.8	--.--	--.--	--.--	1
	Cd	0.84	--.--	--.--	--.--	1
	Pb	5.6	--.--	--.--	--.--	1
11-15	Cu	10.4	3.3	7.1	13.6	2
	Cd	0.60	0.24	0.36	0.83	2
	Pb	4.7	0.6	4.1	5.3	2

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 10 ppm 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:

	Avg. Resuspension Rate (g/sec)	Avg. PCBs (ppb) Total	Dissolved	Particulate
Cutterhead Dredge	12	7.0	0.6	22.3
Horizontal Auger Dredge	329	54.9	10.1	200.3
Matchbox Dredge	46	2.6	0.5	56.9

Measured impacts 300-400 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 and metals levels in composite samples from these stations were similar to background conditions.

Operating procedures were adjusted 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%

Production Rate: This term refers to cubic yards of sediment removed per hour of operation.
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
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 procedures minimized sediment resuspension and reduced the quantity of sediment removed. These modifications included reducing the dredge's swing speed and/ or rate of advance, 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

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.

PART IV CONFINED DISPOSAL FACILITY

This part contains 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, and the construction techniques employed.

The CDF, as shown in Figure 10, 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 northeast 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 dredged material 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.

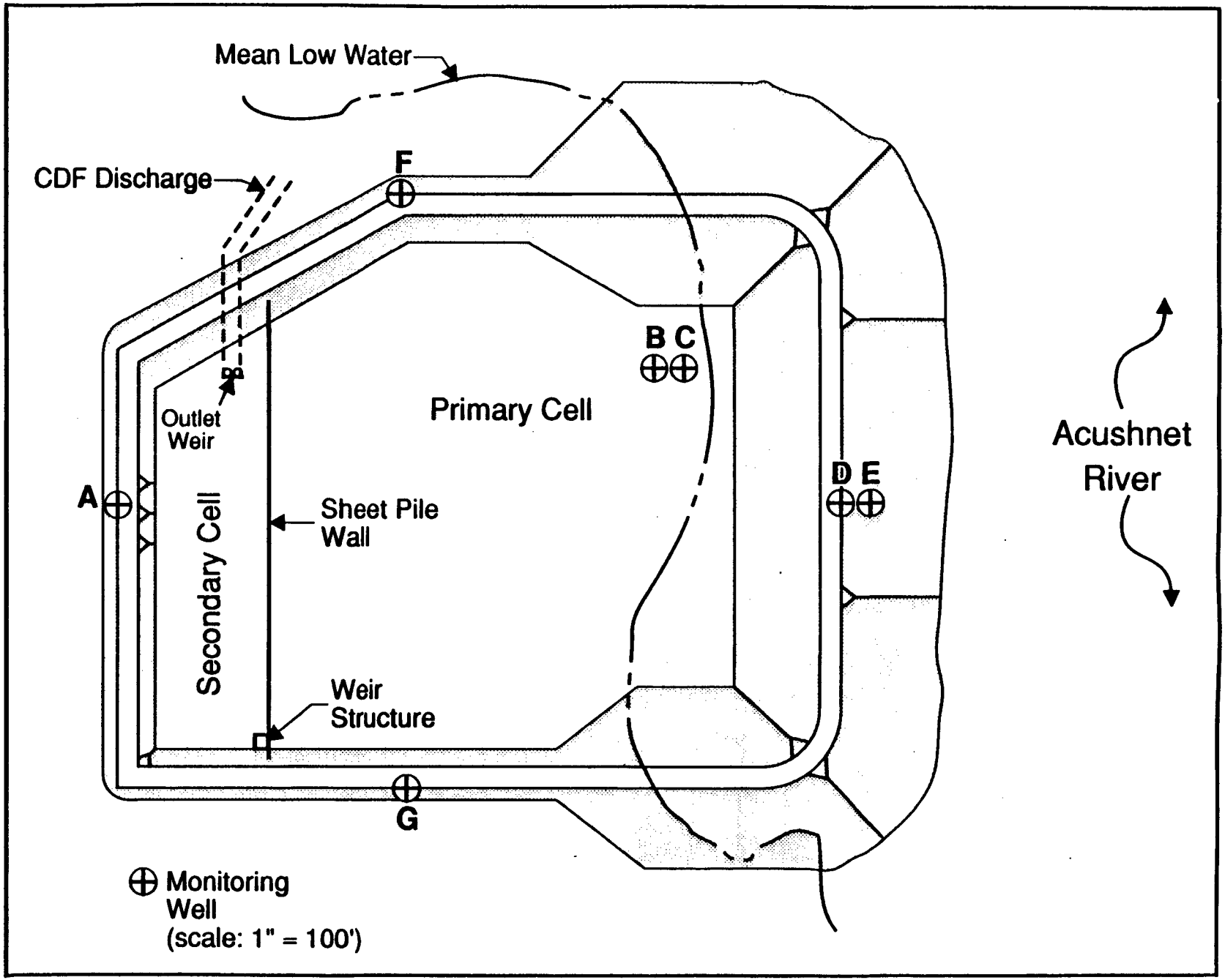

Figure 10 Confined Disposal Facility

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

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 offshore 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. 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 to 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 material 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 hour per day	2.6	4.7	3.3
No. of days required	29.0	16.0	45.0
Cubic yards dredged(a)	2,208.0	3,929.0	6,137.0

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

The above information illustrates the fact that production rates attained during the study were considerably less than our estimate of 100 cubic yards per hour. This situation resulted in dredging area 1 being reduced in size by approximately 30 percent to accommodate funding constraints. The CDF, therefore, was not filled to capacity.

As shown in Figure 10, 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. 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 leaked 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 provided for the adequate discharge of water from the site.

Effluent Quality: Effluent at both the weir between the cells and the discharge 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 (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 discharge was sam-

pled 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 location. This composite sample was analyzed for 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 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 polymer was sprayed into the flow at the primary weir over a six day period.

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 (Table 7). 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.

Contaminant concentrations in the CDF discharge indicate that the modified elutriate test provides a conservative estimate of the contaminant load. The means for the two PCB fractions analyzed are shown below and compared to the elutriate test results. Table 8 summarizes the results of this sampling effort.

	CDF Effluent	Modified Elutriate Test
Dissolved PCBs (ug/l)	1.4	8.2
Particulate PCBs (ug/kg)	10.7	65.6

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 is the period when the potential for leachate flow is greatest. The site is filled with water during this period and 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 (7) wells were installed in and around the CDF to monitor for leachate that may be escaping from the site. The well locations are shown in Figure 10. Well screens were positioned to capture leachate from varying elevations as shown in Figure 2-2. The wells were sampled three times prior to the start of CDF filling and then three times per week over a six week period while the CDF was being filled. They were then sampled weekly for the next three weeks and will be sampled quarterly for the next two years. Shown below are the average PCB levels for the preoperational period and the three week period immediately after disposal into the CDF was completed. The results do not indicate any movement of PCBs out of the site.

Wells	Average PCB Levels (ppb) Pre-operational	Post disposal
A	0.12	0.07
B	2.67	0.07
C	--	0.60
D	0.02	0.02
E	0.24	0.16
F	0.00	0.01
G	0.01	0.00

CONCLUSIONS

Dike Construction: The construction of shoreline CDFs 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 extend 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 production rates and solids content of the dredged slurry. The actual bulking 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 (40 grams/l) varied considerably from our initial estimate and likely influenced the bulking factor.

Effluent Quality: Suspended solids levels in the effluent averaged 75 mg/l which was very close to our 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 and metals levels in the effluent were lower than estimates based on the modified elutriate test. These results indicate that the estimating procedure is 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. Several concrete foundations located within the primary cell also had a positive effect on settling by increasing detention time and minimizing resuspension within the cell.

RECOMMENDATIONS:

The surface area required in the secondary cell of the CDF is determined through the polymer system's design procedure as described in Report 7 of the EFS and EM 1110-2-5027. The surface area in the secondary cell of the pilot study CDF exceeded that determined through the design procedure. This was done because of the physical characteristics of the site and the lack of field data to verify the design procedure. The pilot study indicates that the size of the secondary cell can be more in line with the design procedure. The limited dredge operating periods allow for adequate detention time.

The barrier between the two cells should also be watertight to insure that adequate detention time is available.

TABLE 7
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 8
Contaminant Levels (ppb) - CDF Discharge

	Mean	Standard Deviation	Range	Number
Dissolved Fraction				
PCB	1.4	0.6	0.30-2.9	11
Cu	7.4	3.8	1.7-13.9	8
Cd	1.8	1.6	0.9-5.6	8
Pb	8.8	6.9	1.5-19.8	8
Particulate Fraction				
PCB	10.7	3.6	5.0-19.2	11
Cu	53.7	21.5	30.1-88.0	8
Cd	0.6	0.5	0.1-1.2	8
Pb	26.5	5.6	18.3-33.0	8

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

PART V CONTAINED AQUATIC DISPOSAL

Contained aquatic disposal (CAD) involves the dredging of the contaminated sediments, placement in an 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 5.

This part describes the construction of the CAD cell, placement of contaminated sediment within the cell and subsequent capping of the cell. The results of monitoring efforts to measure sediment resuspension, contaminant release and cap thickness are summarized. Appendix 3 contains detailed information on these issues.

Construction: The cutterhead dredge removed approximately 3900 cubic yards of sediment from dredge area 1 to create the CAD cell. The bottom elevation of the cell was approximately -6 feet at MLW and the cell measured 180 feet by 140 feet. Within this area a 50 by 50 foot section had its bottom elevation at -8 feet MLW.

Disposal and Capping: Approximately 700 cubic yards of contaminated sediment was placed in the CAD cell over a 12 day period between 7-20 January 1989. The dredged material was discharged into the cell through a diffuser attached to the end of the dredge pipeline. The diffuser was positioned approximately 2 feet off the bottom to minimize sediment resuspension and control the placement of the contaminated sediment. The point of discharge was shifted on three occasions to distribute the material throughout the cell. A hydrographic survey of the cell taken on 24 January indicated that a one foot thick layer of material had been placed in the cell.

Approximately 2600 cubic yards of cap material was then placed on the cell over an 18 day period between 25 January and 11 February 1989. Both the contaminated sediment and cap material came from dredging area 2 and were similar in physical characteristics. The diffuser was initially positioned just below the water surface to minimize any disturbance to the contaminated bottom sediments. This operation was discontinued, however, as it resulted in elevated suspended solids levels throughout the cove. The diffuser was then lowered to a position approximately two feet off the bottom for the remainder of the capping operation. The discharge point was also shifted on seven occasions to distribute the cap material throughout the cell.

A hydrographic survey of the CAD cell was not made until June 22. The survey results indicated that a 1-3 foot layer of cap material had been placed in the cell. Six sediment cores were also taken from the cell on 22 June. The cores were divided into 6 inch segments with these samples being analyzed for PCBs. These analyses revealed elevated levels of PCBs in the surface layers of sediment, indicating that capping efforts were unsuccessful.

Sediment Resuspension: An array of 10 stations was established around the CAD cell and sampled hourly during the first four days of disposal operations (Figure 3-4 and 3-5). The suspended solids levels within the cove were elevated above background and increased as the duration of the disposal operation increased. The average suspended solids level for the first sampling event is compared to the last sampling event in the following table:

Date	Average TSS (mg/l) First Event	Average TSS (mg/l) Last Event	Time Difference (HRS)
7 January	41	75	0.5
8 January	27	322	4.0
9 January	34	171	2.3
10 January	28	151	4.0

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. 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	8.6	4.8	4.7	15.3	3

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 in the following table:

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

Suspended sediment and contaminant levels were elevated in the vicinity of the disposal operation (CAD cell) when compared to background conditions and other phases of the study. A statistically significant increase in contaminant levels was not detected at the Coggeshall Street Bridge, however, indicating that transport of contaminants away from the disposal point was limited. The submerged diffuser appeared to be effective in reducing sediment resuspension and in controlling the placement of material. It was most effective when positioned close to the bottom of the cell. A silt curtain was not in place while monitoring for suspended solids and contaminants was ongoing. Monitoring results indicate that a curtain deployed around the disposal point would likely be an advantage.

Sediment cores taken from the CAD cell and analyzed for PCBs showed that a cap was not placed on the contaminated sediment. These results point out the need for a high degree of control on the positioning and movement of the discharge point within the CAD cell. The position of the diffuser within two feet of the contaminated sediment layer may have resulted in a mixing of the sediments. A deeper CAD cell would allow the diffuser to be separated from the contaminated sediment layer while still remaining within the confines of the cell.

PART VI ENVIRONMENTAL MONITORING PROGRAM

The monitoring program included physical, chemical and toxicological evaluations of sediment, harbor water, effluent and leachate from the confined disposl facility and air quality monitoring. The objectives were to monitor contaminant release pathways associated with the construction, dredging and disposal operations; monitor water quality at selected sites in the harbor; and provide data within 24 hours to assist in managing ongoing dredging and disposal operations. The initial effort determined background conditions in the harbor and was followed by intensive monitoring during the various phases of the study.

PRE-OPERATIONAL SAMPLING & WATER QUALITY CHARACTERIZATION

This effort was used to determine the existing ranges of specified physical, chemical and biological response variables which occur within the harbor. These background conditions were then used as monitoring program assessment points, as input to management during the operatonal phase, and as a baseline against which environmental effects could be measured. The pre-operational sampling was conducted on nine separate days between 9 July, 1987 and 23 June, 1988. The results of these efforts show that the sampling protocol was appropriate for this pilot project and that the water quality parameters were measurable, with relatively low variablility.

The basic sample component used to characterize water quality in the harbor were hourly water samples taken at four locations over one tidal cycle and pooled into ebb and flood composites. These four stations were sited throughout the harbor (Figure 11). During the construction activities, station 3 was eliminated and station 7 was established outside of the cove (Figure12). The Coggeshall Street Bridge sampling points, station 2, 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 a 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 12). 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. These five hourly composites were also composited into one sample for each station which represented the ebb or flood condition. Station 4 located near the hurricane barrier at the harbor mouth was considered another control measurement for the same reasons as station 2. The following parameters were determined:

Physical measurements:
- total suspended solids
- water temperature
- salinity
- currents (direction and velocity) at station 2

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

The results of these measurements showed the harbor to be hydrodynamically very complex. The

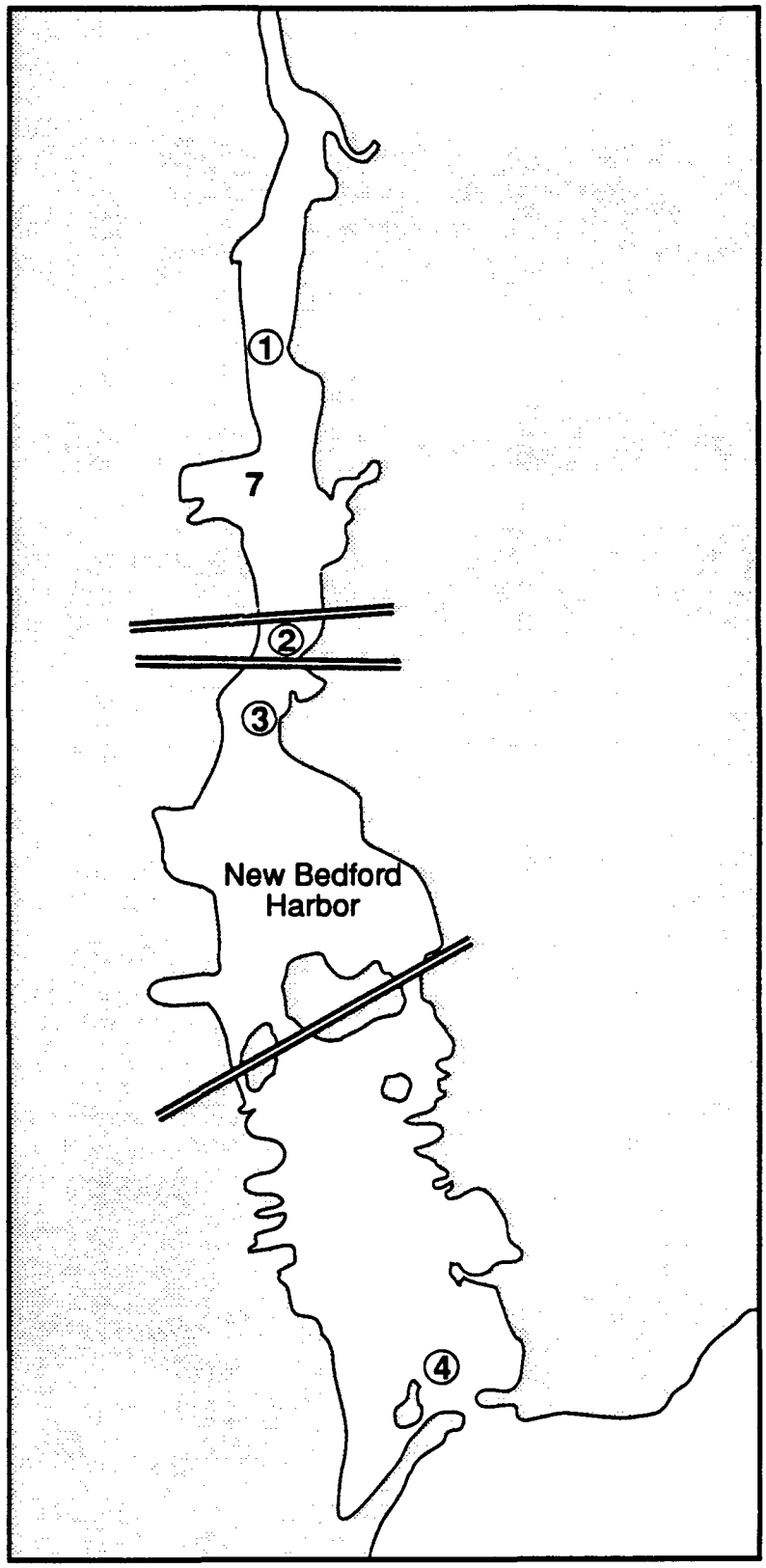

Figure 11 Locations of Harbor Monitoring Stations

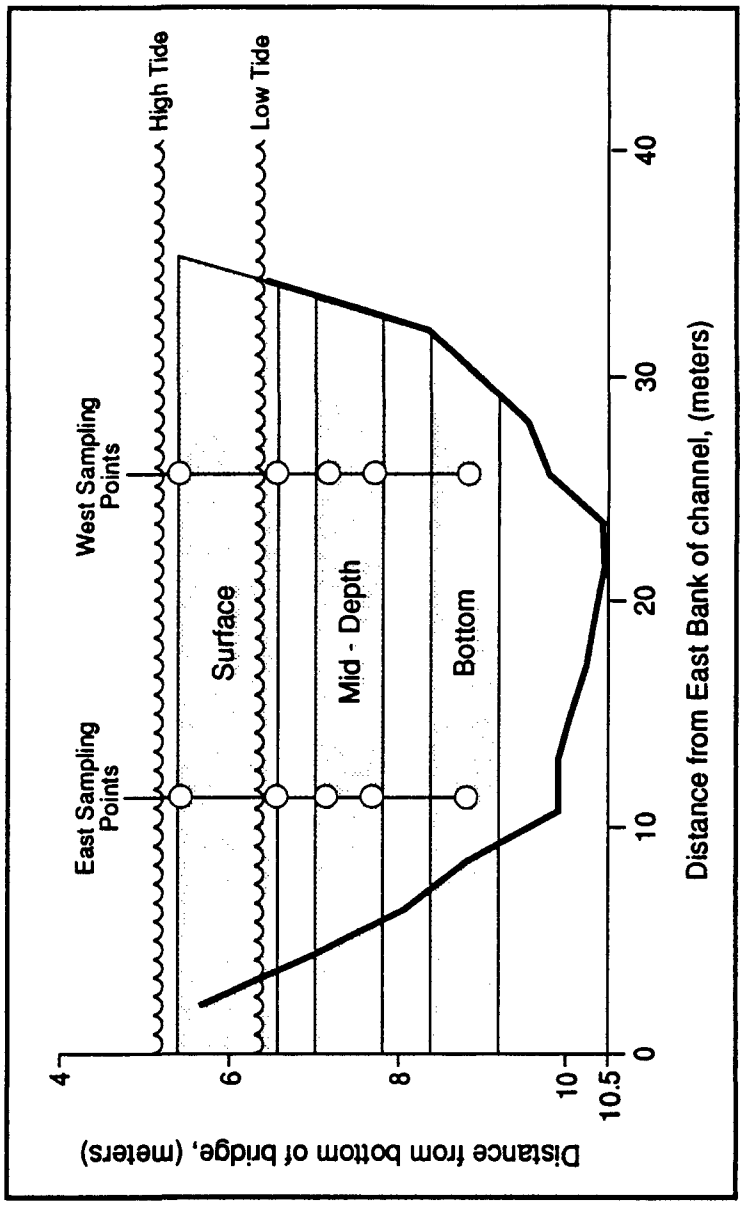

Figure 12 Channel bottom profile at Station 2 (Coggeshall St. Bridge) with approximate sampling locations

seawater temperature (station 2) varied between 18.5°C and 23.5°C during the monitoring. The salinity (station 2) ranged from 24 ppt to 33 ppt. The current velocity ranged from 10 to 50 cm/sec. at station 2 with some differences between each side of the harbor. The tidal fluctuation (station 2) was 1.6 m. The pre-operational TSS measurements means ranged rom 6.4 ± 0.4 to 8.3 ± 1.3 mg/l (ebb tide) and 6.8 ± 1.1 to 10.2 ± 1.7 mg/l (flood tide) at station 2 and 4.4 ± 1.2 to 7.9 ± 1.5 mg/l (ebb tide) and 6.6 ± 1.9 to 7.8 ± 3.4 mg/l (flood tide) 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 EPA's Environmental Research Laboratory at Narragansett, Rhode Island (ERLN) and are described in detail in Standard Methods (1989). The following test were performed:

Arbacia punctulata (sea urchin) sperm cell fertilization test (absence of gamete fertilization)
Champia parvula (red algae) reproduction test (mature cystocarps)
Cyprinodon variegatus (sheepshead minnow) growth and survival tests (increased weight & newly-hatched larvae)
Mysidopsis bahia (mysid) growth and reproduction tests (increased weight & females with eggs)
Mytilus edulis (mussel) scope for growth (SFG); and uptake of PCBs and metals (increased growth & body burden increase)

Based on the statistical analyses of these data, no environmentally significant toxicity effects were detected by the *A. punctulata* sperm cell test, *C. parvula* reproduction test, *C.variegatus* growth and survival tests, and *M. bahia* growth test. The *M. bahia* test had significant mortality at station 2; the cause of this mortality was not determined. The *M. edulis* SFG test indicated an inverse relationship with PCB levels in the water column and mussel tissues. The body burden analyses showed a linear relationship with PCB levels.

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 Harbor. 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 the sublethal biological effects. The Coggeshall Street Bridge station (station 2) and the hurricane barrier station (station 4) were the focal points for decision criteria monitoring. These two stations were hydrodynamic control points for the harbor circulation.

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, and 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 decision criteria was exceeded on three occasions and these events were related to either weather conditions or obvious operational problems which were promptly changed (i.e. moving the anchors).

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 (survival tests)

PCBs and heavy metals were generally restricted to the top two feet of sediment with the highest levels being detected in the top six inches. PCB levels in the 0-6 inch horizon averaged 226 ppm in area 1 and 385 ppm in dredge area 2. 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 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:

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
EPA standard 2 &7 day toxicity tests on effluent

The daily averages for TSS in the CDF discharge ranged from 27-152 mg/l and averaged 75 mg/l. The PCB levels averaged 1.4 ppb with a range of 0.3-2.9 ppb for the dissolved fraction and 10.7 ppb with a range of 5.0-19.2 ppb for the particulate fraction. The toxicity testing (*A. punctulata* (sea urchin) sperm cell test and EPA standard 2 &7 day toxicity tests on effluent) showed no significant effects related to the disposal site discharge. A toxic effect was evident during the period when polymer was being added at the weir between the primary and secondary cells. Further testing showed polymer to be extremely toxic to the test organisms used in the monitoring program.

Seven wells were installed in and around the CDF to capture leachate (Figure 11). 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). The results of this effort indicated that contaminants are not leaching from site. The data is summarized in Part IV and Appendix 2.

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 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. seabreezes) 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 hydrogen sulfide (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. Results of the air monitoring program demonstrated that disposal of contaminated sediment into the shoreline CDF raised the ambient PCB levels above background. However, the increased levels did not threaten worker safety or public health and were confined to the area adjacent to the CDF. A technical report summarizing results of this work is currently being prepared by Ebasco Services Inc.

METEOROLOGICAL DATA

A meteorological station was located adjacent to the CDF as shown in Figure 3. 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 was 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)

Only one significant storm event occurred during pilot study and resulted in increased levels of

contaminants and TSS being detected in the water at the monitoring stations. A technical report on the air monitoring, including these data, is currently being prepared by Ebasco Services Inc.

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 day's dredging and analyzed for TSS, PCBs, and heavy metals (50% of samples). The levels of contaminants and TSS were elevated above background and the other phases of the pilot study during CAD. The monitoring at station 2 showed no significant increase in contaminants levels moving out of the upper harbor (Part V and Appendix 3).

The second phase involved sampling of the CAD cell to determine if a cap had been effectively placed and if contaminants were migrating into the cap material. Sediment cores were taken in June 1989 and analyzed for PCBs. The results of these monitoring efforts show elevated PCB levels in the surface sediment layers indicating that capping efforts were unsuccussful (Part V and Appendix 3).

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. The results of these efforts appear in Part II and Appendix 1.

Removal Efficiency: A grid of either 16 or 32 sampling stations was established within each dredging area. Each station was randomly assigned a number from either 1-4 or 1-8 depending on the size of the area. A sediment core 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, metals, and *A. abdita* toxicity. These data show that the dredges could effectively remove the contaminated sediment layer.

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 minute intervals during operating periods. Each individual sample was analyzed for TSS. Composite samples were taken 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). The results of these efforts indicated that the dredges generated elevated contaminant and TSS levels in the water adjacent to the operation. Elevated levels returned to background levels within 150 meters.

Far Field Water Quality: This sampling effort was conducted just prior to the start of each dis-

tinct phase of the pilot study (CDF construction, dredging) and during the first 4 days of each operation (dike construction, each dredge operating in area 1 with disposal into the CDF, CAD). The sampling procedures were the same as those of the preliminary monitoring program, and the composite samples from the 4 stations were analyzed in the same manner. This allowed the results from operational periods to be compared with background (pre-operational) conditions. The results of this effort are contained in Appendix 4 and showed no significant difference between pre and operational periods.

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APPENDIX 1

DREDGES

APPENDIX 1 - DREDGES

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 14.

Operating procedures and production rates: The dredge operating procedures which proved most effective are listed below:

Swing Speed: This represents side to side movement of the dredge. It was kept steady and as slow as allowable, averaging 0.5 feet per second (40% of maximum).

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 1-1): 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

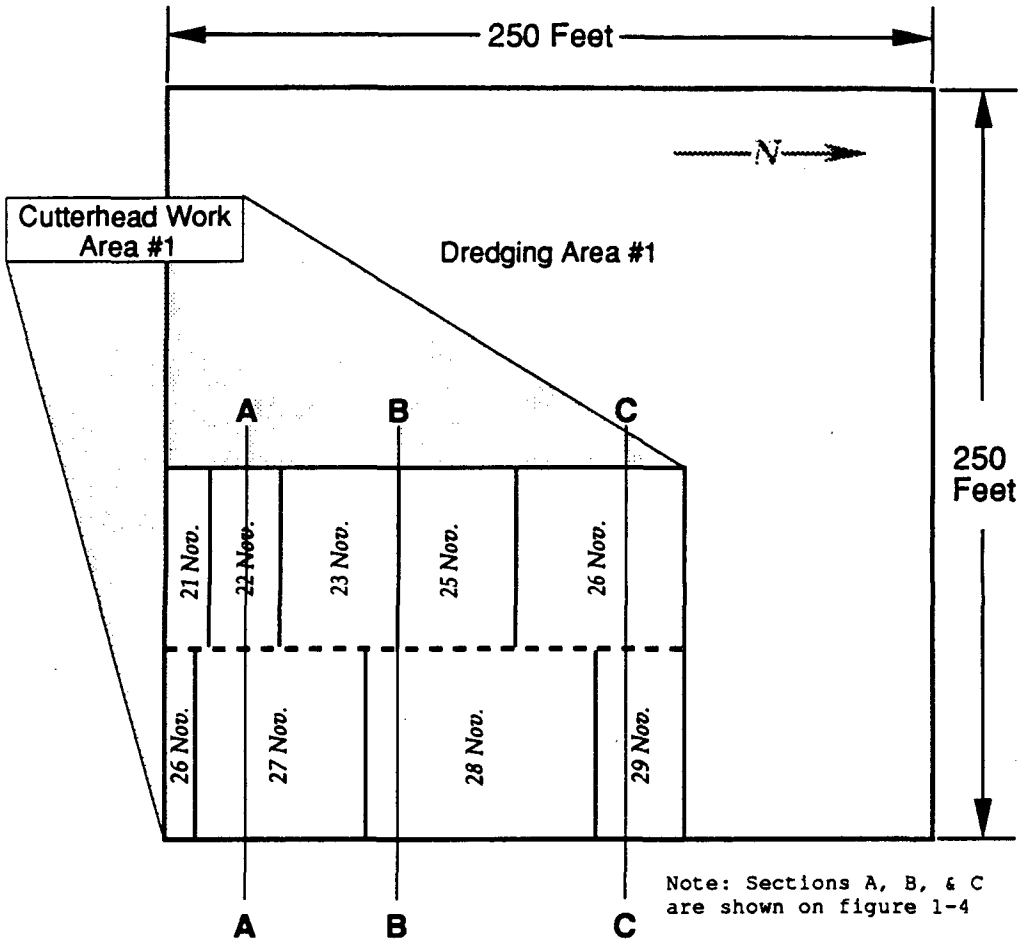


Figure 1-1 Cutterhead Work Area #1

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

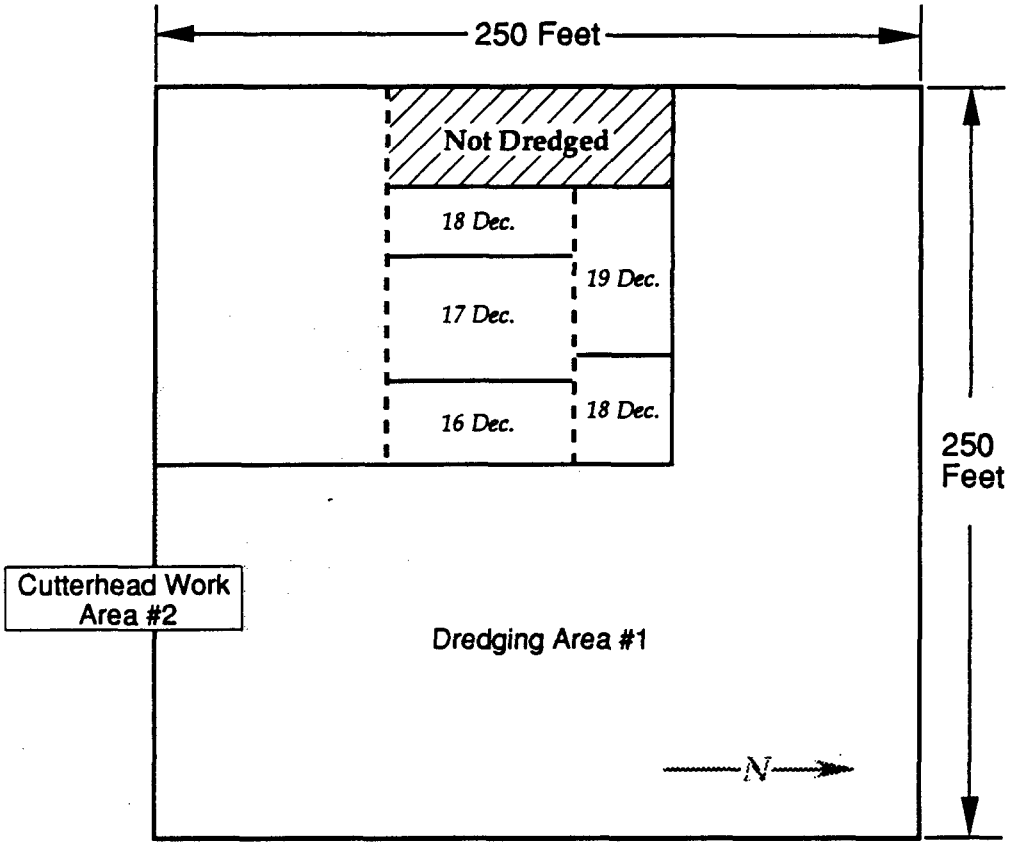
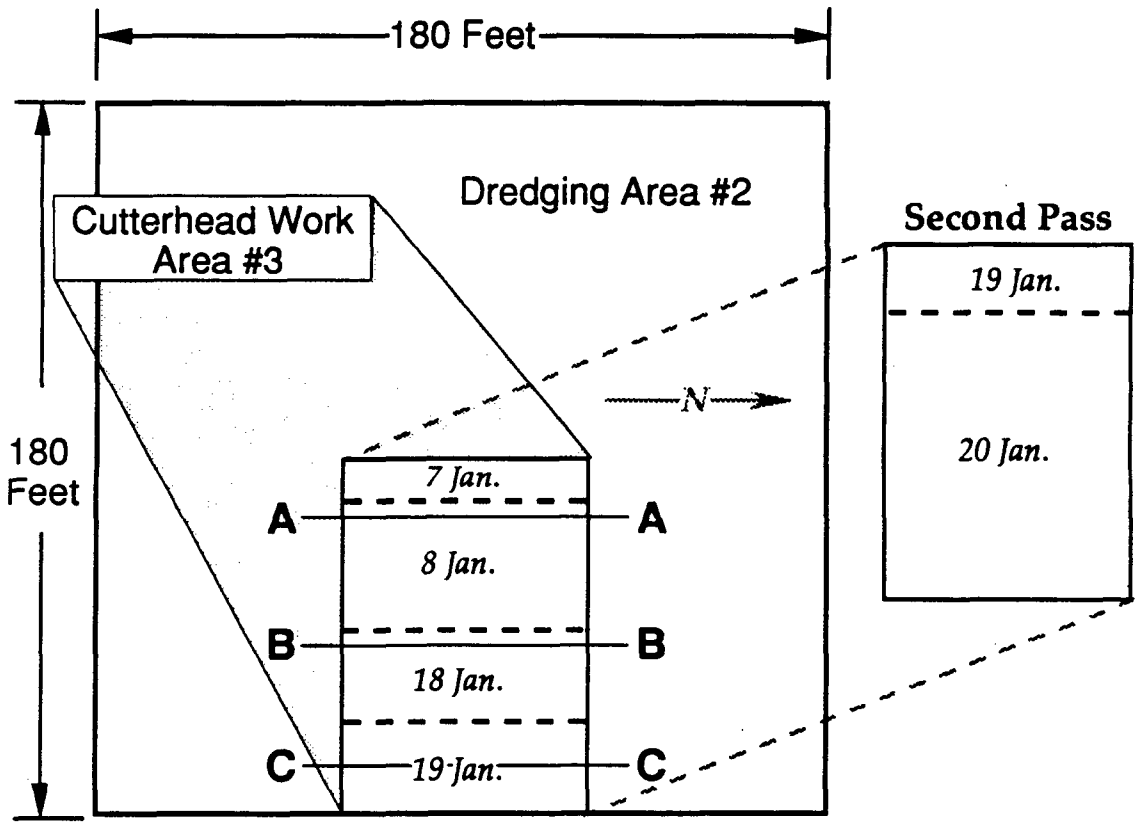


Figure 1-2 Cutterhead Work Area #2

Dredging area 1- work area #2 (Figure 1-2): 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:



Note: Sections A, B, & C are shown on figure 1-5

Figure 1-3 Cutterhead Work Area #3

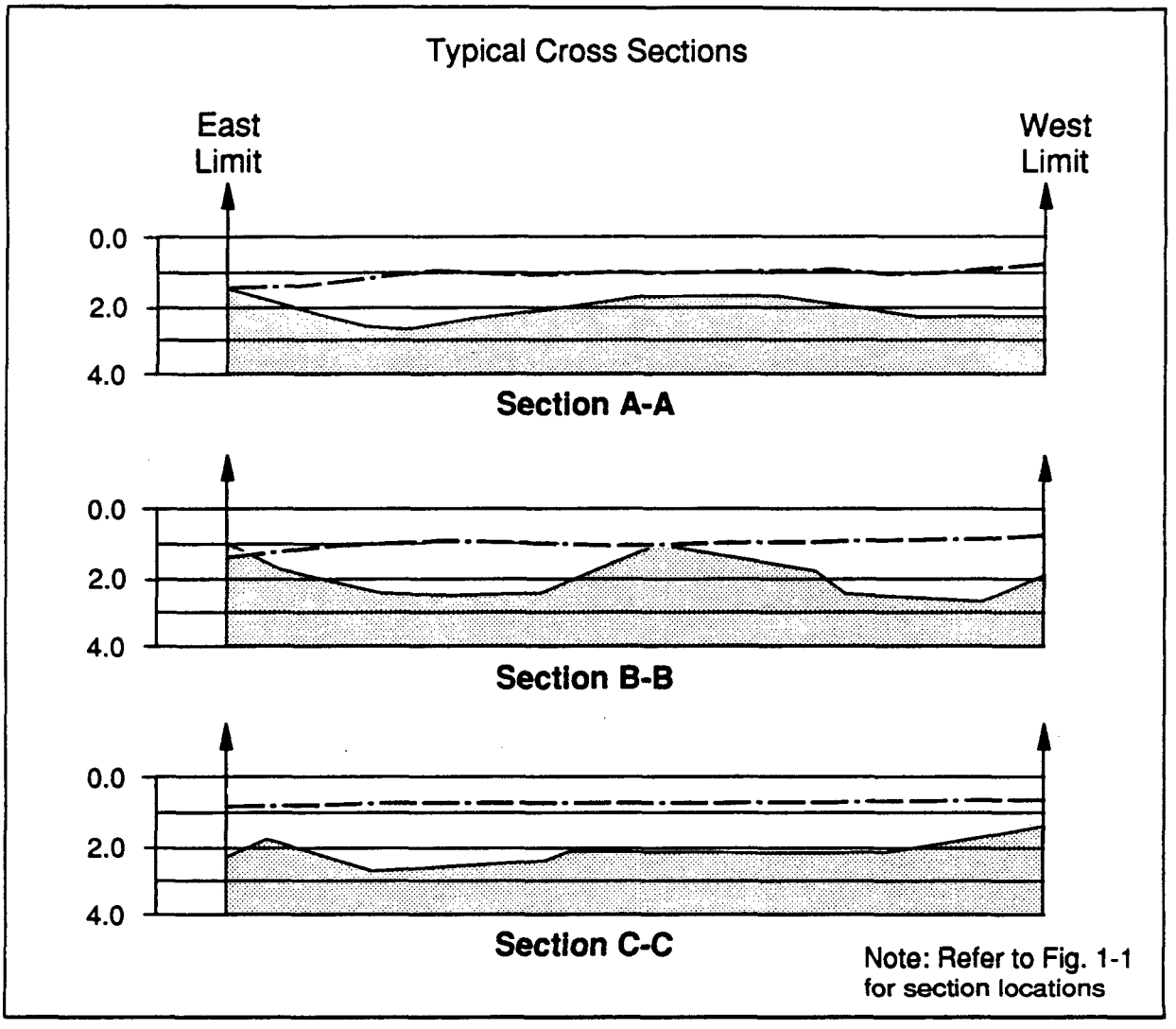


Figure 1-4 Dredge Area 1 - Cutterhead Dredge

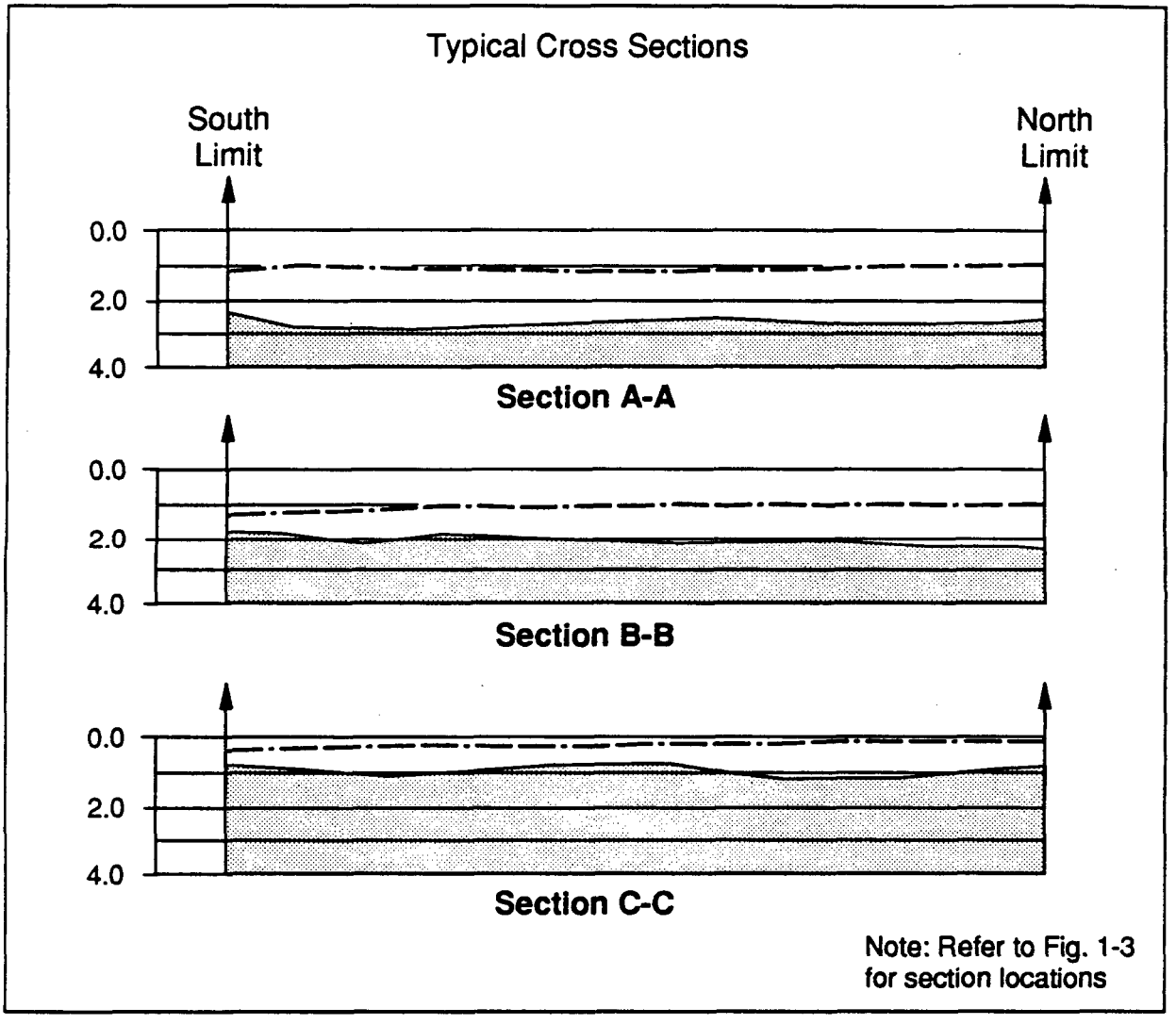
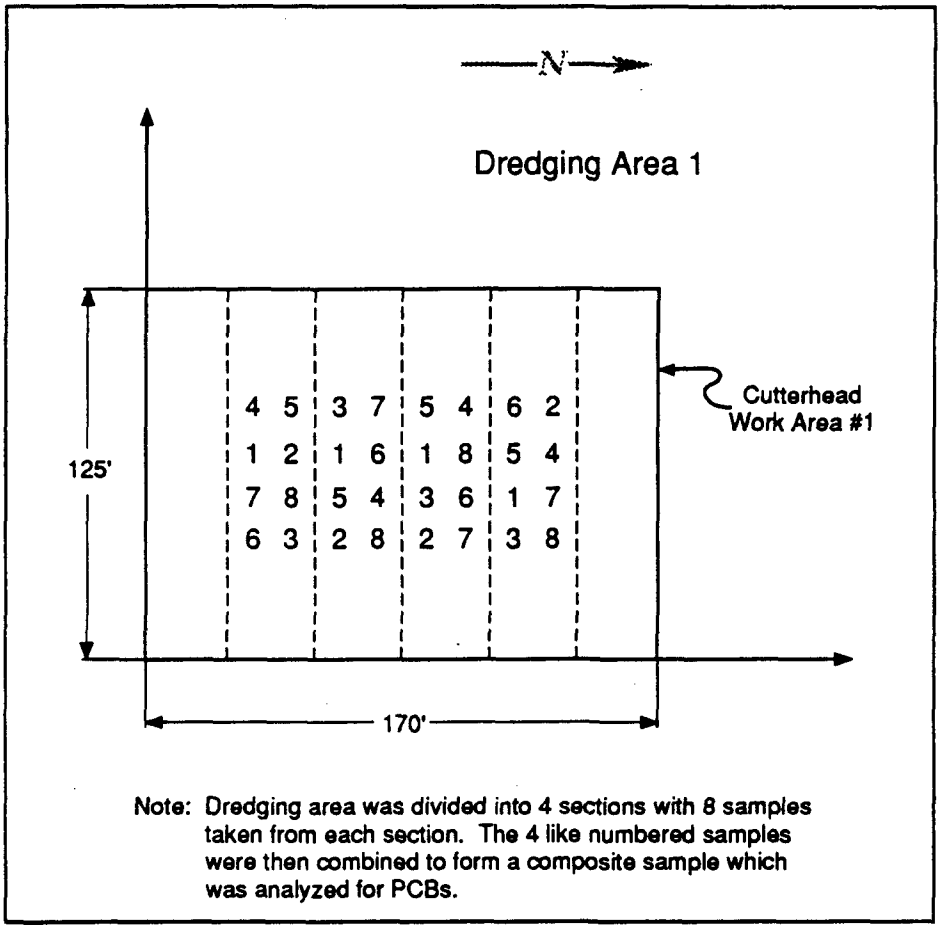


Figure 1-5 Dredge Area 2 - Cutterhead Dredge



Note: Dredging area was divided into 4 sections with 8 samples taken from each section. The 4 like numbered samples were then combined to form a composite sample which was analyzed for PCBs.

Figure 1- 6 Sediment Sample Locations

	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

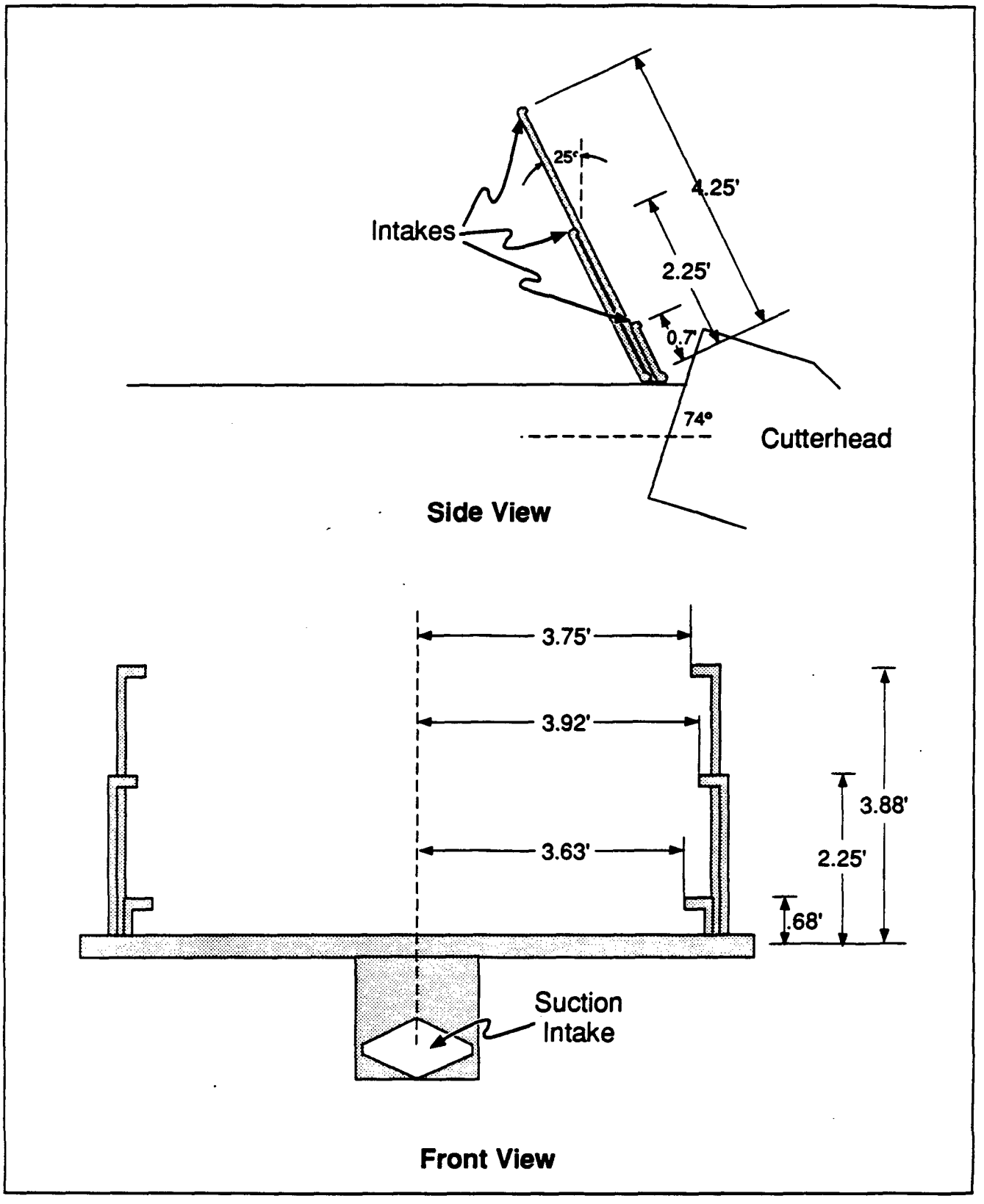


Figure 1-7 Dredgehead Sampler - Cutterhead Dredge

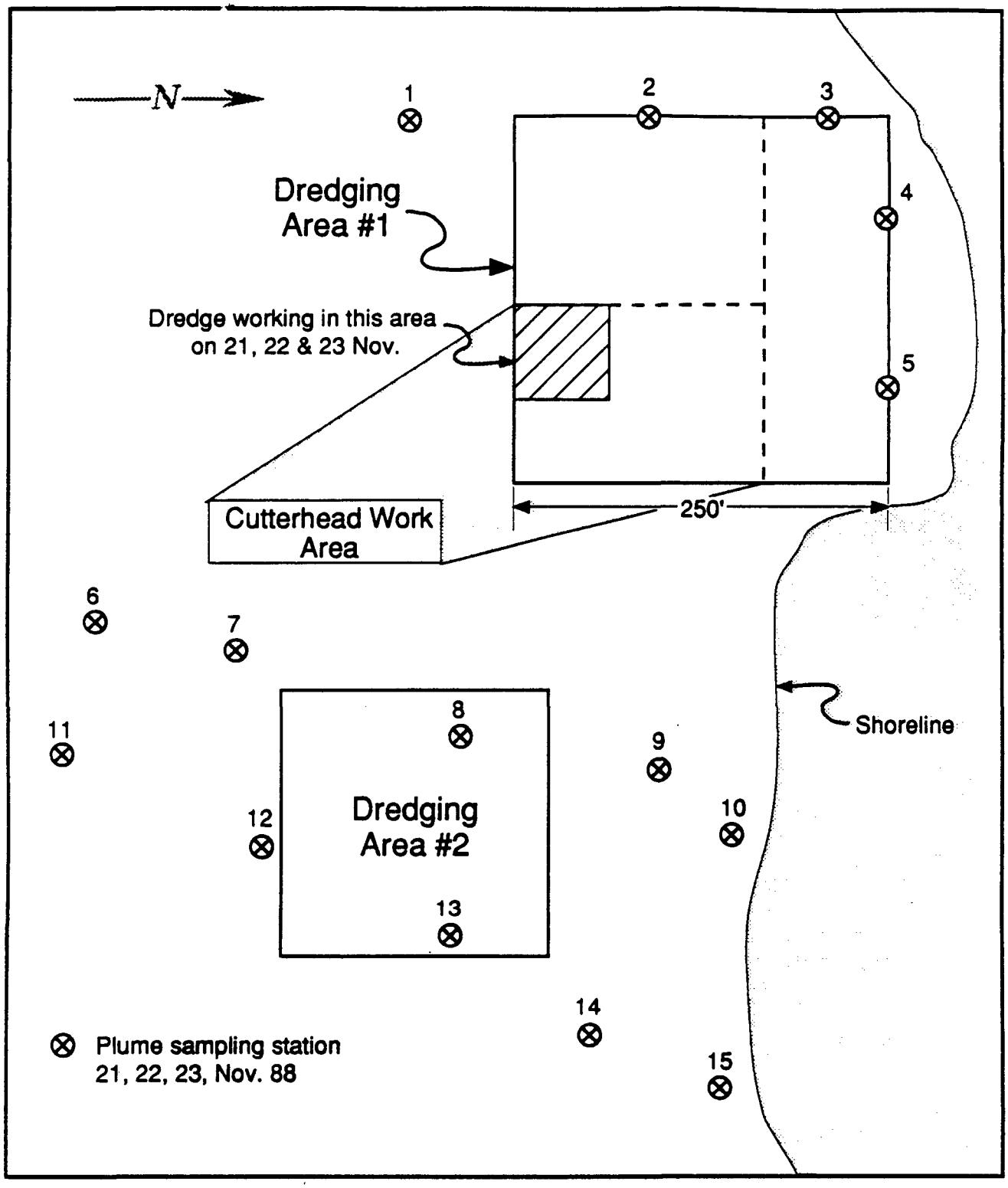


Figure 1-8 Plume Sampling Stations-Cutterhead Work Area

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

Dredging Area 2 - work area #3 (Figure 1-3): 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 summarizes 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

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

Contaminant Removal: Two separate evaluations were made of the cutterhead dredge's ability to remove the PCB contaminated sediment. In work area 1 of dredging area 1, the dredge made one pass over the 125 by 170 foot area. Comparing the results of hydrographic surveys taken on 12 September and 15 December 1988 revealed that on average a 1.5 foot thick sediment layer was removed. Typical cross sections of this area are shown in Figure 1-4. Thirty two (32) sediment cores were taken from the area on 30 November and composited into 8 samples which were analyzed for PCBs. The samples represented the top 3 inches of sediment. PCB levels ranged from 8.2 ppm to 189.0 ppm with the average being 80.5 ppm. The sampling grid is shown in Figure 1-6.

In dredging area 2 the cutterhead dredge made two passes over the 90 by 60 foot area. On the second pass the dredge attempted to remove only the surface layer of sediment. The dredgehead (cutterhead) was positioned at the sediment/water interface and the swing speed was increased. These procedures resulted in very little additional material being removed. Comparing the results of hydrographic surveys taken on 12 September 1988 and 24 January 1989 revealed that on average a 1.1 foot thick sediment layer had been removed. Typical cross sections of this area are shown in Figure 1-5. Sixteen (16) sediment cores were taken from the area on 24 January and composited into 4 sam-

ples which were analyzed for PCBs. PCB levels ranged from 0.5 ppm to 15.3 with the average being 8.6 ppm.

Sediment Resuspension and Contaminant Release: A sampling device (Figure 1-7) was attached to the dredge to allow for six locations around the dredghead to be sampled at once. Samples were taken at approximately 15 minute intervals during operating periods with each individual sample analyzed for total suspended solids (Table 5). This data was used with the dredge's swing speed and the water depth to develop a sediment resuspension rate. Rates were computed from four days of operation which best represented the recommended operating procedures (Nov. 22, 23, 25 and Dec. 17). The average resuspension rate for these days was 12.1 grams per second. Sediment resuspension rates were also computed for January 8. On this day the dredgehead (cutterhead) was rotated at full RPM, approximately twice the speed of the other days. This resulted in a higher sediment resuspension rate which would bring the overall average up to 21.6 grams per second. 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	46.3 - 11.8	21.0
11-23	12.3 - 5.2	8.5
11-25	21.8 - 3.0	9.8
12-17	45.6 - 6.4	14.7
1-8*	98.6 - 34.7	60.5

*On this day the cutterhead was rotating at full RPM.

Composite samples were taken randomly from the mid-depth ports of the dredgehead sampler and analyzed for PCBs and metals (Cd, Cu, Pb). These results are shown in Table 2.

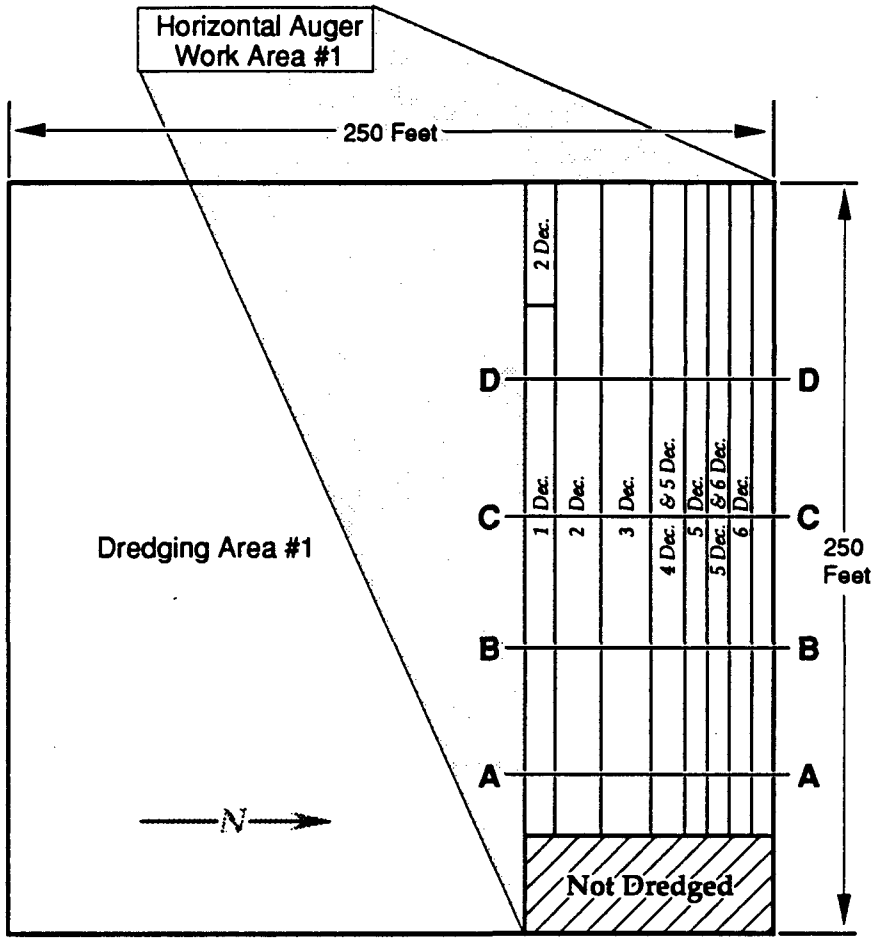
Sediment and Contaminant Transport: Figure 1-6 shows the location of the 15 stations established around the cutterhead dredge work area, 10 of which were sampled hourly during the dredge's first three days of operation. These samples were analyzed for total suspended solids with the results appearing in Table 4.

Composite samples representing rows 1-5, 6-10, 11-15 were formed by combining samples from the five individual stations in each group. These samples represented a cross sectional area of the cove and were taken after the dredge had been operating for several hours. These samples were analyzed for PCBs and metals with the results appearing in Table 3.

HORIZONTAL AUGER DREDGE

An Ellicott SP-915 Mudcat dredge was used during the study. The physical dimensions of the equipment are shown in Table 15.

Operating Procedures and Production Rates: The dredge operating procedures which proved to be the most effective are listed below:



Note: Sections A-D shown on figure 1-10

Figure 1-9 Horizontal Auger Work Area #1

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.

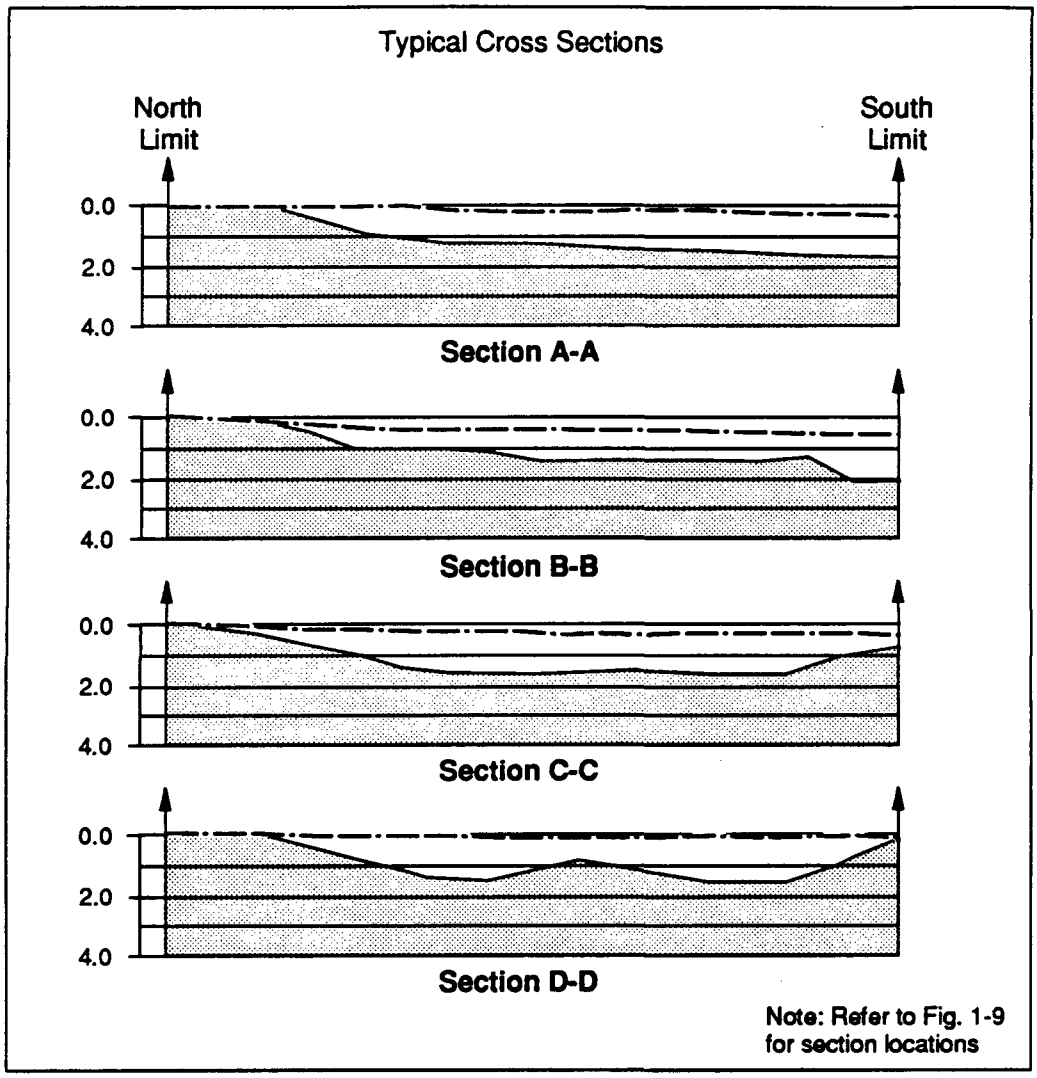


Figure 1-10 Dredge Area 1 - Horizontal Auger Dredge

Dredging area 1 (Figure1-9): 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

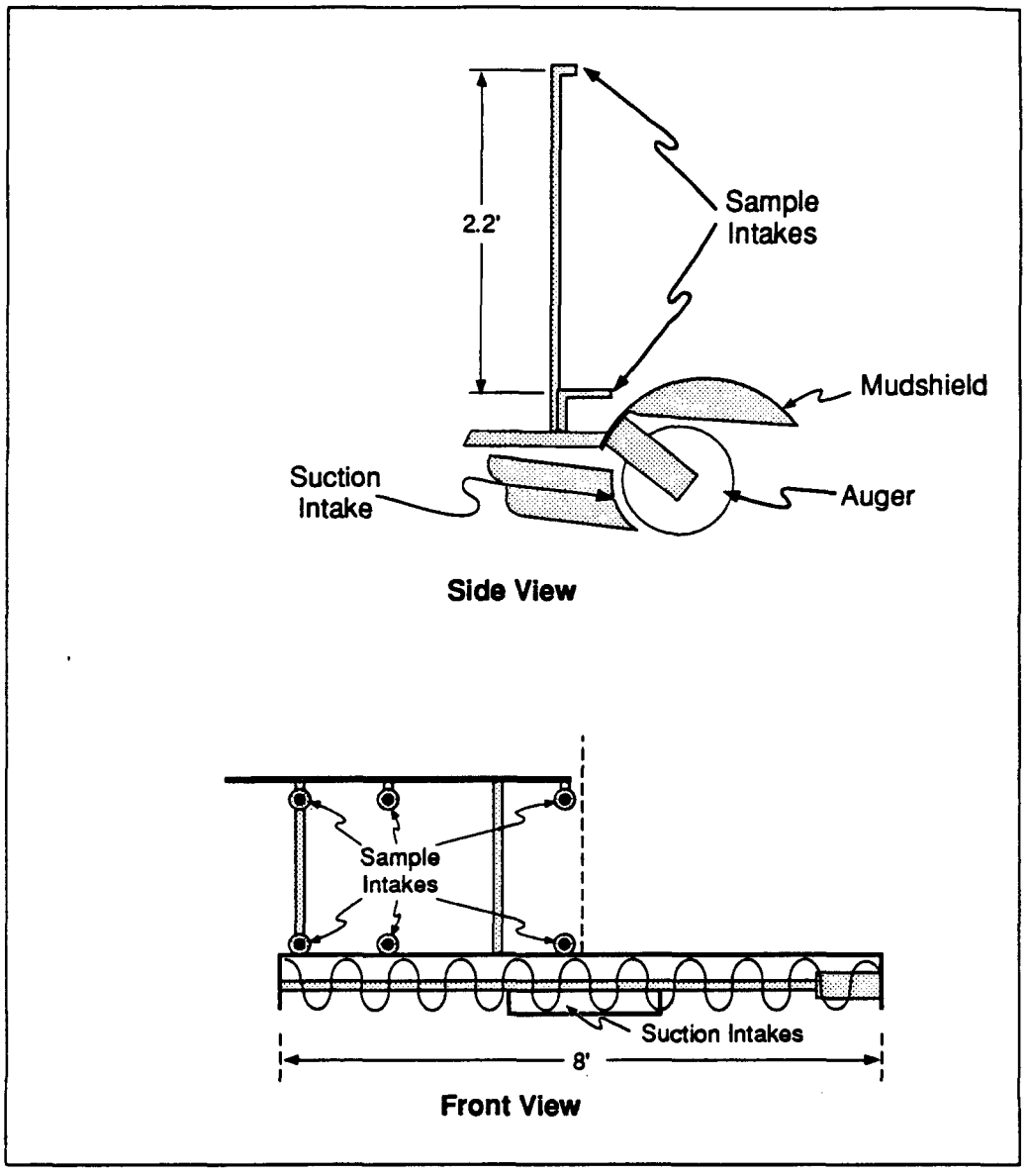


Figure 1-11 Dredgehead Sampler - Horizontal Auger Dredge

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

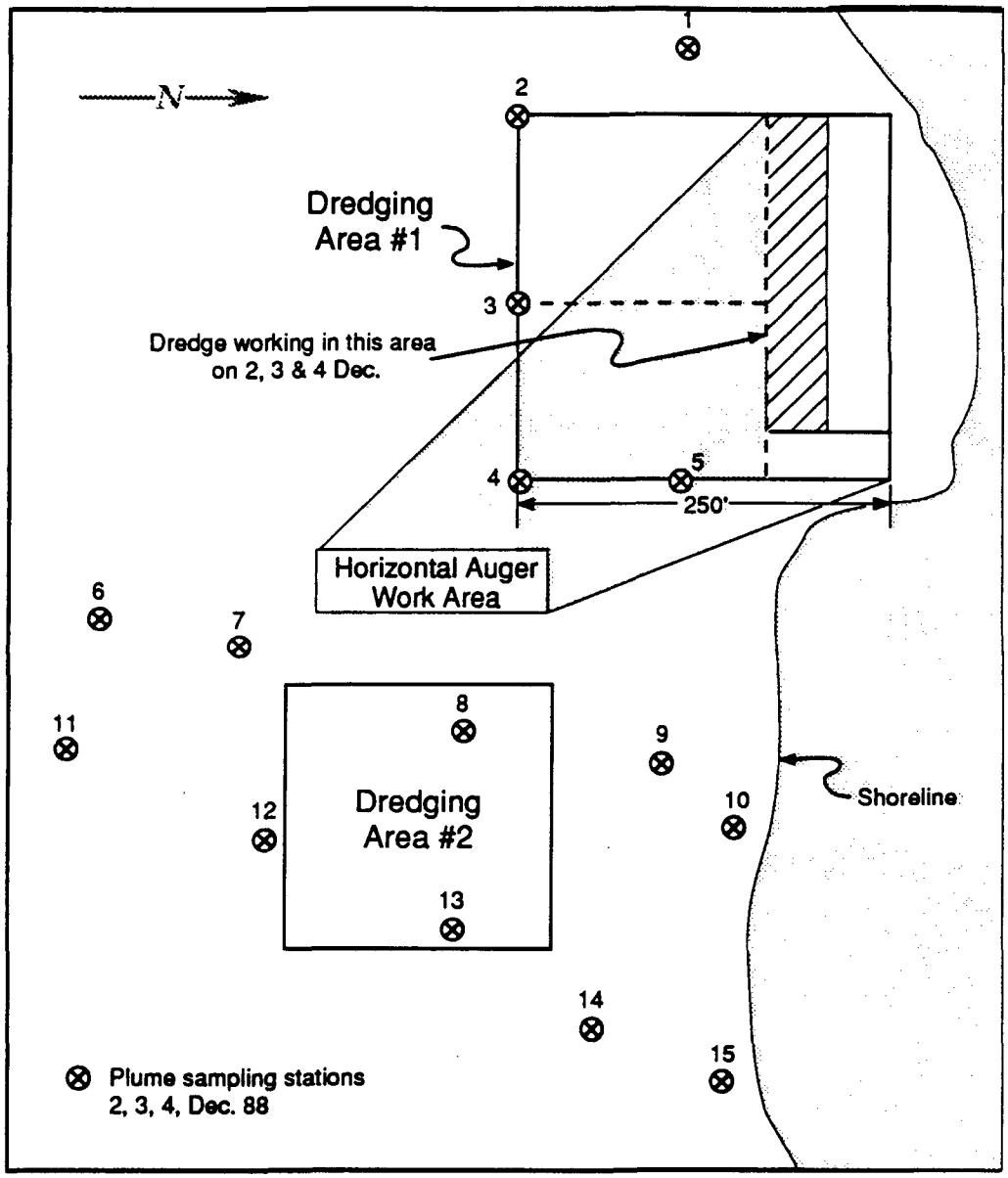


Figure 1-12 Plume Sampling Location-Horizontal Auger Work Area

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

Contaminant Removal: In dredging area 1 the dredge attempted to remove 6 inches of sediment per pass over an area. Four passes were made, two in the forward direction and two in reverse, before the dredge was moved over to the next cut. Comparing the results of hydrographic surveys taken on 12 September and 15 December revealed that on average a 1.0 foot thick sediment layer was removed. Typical cross sections of this area are shown in Figure 1-10. Thirty two (32) sediment cores were taken from the 215 by 80 foot area on 7 December and composited into 8 samples which were analyzed for PCBs. The samples represented the top 3 inches of sediment. PCB levels ranged from 9.3 ppm to 270.2 ppm with the average being 66.4 ppm.

Sediment Resuspension and Contaminant Release: A sampling device (Figure 1-11) was attached to the dredge to allow for six locations around the dredghead to be sampled at once. Samples were taken at approximately 15 minute intervals during operating periods with each individual sample analyzed for total suspended solids (Table 9). This data was used with the dredge's rate of advance and the water depth to develop a sediment resuspension rate. Rates were computed from four days of operation when the dredge was operating in contaminated sediment. The results are summarized below with the data used in deriving these values contained in Table 6.

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

Composite samples were taken randomly from the dredgehead sampler and were analyzed for PCBs and metals (Cd, Cu, Pb). These results are shown in Table 7.

Sediment and Contaminant Transport: Figure 1-12 shows the location of the 15 stations established around the horizontal auger dredge work area, 10 of which were sampled hourly during the dredge's first three days of operation. These samples were analyzed for total suspended solids with the results appearing in Table 8.

Composite samples representing rows 1-5, 6-10, 11-15 were formed by combining samples from the five individual stations in each group. These samples represented a cross sectional area of the cove and were taken after the dredge had been operating for several hours. These samples were analyzed for PCBs and metals with the reusults appearing in Table 3.

MATCHBOX DREDGE

This piece of equipment operates in the same manner as the cutterhead dredge. 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 and designed, built and installed the dredgehead. Because there is no mechanical action at the dredgehead, this dredge had to be considerably larger than either the cutterhead or horizontal auger. The equipment had to be transported to New Bedford in sections and as-

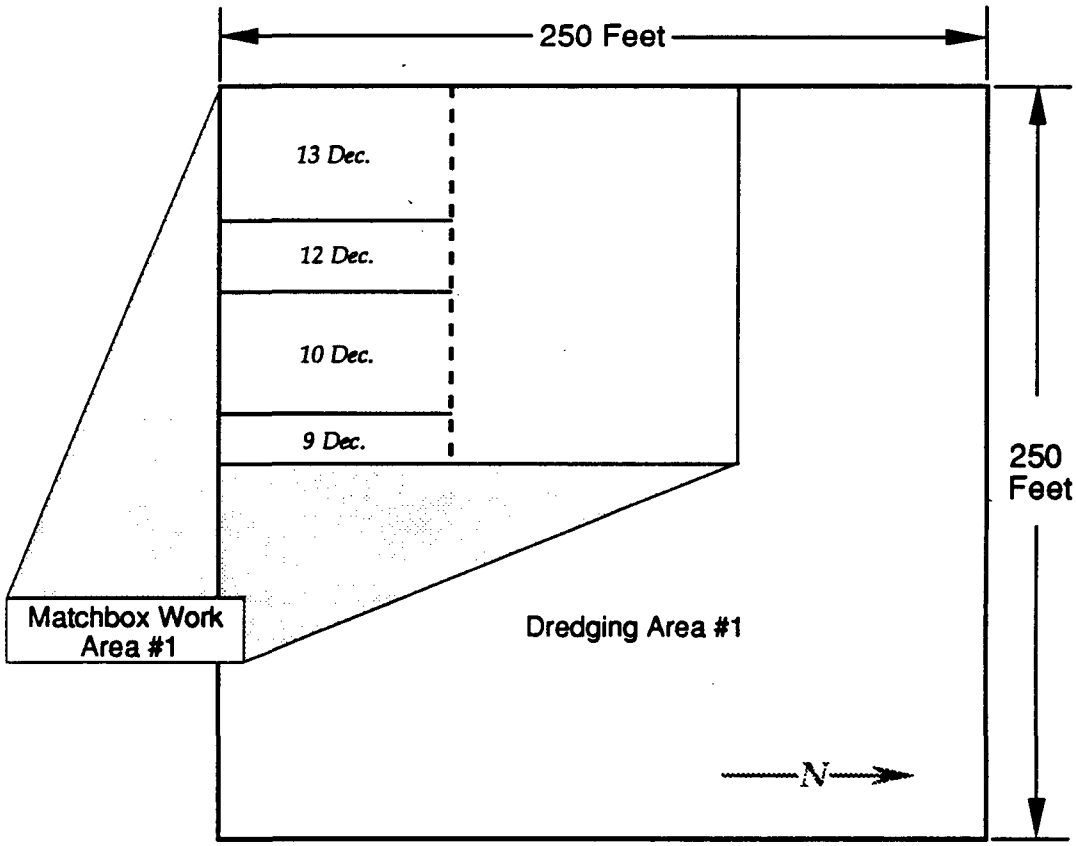
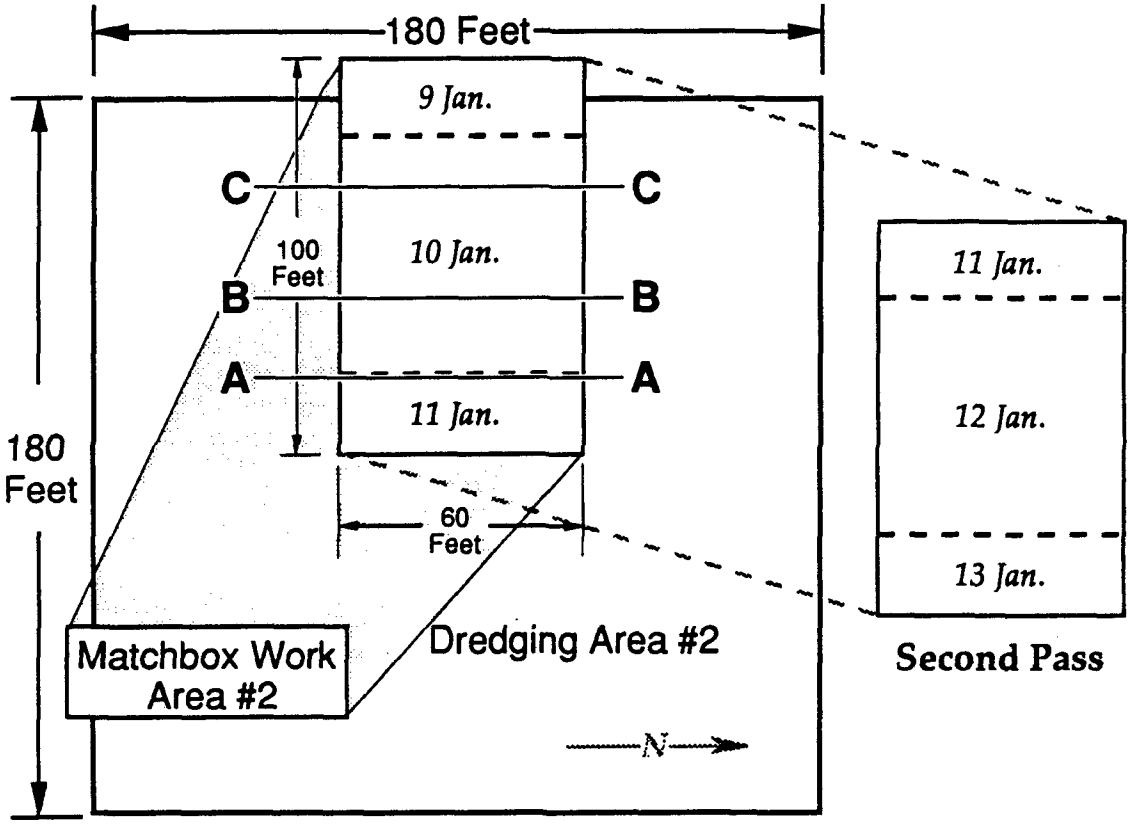


Figure 1-13 Matchbox Work Area #1



Note: Sections A-C shown on figure 1-15

Figure 1-14 Matchbox Work Area #2

sembled on site. Using a launch ramp constructed adjacent to the south-east corner of the CDF, the dredge was floated into the estuary upstream of the Coggeshall Street Bridge at high tide. The physical dimensions of the equipment are shown in Table 16.

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, averaging 0.28 feet per second.

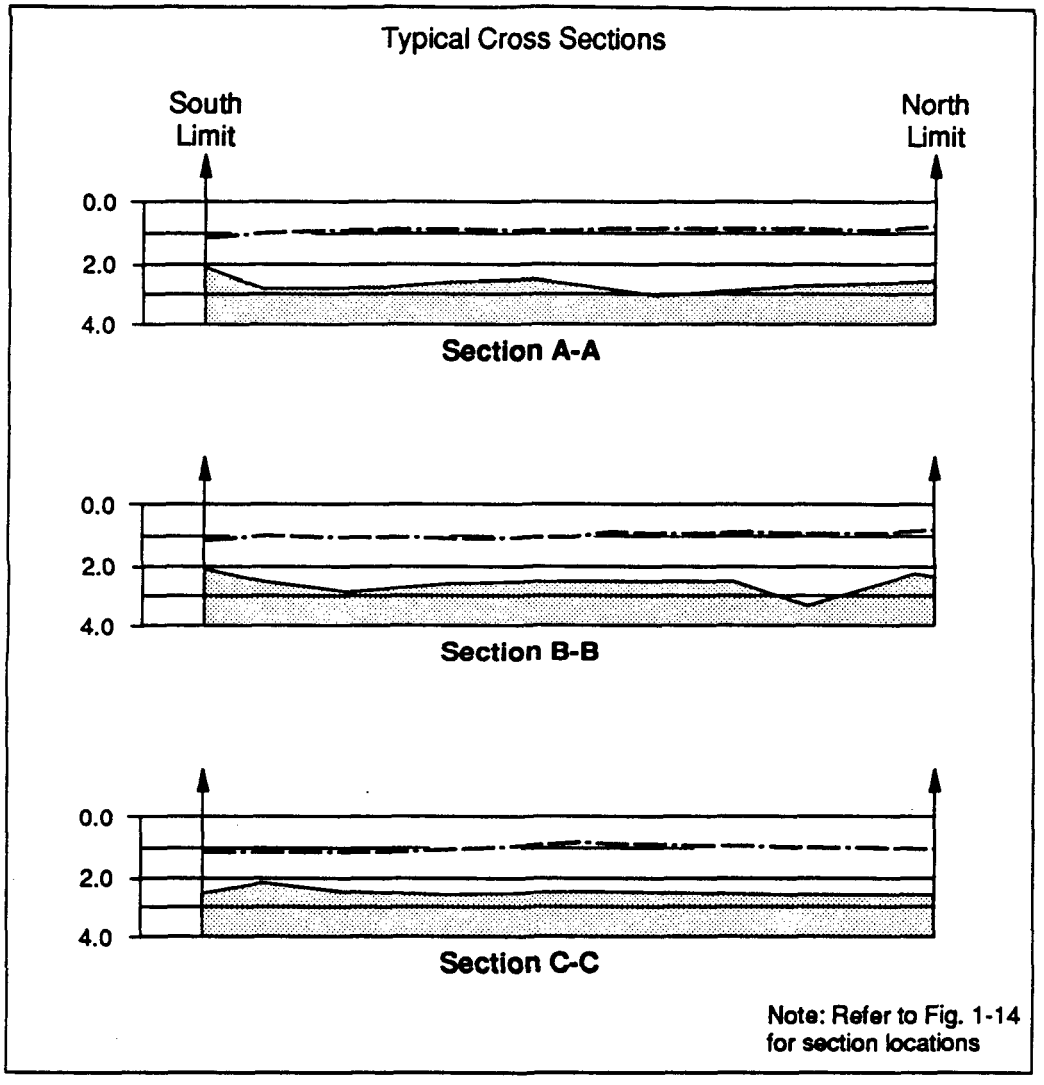


Figure 1-15 Dredge Area 2 - Matchbox Dredge

Depth of Cut: Six inches per swing

Width of Cut: 60 feet

Dredge Pump: Run at maximum RPM

Dredging area 1: (Figure1-13) 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 1-14) 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. 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

1. Quantity of material removed: 359.0 cubic yards

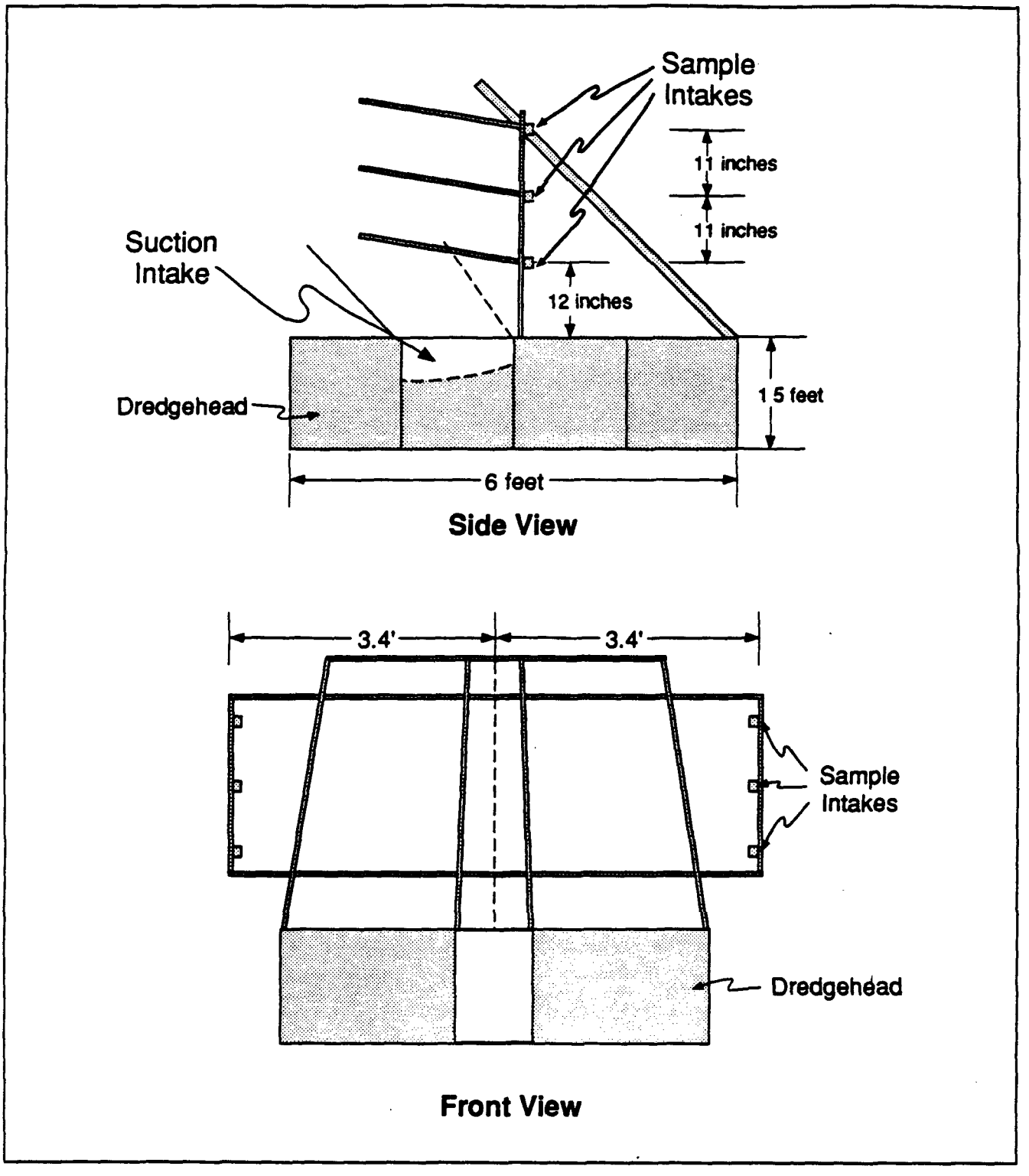


Figure 1-16 Dredgehead Sampler - Matchbox Dredge

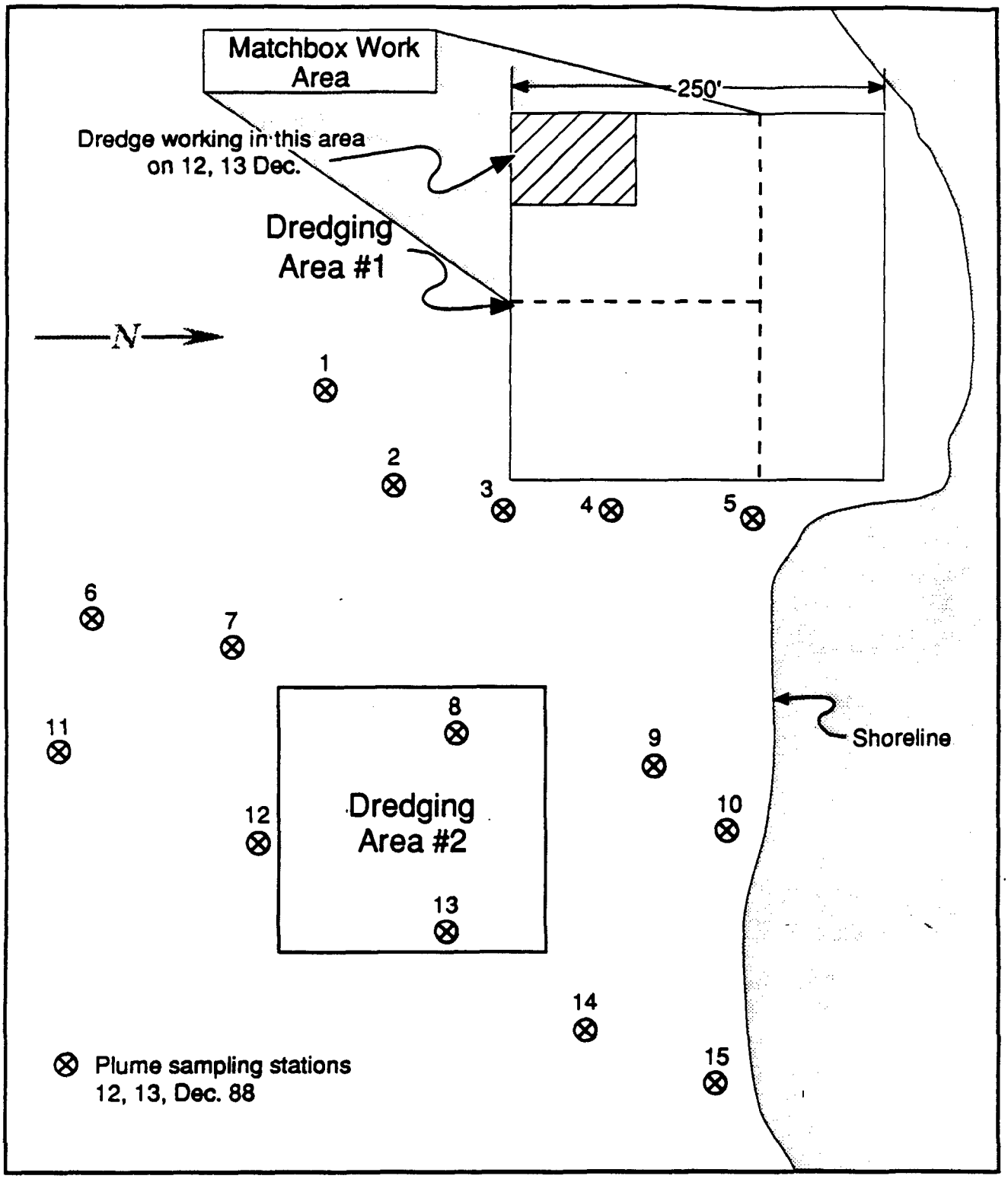


Figure 1-17 Plume Sample Locations - Matchbox Work Area

2. Production rate: 24.5 cubic yards/hour

3. Rate of advance: 14.9 feet/hour

Contaminant Removal: Contaminant removal was not evaluated in dredge area 1. In area 2 the dredge made two passes over the 100 by 60 foot area. The dredge attempted to remove a 6 inch lift of sediment with each swing and made 2 swings per advance. This procedure was then repeated during the second pass. Comparing the results of hydrographic surveys taken on 12 September 1988 and 24 January 1989 revealed that on average a 1.5 foot thick sediment layer was removed. Typical cross sections of this area are shown in Figure 1-15. Sixteen (16) sediment cores were taken from the 100 by 60 foot area on 23 January and composited into four samples which were analyzed for PCBs. The samples represented the top 3 inches of sediment. PCB levels ranged form 3.0 ppm to 9.6 ppm with the average being 5.4 ppm.

Sediment Resuspension and Contaminant Release: A sampling device (Figure 1-16) was attached to the dredge adjacent to the dredgehead to allow for six locations around the dredgehead to be sampled at once. Samples were taken at approximately 15 minute intervals during operating periods with each individual sample analyzed for total suspended solids (Table 13). This data was used with the dredge's swing speed and the water depth to develop a sediment resuspension rate. Rates were computed from five days of operation when the dredge was operating in contaminated sediments. The results are summarized below with the data used in deriving these values contained in Table 10.

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 were taken randomly from the mid-depth ports of the dredgehead sampler and were analyzed for PCBs and metals (Cd, Cu, Pb). These results are shown in Table 11.

Sediment and Contaminant Transport: Figure 1-14 shows the locations of the 15 stations established around the Matchbox dredge's work area, 10 of which were sampled hourly during the dredge's first three days of operation. These samples were analyzed for total suspended solids with the results appearing in Table 12.

Composite samples representing rows 1-5, 6-10, 11-15 were formed by combining samples from the five individual stations in each group. These samples represented a cross sectional area of the cove and were taken after the dredge had been operating for several hours. These samples were analyzed for PCBs and metals with the results appearing in Table 3.

Table 1
Resuspension Rate - Cutterhead Dredge
November 22

Time	Tide Ht. (ft)	Area* (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

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

November 25

Time	Tide Ht. (ft)	Area* (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

*tide height x length of dredgehead (2.6 ft)

Table 1

Resuspension Rate - Cutterhead Dredge Con't
December 17

Time	Tide Ht. (ft)	Area* (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

January 8 **

Time	Tide Ht. (ft)	Area* (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

* tide height x length of dredgehead (2.6 ft)
** cutterhead was rotated at maximum RPM (40 RPM). These values were not used in determining average resuspension rate.

Table 2
Dredgehead Samples - Cutterhead Dredge

Date	Sample No.	Time	PCB (ppb)	Cu (ppb)	Cd (ppb)	Pb (ppb)	
11-21	519121	0730	5.43				WWC
	519122	0730	18.00	228	6	71	FWC
	519122	0730	0.53				WFC
	519123	0730	3.76	90	2	31	WWC
11-22	519321	0742	6.87				WWC
	519322	0742	0.56				FWC
	519322	0742	0.51				WFC
11-23	519521	0741	3.59				WWC
	519522	0903	3.48	91	2	32	WWC
	519523	0903	0.50				WFC
	519523	0903	3.16				FWC
12-16	520921		26.60				WWC
	520923		14.30	281	10	120	WWC
	520922		66.70	330	9	110	FWC
	520922		1.59	2	0.1	0.4	WFC
12-17	521950	1420	32.80	687	25	203	FWC
	521950	1420	0.99	2	0.2	0.5	WFC
	521951	1520	3.20				WWC
	521952	1620	3.39	91	3	39	WWC
1-8	526222	1120	4.97				WWC
	526223	1120	12.40				FWC
	526223	1120	0.68				WFC

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

Table 3
Plume Sampling Stations

Date	Sample No.	Event	Stations	PCB	Cu	Cd (ppb)	Pb	
Cutterhead Dredge								
11-21	513151	2	1-5	1.41				WWC
	513153	2	11-15	1.41				WWC
11-22	513251	4	6-10	1.65				WWC
	513252	4	6-10	0.77				WFC
	513252	4	6-10	1.94				FWC
	513253	4	6-10	0.66				WWC
11-23	513351	2	1-5	0.62				WWC
	513352	5	6-10	0.17				FWC
	513325	5	6-10	0.31				WFC
	513353	5	11-15	0.54				WWC
Horizontal Auger Dredge								
12-2	513451	2	1-5	1.45				WWC
	513452	3	6-10		16.2	0.74	8.1	WWC
	513452	3	6-10	1.32	12	0.06	1.2	FWC
	513452	3	6-10	1.02	4.3	0.43	0.3	WFC
	513453	3	6-10	0.71				WWC
12-3	513551	3	1-5	1.74				WWC
	513552	3	6-10	1.97				FWC
	513552	3	6-10	1.13				WFC
	513553	5	11-15	1.85	24.9	0.84	10.4	WWC
12-4	513651	2	1-5	2.19				WWC
	513652	3	6-10	0.62	8.6	0.18	3.3	FWC
	513652	3	6-10	0.29	4.2	0.53	1.4	WFC
	513653	3	6-10	1.90	9.7	0.74	4.3	WWC
Matchbox Dredge								
12-10	513751	3	1-5	1.05				WWC
	513752	5	6-10	0.84	4.9	0.16	2.3	FWC
	513752	5	6-10	0.21	2.9	0.33	4.8	WFC
	513753	5	11-15	1.05	7.1	0.36	4.1	WWC
12-12	513851	1	1-5	1.64				WWC
	513852	3	6-10	5.13	24.8	0.60	10.8	FWC
	513852	3	6-10	0.26	25.0	0.43	1.5	WFC
	513853	3	11-15	1.13	13.6	0.83	5.3	WWC
12-13	513951	3	1-5	1.10				WWC
	513952	3	1-5	0.89	3.1	0.42	1.9	FWC
	513952	3	1-5	49.4	11.2	0.20	3.3	WFC
	513953	3	1-5	1.23	12.8	0.84	5.6	WWC

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

Table 4
Plume Sampling - Cutterhead Dredge
Total Suspended Solids (mg/l)

Station	Sampling Event 1	2	3	4	5
November 21					
6	2	10			
7	3	24			
8	4	15			
9	3	80			
10	4	57			
11	5	5			
12	6	2			
13	7	4			
14	7				
15	7				
November 22					
6	3	7	8	16	5
7	8	6	8	23	13
8	3	6	7	13	7
9	12	7	5	17	4
10	9	4	9	13	9
11	8	6	16	14	6
12	6	4	6	8	14
13	4	6	11	41	16
14	5	5	24	9	28
15	5	5	9	8	7
November 23					
1	3	5			
2		3			
3	3	7			
4	3	7			
5	6	5			
6	5	10	3	4	5
7	6	12	7	6	7
8	5	4	5	4	8
9	6	4	9	2	5
10	3	5	4	3	4
11			5	5	4
12			5	10	5
13			3	4	3
14			4	6	4
15			4	5	7

1) Initial sampling event took place approximately 15 minutes after the start of dredging. There was a 45 minute interval between events.
2) Refer to Figure 1-8 for location of sampling stations.

Table 5
Dredgehead Sampling - Cutterhead Dredge
Total Suspended Solids (mg/l)

Time	Sampling Port 1	2	3	4	5	6	
November 21							
0726	66			46			P-S
0741	34			8			S-P
November 22							
0654	237	444	109	592	221	228	S-P
0709	209	177	126	225	253	66	P-S
0726	214	210	49	51	98	65	P-S
0743	122	27	185	47	57		S-P
0755	112	169		77	31		S-P
0813	48	104	68		169		S-P
November 23							
0710	16	69	26	16	34	63	P-S
0719	70	30	20	82	93	39	S-P
0732	26	79	96	36	71	19	P-S
0748	39	77	41	41	52	26	S-P
0804	35	46	47	40	71	34	S-P
0819	38	55	37	25	36	54	P-S
0842	33	46	40	24	23	22	S-P
0848	29	79		14	33		P-S
0903	79	57		67	42		S-P
0928	83	163		122	42		P-S
0933	68	74		51	44		S-P
0948	71	130		30	44		S-P
0741							P-S
November 25							
0730	17	65		65	115		P-S
0741	63	21		76	25		S-P
0752	107	87		66	90		P-S
0817	48	97		70	25		P-S
0856	27	111	67	41	35	18	S-P
0925	7	121	35	31	24	26	S-P
0941	14	24	16	19	13	27	P-S
0953	16	40		6	10		S-P
1008	60	73	72	76	67	44	P-S
1023	40	245	143	185	97	97	S-P
1039	156	121	109	85	78	76	S-P
1056	53	48		78			S-P
1108	27	35		60			P-S
1123	70	32		96	66		S-P

Table 5 Con't

Time	Sampling Port 1	2	3	4	5	6	
December 17							
1430	145	29		185	151		P-S
1445	218	214		185	87		S-P
1500	46	33		124	53		P-S
1515	69	81		87	108		P-S
1530	74	56		40	90		P-S
1545	77	161		109	55		S-P
1600		170		82	143		P-S
1615		203		180	108		P-S
1630	531	101		385	1208		S-P
January 8*							
0848	327	113	94	907	255	842	P-S
0900	297	41	286	1987	94	458	S-P
0915	139	1127	170	253	92	631	P-S
0930	92	41	152	655	135	1650	S-P
0945	214	471	334	541	122	885	P-S
1005	76	61	138	679	167	514	S-P
1025	271	329	180	276	135	104	P-S
1034	496	634	112	426	123	314	S-P
1055	482	337	177	167	211	122	P-S
1150	486			350			S-P

* Cutterhead rotating at full power
** P-S - dredgehead swinging from port to starboard
S-P - dredgehead swinging from starboard to port

Table 6
Resuspension Rate - Horizontal Auger Dredge

December 2

Time	Tide Ht. (ft)	Area* (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

Table 6 Con't

December 3

Time	Tide Ht. (ft)	Area* (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

December 4

Time	Tide Ht. (ft)	Area* (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

*tide height x width of dredgehead (9 feet)

Table 6 Con't

January 15

Time	Tide Ht. (ft)	Area* (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

*tide height x width of dredgehead (9 feet)

Table 7
Dredgehead Samples - Horizontal Auger Dredge

Date	Sample No.	Time	PCB (ppb)	Cu	Cd (ppb)	Pb	
12-2	519922	1535	364.0	4644	138	1483	FWC
	519922	1535	22.9	5	0.5	22	WFC
	519923	1535	133.0	1363	163	1707	WWC
12-3	520122	1755	19.9				WWC
	520122	1755	18.2				FWC
	520122	1755	8.8				WFC
	520123	1755	29.1				WWC
12-4	520323	1630	29.6	1188	31	608	WWC
	520323	1630	12.6				WWC
	520323	1630	36.8	832	23	392	FWC
	520323	1630	7.8	3	0.1	1	WFC
1-15	527421	1220	16.2				WWC
	527422	1220	1.0				WFC
	527422	1220	382.0	4219	95	1372	FWC
	527423	1400	98.6	3617	131	1550	WWC
	527424	1525	108.0	3932	146	1592	WWC
	527425	1635	47.4	1884	27	642	WWC

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

Table 8
Plume Sampling - Horizontal Auger Dredge
Total Suspended Solids (mg/l)

	Sampling Event				
Station	1	2	3	4	5
December 2					
1	7	11			
2	7	14			
3	4	12			
4	31	5			
5	11	16			
6	11	12	4	16	
7	7	6	6	9	
8	8	9	10	7	
9	5	9	8	7	
10	9	12	11	7	
11			12	11	
12			9	7	
13			7	9	
14			5	6	
15			11	6	

Table 8 con't

Station	Sampling Event 1	2	3	4	5
December 3					
1	9	17	22		
2	7	7			
3	7	6			
4	18	3	5		
5	5	10	13		
6	3	2	21	4	4
7	3	4	37	2	2
8	2	2	34	3	2
9	5	5	36	2	3
10	6	13	41	12	8
11				9	3
12				2	2
13				1	1
14					4
15				1	5
December 4					
1	8	6			
2	13	16			
3	29	67			
4	11	10			
5	16	19			
6	12	16	9		
7	13	9	11		
8	9	5	8		
9	7	8	11		
10	11	9	9		
11			13		
12			9		
13			7		
14			9		
15			11		

1) Initial sampling event took place approximately 15 minutes after the start of dredging. There was a 45 minute interval between events.
2) Refer to Figure 1-12 for location of sampling stations.

Table 9
Dredgehead Sampling - Horizontal Auger Dredge
Total Suspended Solids (mg/l)

	Sampling Port						
Time	1	2	3	4	5	6	Direction
December 2							
1345	596	1012	1895	616	361	147	Forward
1350	2942	5020		4716	954	274	Reverse
1425	1287	2840					Forward
1430	1694	1222	730				Reverse
1438	2616	1752	1450				Forward
1535	6162	1330	4620				Forward
1555	1812	4141	1138				Reverse
1602	4354	2820	3047				Forward
1620	2197	2150	3115				Reverse
December 3							
1630	132	1186	971	1149	356	358	Reverse
1637	416	1564	912	162	63	53	Forward
1640	258	2340	6553				Reverse
1720	2078	1277	551				Forward
1755	727	1854	604	268	141	209	Reverse
1815	1007	722	680				
December 4							
1555	1799	1460					Forward
1615	401	2055	349				Reverse
1640	1913	1423	356				Reverse
1715	1331	2553	4008				Forward
1735	540	2603	474				Reverse
1750	7379	4834	3248				Forward

Table 9 con't

Time	Sampling Port 1	2	3	4	5	6	Direction
January 15							
1105	2412	386	129				Reverse
1135	103	184	223				Forward
1205	163	259	315				Forward
1220	321	903	312				Reverse
1235	656	1516	1350				Forward
1250	229	1267	642				Reverse
1335	1063	1148	592				Forward
1350	404	343	451				Reverse
1400	2516	1428	4042	456	444	718	Forward
1415	128	494	356	525	641	265	Reverse
1455	377	319	174	562	514	79	Forward
1505	61	136	1806	1727	889	72	For. & Rev.
1515	436	1983	1367	466	700	117	Reverse
1525	364	3095	2925	4049	5950	350	Forward
1535	3313	2904	3276	3121	4188	372	Forward
1545	366	3099	726	581	983	111	Reverse
1555	117	123	769	725	690	76	Reverse
1635	1452	4634	5888				Forward
1645	2045	2407	3936				Reverse
1655	2012	1873	2176				Reverse
1705	2418	1664	1338				Forward

Table 10
Resuspension Rate - Matchbox Dredge

January 9

Time	Tide Ht. (ft)	Area* (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

Table 10 Con't
January 10

Time	Tide Ht. (ft)	Area * (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

January 11

Time	Tide Ht. (ft)	Area* (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

*tide height x length of dredgehead (6 feet)

Table 10 Con't
January 12

Time	Tide Ht. (ft)	Area * (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

January 13

Time	Tide Ht. (ft)	Area* (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

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

Table 11
Dredgehead Samples - Matchbox Dredge

Date	Sample No.	Time	PCB	Cu	Cd (ppb)	Pb	
12-12	520521	1252	4.54				WWC
	520522	1252	17.10	99	3.0	32	FWC
	520522	1252	0.59	3	0.5	2	WFC
	520523	1252	4.39	102	3	39	WWC
1-9	526322	1119	119.00				FWC
	526322	1119	0.52				WFC
1-10	526522	0942	205.00				FWC
	526522	0942	1.12				WWC
1-11	526722	1230	0.19				WWC
1-12	526923	1100	7.47				FWC
	526923	1100	0.34				WFC
	526924	1220	12.60				FWC
	526924	1220	0.39				WFC
	526925	1220	30.40				FWC
1-13	527924	1125	6.72	7.1	2	28	FWC

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

Table 12
Plume Sampling - Matchbox Dredge
Total Suspended Solids (mg/l)

Station	1	2	3	4	5
December 12					
1	12				
2	4				
3	6				
4	6				
5	11				
6	8	14	37		
7	9	14	53		
8	9	10	10		
9	8	5	6		
10	20	20	14		
11		9	17		
12		16	14		
13		7	9		
14		4	4		
15		5	10		
December 13					
1	41	19	13		
2					
3	39	6	7		
4	45	18	20		
5	46	66	45		
6	12	10	41		
7	13	9	13		
8	9	3	10		
9	9	11	19		
10	16	14	10		
11					
12					
13					
14					
15					

1) Initial sampling event took place approximately 15 minutes after the start of dredging. There was a 45 minute interval between events.

2) Refer to Figure 1-17 for location of sampling stations.

Table 13
Dredgehead Sampling - Matchbox Dredge
Total Suspended Solids (mg/l)

Time	Sampling Port 1	2	3	4	5	6	
December 12							
1220	68			45	33		S-P
1230	246			45	51		P-S
1235	59			45	38		S-P
1243	20				110		P-S
1252	112			39			S-P
1257	87			89			P-S
1301	127			136			S-P
December 13							
0945	293	47	63	35	49	35	P-S
0950	85	26	20				S-P
0955				17	23	27	P-S
1000	19	21	25	25	22	30	S-P
1005	46	18	19				S-P
1010				37	7		P-S
1025	43	31	53	39	63		P-S
1035	29	23	24	1149	25	21	S-P
January 9							
0855	1100	63	60	39	190	408	S-P
0919	2244	251	216	2216	436	2815	P-S
0930				77	528	1804	S-P
1105	254	148 (P-S)		682	330 (S-P)		
1111	164	113		248			P-S
1121		77		144			S-P
January 10							
0900	859	53	100	225	305	1348	S-P
0915	63	43	53	70	55	36	P-S
0925	23	40	59	167	47	34	S-P
0946	46	36	30	196	29	37	P-S
0953	97	118	84	95	90	116	S-P
1003	87	95	78	65	65	88	S-P
1052	145	160	297	388	813	830	P-S
1103		199		688	1152		P-S
1111	1649	497	35	101	254	353	S-P
1125	257	164	537	746	1247		P-S
1141	218	123		183	193		
1146	223	253		152	339		P-S
1158	119	164		269	355		S-P
1200	341	138		221	1025		P-S

Table 13 con't

Time	1	2	3	4	5	6	
			Sampling Port				
January 11							
0845	75	44	40	148	51	1082	S-P
0900	37	31	32	33	25	88	P-S
0912	31	49	32	41	36	55	S-P
0918	38	34	26	33	32	28	P-S
0935	40	27	25	34	35	207	S-P
1135		101	88	266	918	126	S-P
1142	170	185	339	89	77	77	P-S
1155	103	89	162				P-S
1205	79	139	531	89	97	86	S-P
	272	454	560	2781	3048	1096	P-S
1229	1399	1824	961	1016	589	1926	S-P
1230	161	165	176	166	186	178	
Janaury 12							
1008	61	67	112	56	100	717	P-S
1030	110	265	150	116	603	972	S-P
1037	263	231	187	219	271	211	P-S
1045	184	109	190	279	302	716	S-P
1050	319	209	198	198	200	300	P-S
1100	187	200	50	263	287	220	S-P
1105	187	367	182	228	602	364	P-S
1110	185	380	269	121	159	136	S-P
1115	246	153	375	244	231	229	P-S
1120	289	381	208	217	233	247	S-P
1125	194	171	241	322	273	250	P-S
1130	193	171	193	217	240	182	S-P
1200	218	186	199	230	257	220	P-S
1220	200	211	224	176	312	232	S-P
1330	211	207	171	146	316	456	P-S
1350	206	214	213	172	175	165	S-P
1400	249	268	182	188	191	206	P-S
1410		1020	722	331	518	883	S-P
January 13							
1015		176	122	363	390		P-S
1025	102	84	82	118	94	74	P-S
1035	13	1275	601	90	64	58	S-P
1040	4833	169	103	1083	654	181	P-S
1053	503	237	95	76	124	326	S-P
1100	28	18	23	22	16	17	P-S
1115		76	208	59	45	45	P-S
1125			89	174	146	56	P-S

(1) P-S - dredgehead swinging from port to starboard
S-P - dredgehead swinging from starboard to port

Table 14
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)	.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

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	.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

Table 14 Con't

Electrical System:
Battery (24 VDC) 220 amp-hr 220 amp-hr

Capacities:
Fuel
Port Fuel Compartment 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 15
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 Auger Assembly:
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

Table 15 Con't

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 Drive System: Dual Pumps
Capacity Total-30.5 GPM @ 1800 RPM
Reservoir-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)
Reservoir-30 Gallon
Relief Valve Setting: 5000 PSI

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 16
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

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

Table 17
Contaminant Levels Remaining After Dredging

Dredge	Dredging Area	Sample No.	PCB	Cu	Pb (ppm)	Cd
C	1	517002	182.0	1166.9	368.1	33.5
		517003	51.7	989.7	313.9	26.7
		517004	189.0	1546.5	472.8	55.9
		517005	8.2	1767.5	554.9	55.4
		517006	54.0	967.9	291.8	32.4
		517007	47.3	755.4	217.3	22.3
		517008	31.1	536.9	158.2	20.4
C	2	517025	8.0	115.0	68.3	1.8
		517026	15.3	133.9	64.7	2.7
		517027	10.7	223.4	99.9	3.5
		517028	0.5	62.9	60.4	1.0
HA	1	517009	270.2	473.6	300.3	6.4
		517010	30.4	297.8	190.4	4.1
		517011	15.5	463.1	268.8	6.3
		517012	96.1	647.2	256.3	16.1
		517014	19.9	415.1	307.2	3.8
		517015	23.5	530.6	303.4	9.1
		517016	9.3	140.4	90.5	2.9
M	2	517021	3.0	39.9	17.2	1.4
		517022	9.6	77.1	33.7	2.0
		517023	4.6	50.9	19.4	1.3
		517024	4.4	62.9	25.9	1.4

C - Cutterhead Dredge
HA - Horizontal Auger Dredge
M - Matchbox Dredge

APPENDIX 2

CONFINED DISPOSAL FACILITY

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 was constructed below the high water line. This appendix discusses the operation of the facility and the monitoring of 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 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.

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 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 sheet pile 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:

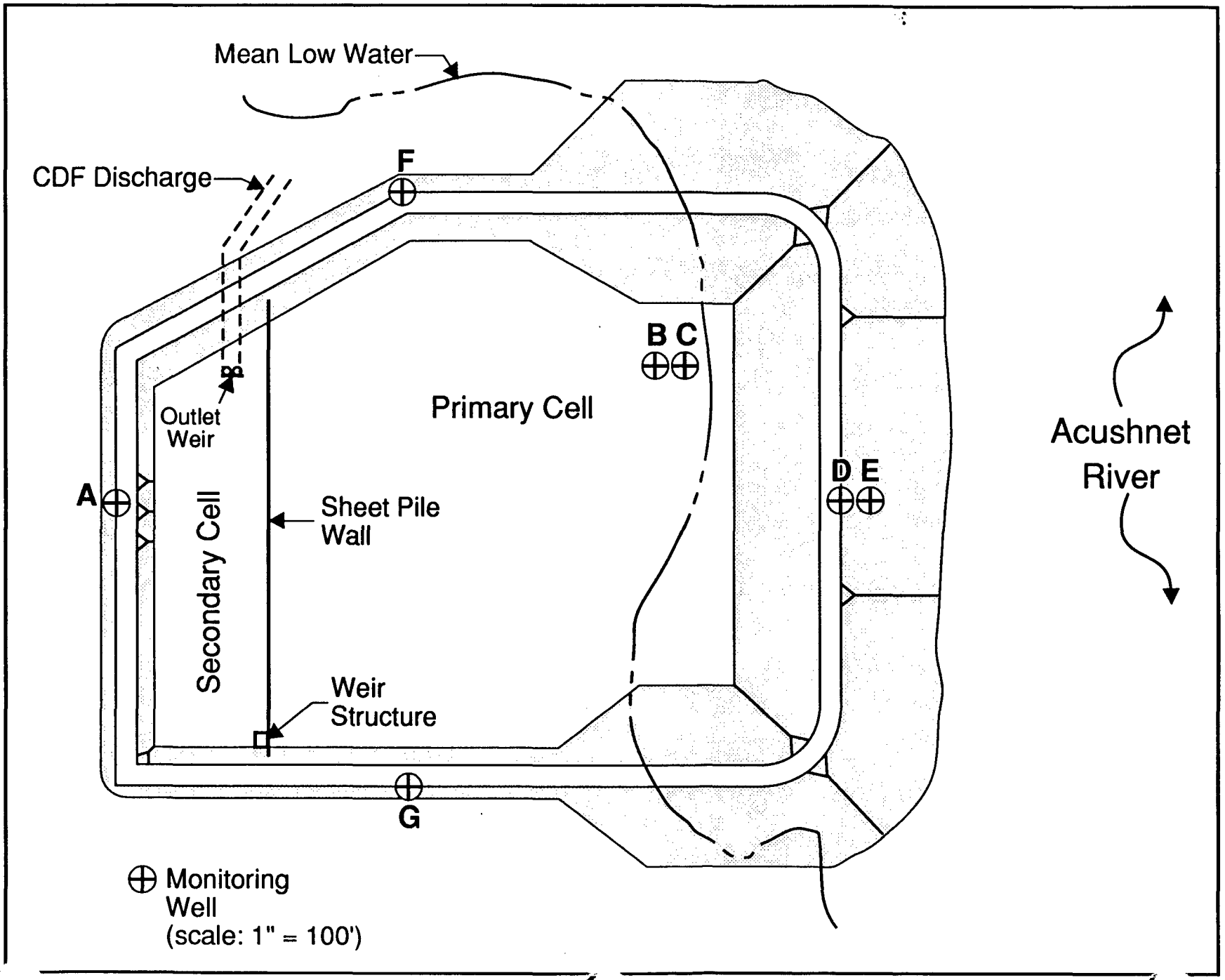


Figure 2-1 Confined Disposal Facility

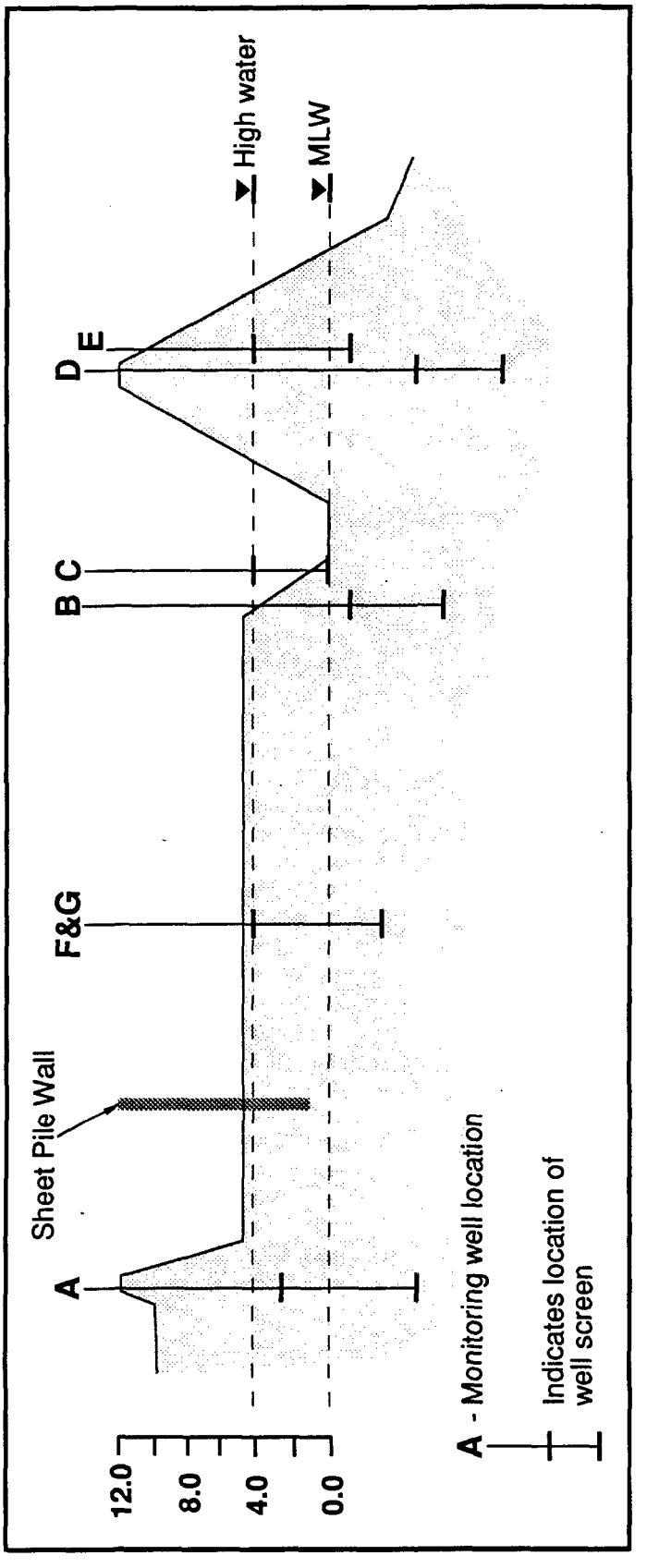


Figure 2-2 Confined Disposal Facility Monitoring Well Locations

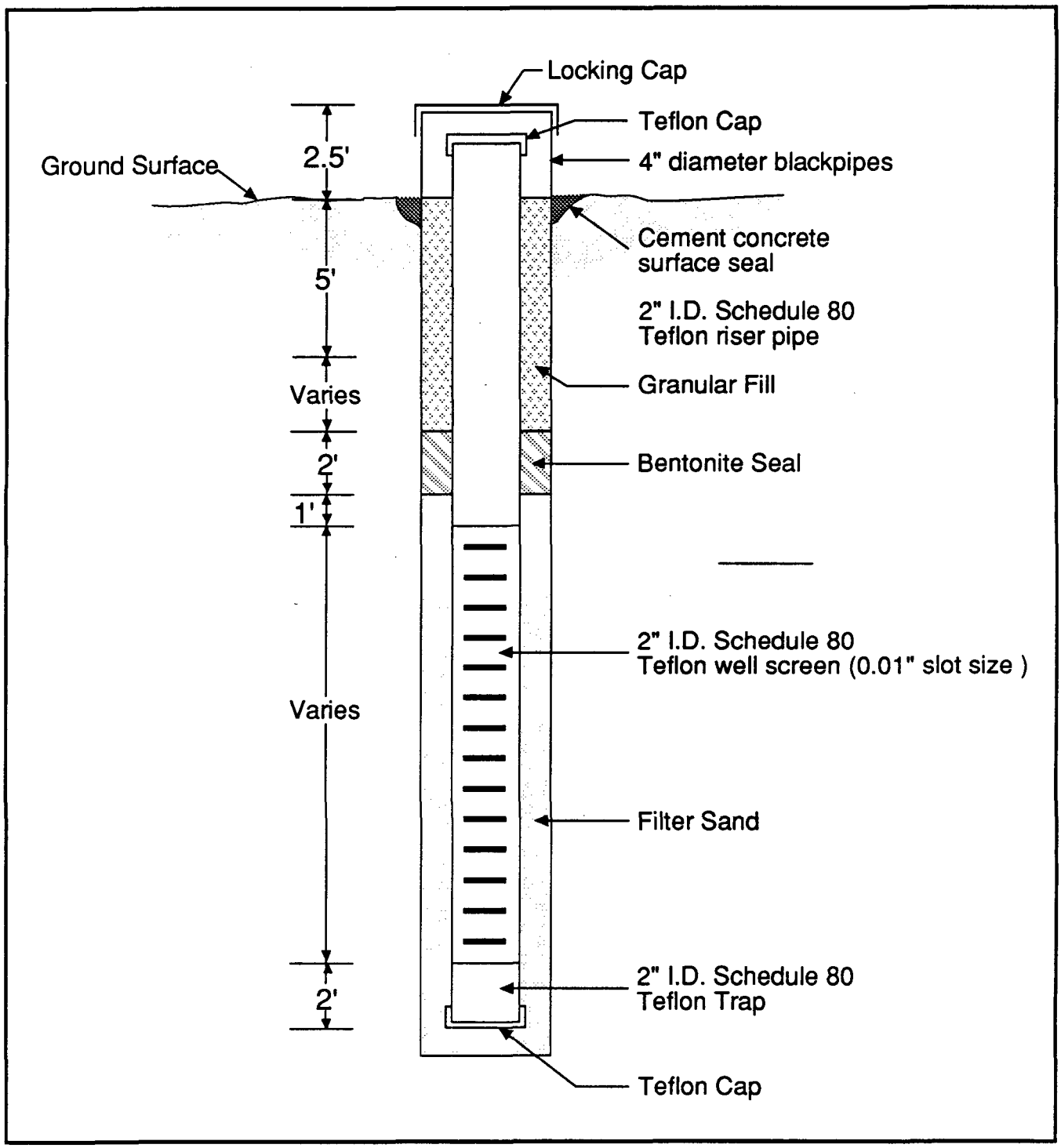


Figure 2-3 Typical Monitoring Well, Confined Disposal Facility

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

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 15 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.

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 impact 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 5 and summarized in table 3. Tables 4 and 5 contain the contaminant concentrations found in the CDF effluent composite samples. The results indicate that the modified elutriate test provides a conservative estimate of the contaminant loading in the CDF effluent.

Leachate: Seven monitoring wells were installed in and around the CDF as shown in Figures 2-1. Well screens were positioned to capture leachate from varying elevations as shown in Figure 2-2. The wells were sampled three times prior to the start of CDF filling with the results shown in table 5. The wells were also sampled weekly for a three week period immediately after the disposal of dredged material into the CDF was completed. These results are shown in table 6 and do not indicate that contaminants are leaching from the site.

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

December 5

Dredging began at 1445 - Dredge operating for 3.4 hours.

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	36.12	
2400	38.2	
0100	57.40	

December 10

Dredging began at 0615 - Dredge operated for 3 hours

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

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

December 17

Dredge began at 1320 and operated for 3.7 hours.

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.

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
2000	43.6	67.0

December 18 Con't

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
1400	201.9	184.1

December 20 Con't

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.

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

December 22

Dredge began at 0540. Dredge operated for 3.7 hours.

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

December 22 Con't

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.

December 28

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

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.

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

December 30

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

P Indicates that Polymer system was operating

Table 2
Modified Elutriate Test Dredge Area I

Sample No.	Description	Suspended Solids (mg/l)	Total PCBs (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 (ppb)	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 3

Confined Disposal Facility Effluent Contaminant Levels
Primary Weir

Date	Sample No.	TSS* (mg/l)	PCB	Cu (ppb)	Cd	Pb	
12-2	514025	47	5.2	34.1	0.3	17.1	FWC
	514025		1.3	3.1	0.7	7.4	WFC
12-3	514050	132	8.5	70.7	1.1	37.9	FWC
	514050		2.4	6.4	0.4	8.6	WFC
12-4	514075	105	6.4	51.7	1.1	26.6	FWC
	514075		2.4	30.2	0.5	17.5	WFC
12-5	514100	37	8.2				FWC
	514100		2.0				WFC
12-10	514125	58	7.2	36.3	0.2	21.8	FWC
	514125		1.8	3.0	1.0	1.5	WFC
12-11	514150	49	6.6	22.7	0.1	14.2	FWC
	514150		1.9	10.8	1.9	9.0	WFC
12-12	514175	47	8.7				FWC
	514175		2.4				WFC
12-13	514200	136	12.9	84.0	2.0	39.2	FWC
	514200		4.3	12.4	1.1	6.1	WFC
12-16	514275	51	6.4	25.6	0.3	8.8	FWC
	514275		1.4	7.6	2.0	6.5	WFC
	514275			23.7	1.8	21.4	WFC
12-17	514300	47	12.4	56.4	0.7	20.5	FWC
	514300		1.3	7.0	1.3	12.1	WFC
12-18	514325	35		27.2	1.6	14.5	WWC
	514325		15.9	59.8	0.8	22.8	FWC
	514325		1.0	25.8	1.2	24.0	WFC
12-19	514350	55	10.8	51.7	0.6	22.8	FWC
	514350		0.6	14.1	0.8	15.7	WFC
12-20	514375	131	5.3	28.4	0.3	14.8	FWC
	514375		0.8	13.1	0.4	14.1	WFC
12-21	514400	115	1.2	8.0	0.1	4.6	FWC
	514400		0.2	1.9	0.1	1.7	WFC
12-22	514425	77	0.9				FWC
	514425			13.9	0.5	3.3	WWC
12-28	514450	344	0.5	11.1	0.4	7.9	WWC
	514450		0.4	18.6	0.2	11.8	FWC
	514450			1.5	0.1	1.7	WFC
12-29	514475	276	1.8	20.4	0.5	8.9	WWC
	514475		2.1	14.3	0.3	8.4	FWC
	514475			0.7	0.3	0.9	WWC

* 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 4
Confined Disposal Facility Effluent Contaminant Levels Discharge

Date	Sample No.	TSS* (mg/l)	PCB	Cu (ppb)	Cd	Pb	
12-9	515125		7.2	41.3	0.2	27.4	FWC
	515125		2.9	5.7	1.5	2.0	WFC
12-10	515150	61	10.8	32.7	0.2	19.8	FWC
	515150		1.5	10.0	5.6	7.5	WFC
12-11	515175	48	9.0	36.3	0.2	22.9	FWC
	515175		1.7	6.7	1.6	3.3	WFC
12-12	515100	27	9.2	30.1	0.1	18.3	FWC
	515100		1.3	13.9	2.0	6.6	WFC
12-13	515200	152	19.2				FWC
	515200		1.7				WFC
	515225		5.0				FWC
	515225		1.8				WFC
12-15	515250		13.9	66.1	1.0	32.4	FWC
	515250		1.0	1.7	0.9	1.5	WFC
12-17	515300	64	10.5	72.9	1.2	30.1	FWC
	515300		1.2	10.2	1.0	13.7	WFC
12-18	515325	57		4.9	1.5	7.0	Total
	515325		13.3	88.0	1.2	33.0	FWC
	515325		1.0	5.5	0.9	19.8	WFC
12-19	515350	59	11.7	62.3	0.6	27.9	FWC
			0.3	5.1	1.0	15.7	WFC
12-20	515375	128	7.4	32.5	0.3	14.5	FWC
	515375		0.8	17.9	0.8	20.4	WFC
12-21	515400	84	2.2	12.1	0.1	5.3	FWC
	515400		0.5	3.5	0.3	3.3	WFC
12-22	515425	56	0.6				WFC
	515425		0.2				FWC
	515425			8.6	0.2	2.2	WWC
12-28	515450	130	0.3	2.5	0.03	1.9	FWC
	515450		0.2	6.7	0.2	2.3	WWC
	515450			0.9	0.06	1.1	WFC
12-29	515475	97	0.5	2.8	0.07	2.1	FWC
	515475		0.3	6.1	0.3		WWC
	515475				0.06	0.3	WFC

* 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 - Monitoring Wells

Pre-operational

Well	Sample No.	PCB (ppb)	Cu	Pb	Cd
A	518001	0.17	21.7	72.9	8.8
	518007	0.11	19.8	91.1	6.2
	518013	0.07	9.4	51.6	3.3
B	518002	2.46	337.2	85.9	1.2
	518008	2.32	333.0	67.7	0.9
	518014	3.23	234.5	64.4	0.6
D	518010	0.00			
	518016	0.03	0.0	4.9	0.3
E	518005	0.12	13.2	6.5	0.4
	518011	0.19	23.7	8.5	0.0
	518017	0.41	7.1	3.3	0.1
F	518006	0.00			
	518012	0.00	4.3	12.0	0.0
	518018	0.00			
G	518003	0.02	20.6	17.1	1.0
	518009	0.00			
	518015	0.00			

Note: 1) Samples are whole water samples
2) Values shown for metals are the mean of 3 replicates

Table 6
Confined Disposal Facility - Monitoring Wells

Operational Period*

Well	Sample No.	PCB (ppb)	Cu	Pb (ppm)	Cd
A	518082	0.15			
	518089	0.00			
	5188096	0.06	9.4	21.8	32.7
B	518083	0.80			
	518090	0.02	16.9	3.7	1.9
	518097	0.28	138.3	33.4	6.5
C	518084	0.02			
	518091	1.08	2.6	0.0	0.5
	518098	0.71	137.1	54.9	19.3
D	518085	0.05			
	518092	0.00			
	518099	0.01			
E	518086	0.33			
	518093	0.02	0.0	1.9	0.0
	518100	0.13			
F	518087	0.02			
	518094	0.00			
	518101	0.00	25.1	0.0	0.2
G	518088	0.00			
	518095	0.00	1.9	0.0	20.2
	518102	0.00			

* Samples taken after disposal of dredged material into the CDF had been completed.
Event #1 - December 27 & 28, 1988
Event #2 - January 4, 1989
Event #3 - January 9, 10, & 11, 1989
Note: 1) Samples are whole water samples
2) Values shown for metals are the mean of 3 replicates

Appendix 3

Contained Aquatic Disposal

APPENDIX 3 CONTAINED AQUATIC DISPOSAL

Contained aquatic disposal (CAD) involves the dredging of the contaminated sediment, placement in an 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.

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 Dredge
HA - Horizontal Auger Dredge

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

The cutterhead dredge then removed an additional 2600 cubic yards of sediment from dredge area 2 and placed it in the CAD cell to cap the contaminated sediment. This operation took place over an 18 day period from 25 Janauary to 11 February 1989 with the dredge operating for a total of 64 hours.

Hydrographic surveys of the CAD cell were made on three occasions: 6 January after the cell was dredged, 24 January after contaminated sediment was placed in the cell and 22 June 1989 after the

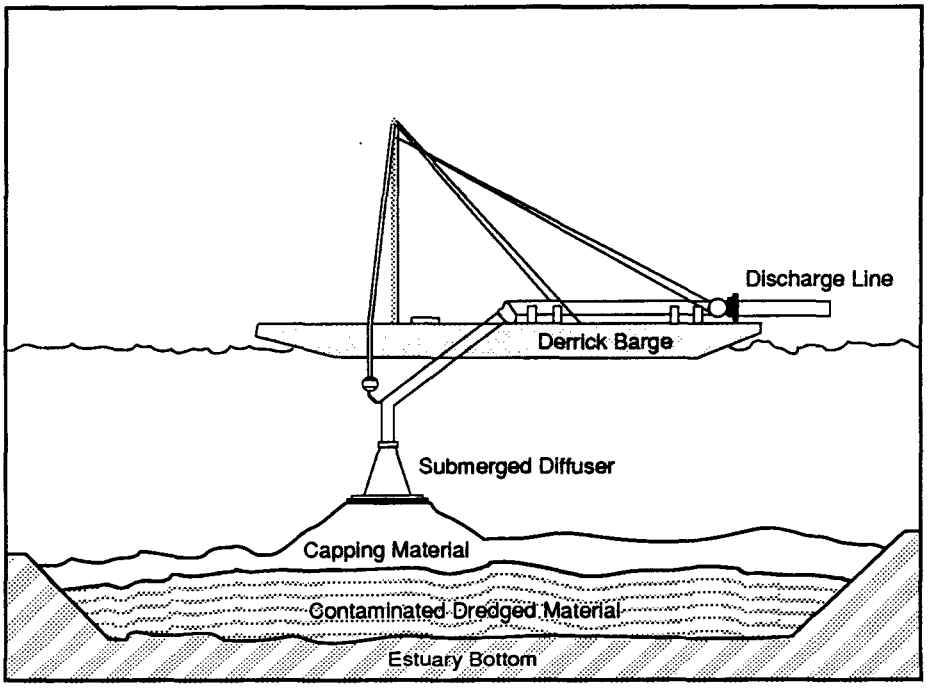


Figure 3-1 Contained Aquatic Disposal (CAD)

cell was capped and the material was allowed to settle and consolidate. Figure 3-2 contains typical cross sections of the CAD cell which reflect the results of these surveys.

Sediment Resuspension: A predictive test for estimating the mass of suspended sediment released from 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 total suspended solids content at the discharge point would be 40 grams per liter.

An array of ten 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. Table 1 contains 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 suspended solids levels were elevated above background and increased as the length of the dredging period increased.

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 shows the average suspended solids level of five hourly samples taken on the ebb tide at station 7 while CAD was taking place.

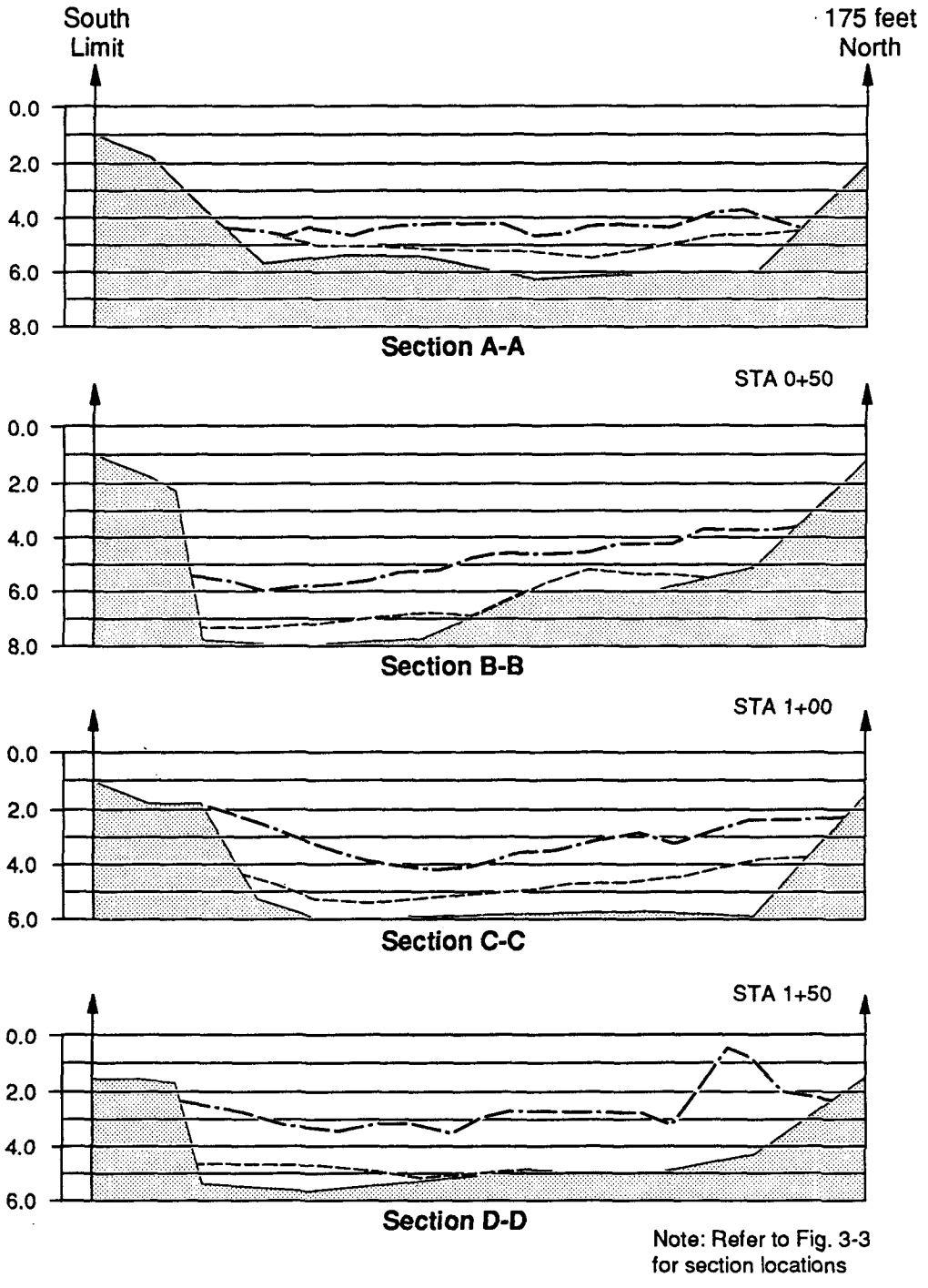


Figure 3-2 CAD Cell - Typical cross sections

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.

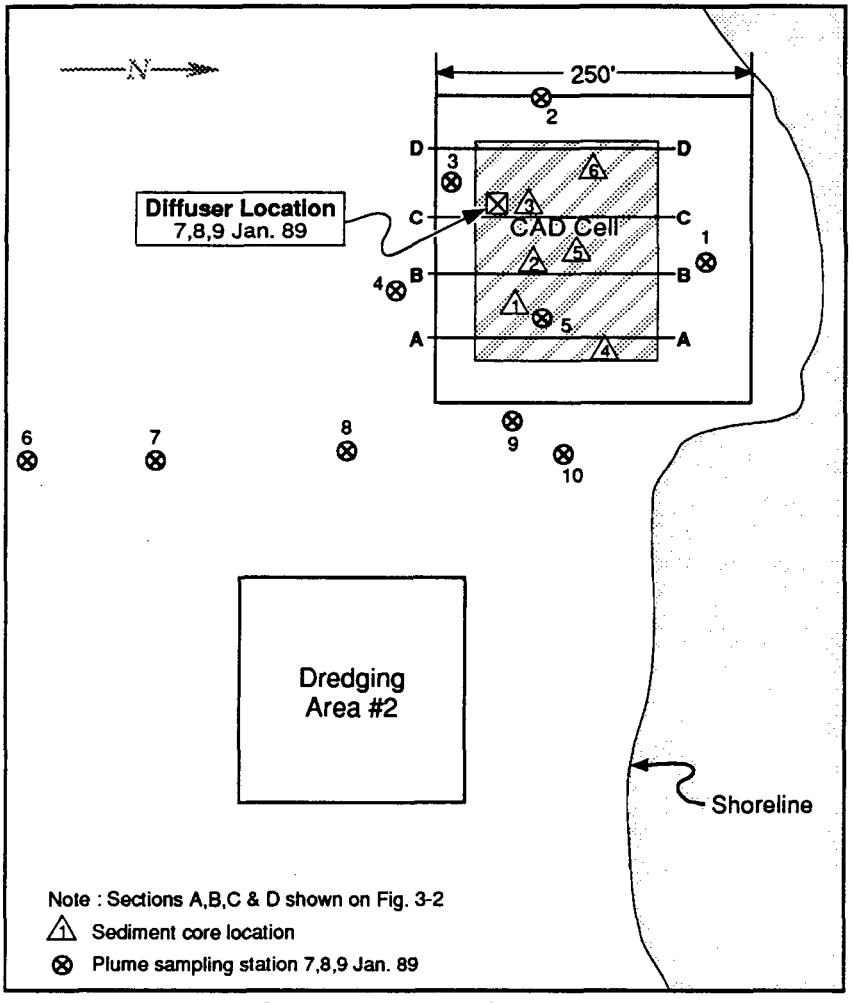


Figure 3-3 Plume Sample, Sediment Cores and Diffuser Locations

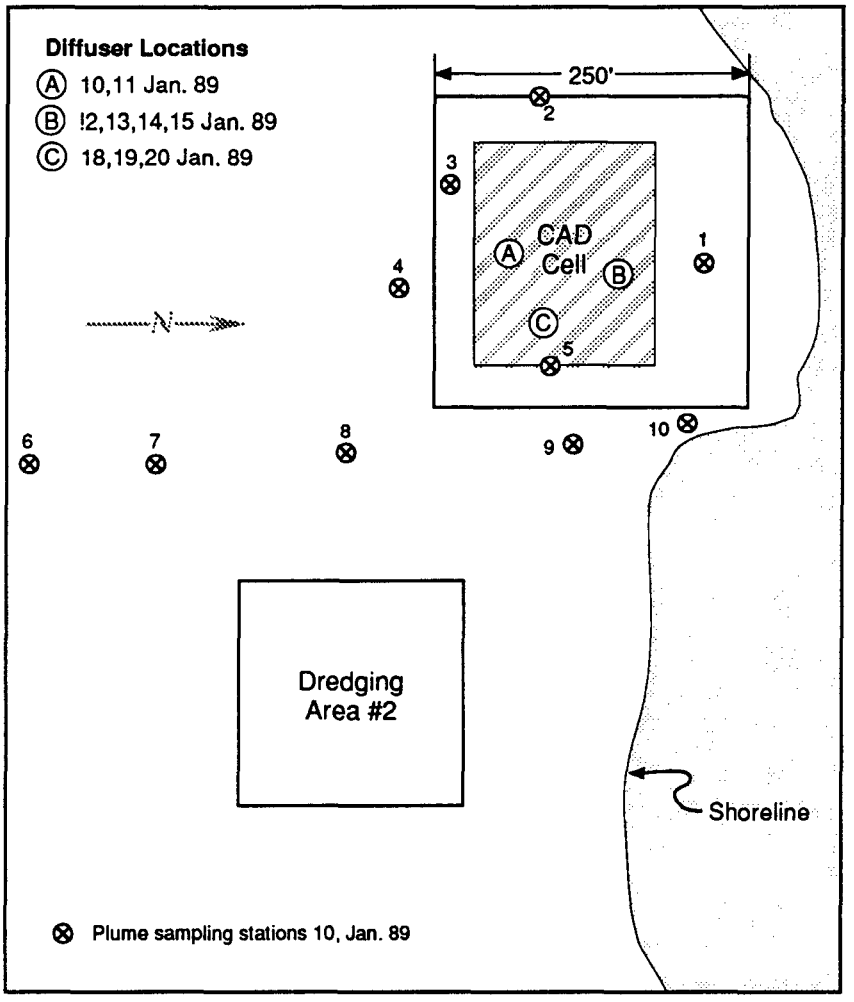


Figure 3-4 Plume Sample and Diffuser Locations

Contaminate Release: Composite samples representing stations 1-5 and 6-10 were formed by combining samples from the five individual stations in each group. These samples were taken at the mid-point and end of the day's operations. These samples were analyzed for PCBs, and the results are shown in Figure 2.

PCB levels detected at monitoring stations 2 and 7 during CAD are compared with background conditions and other phases of the pilot study in table 3. The PCB levels detected at the Coggeshall Street Bridge did not represent a statistically significant increase above background conditions.

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.

Cap Effectiveness: A hydrographic survey of the CAD cell was made on 22 June 1989, approximately four months after the completion of capping operations. The survey showed a change in bottom elevations of 1 to 3 feet from the survey made on 24 January, indicating that a cap of this thickness had been placed on the contaminated sediment. Six sediment cores were taken from the cell on 22 June. These cores were divided into 6 inch segments with these samples being analyzed for PCBs. The results revealed that the capping effort was unsuccessful, as elevated levels of PCBs were found in the surface sediment layers. The locations of the sediment cores are shown in Figure 3-3 with the results of their analyses appearing in table 4.

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

January 9
Matchbox Dredge

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 2
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	2.50 WWC	CH
	516052	-	6-10		2.65 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		3.24 FWC	CH
	516152	1138-1148	6-10		0.03 WFC	CH
	516153	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		4.20 FWC	M
	516252	1128-1135	6-10		0.04 WFC	M
	516253	1128-1135	1-5	59	31.80 WWC	M
	516254	1128-1135	6-10		5.70 FWC	M
1-10	516351	1245-1255	1-5	179	7.29 WWC	M
	516352	1145-1155	6-10		42.5 FWC	M
	516352	1145-1155	6-10	78	1.53 WFC	M
	516353	1245-1255	6-10	117	15.30 WWC	M
1-12	516552	--	#3		3.17 FWC	M
	516552		#3		0.04 WFC	M
1-13	516652	--	#3		4.60 FWC	M
	516652		#3		0.17 WFC	M

CH - Cutterhead Dredge
M - Matchbox Dredge

Table 3
Contained Aquatic Disposal
Monitoring Stations 2 & 7 Ebb Tide PCB Analysis

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

Table 4
Contained Aquatic Disposal
Sediment Cores - PCB Levels

Sediment Core	Horizon (inches)	Total PCB (ppm)
1	0-6	81.5
	6-12	27.4
	12-18	1.8
	18-24	0.1
	24-30	0.0
	30-36	0.0
2	0-6	0.0
	6-12	1.2
	12-18	56.6
3	0-6	1.2
	6-12	2.9
	12-18	4.7
	18-24	0.4
	24-30	0.0
	30-36	0.0
4	0-6	0.2
	6-12	0.1
	12-18	0.1
	18-24	0.1
5	0-6	95.9
	6-12	61.2
	12-18	19.8
	18-24	0.3
	24-30	0.3
	30-36	0.2
6	0-6	25.9
	6-12	17.5
	12-18	0.4
	18-24	0.7

Note: (1) The sediment cores varied in length from 18-36 inches. All cores had sand in the bottom of the tubes indicating that they had penetrated the bottom of the CAD cell. The material in the cores was not physically analyzed. Visual observation of the cores indicated that all material above the sand layer was similar, a fine grained dark sediment.
(2) Locations shown in Figure 3-4

Appendix 4

Environmental Monitoring Program

Appendix 4 Environmental Monitoring Program

INTRODUCTION

The high levels of contaminants 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 turnaround time, ERLN's 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 further 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 50 meters wide channel at the hurricane barrier. Release of contaminants pass 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 1 , and the Corps of Engineers, with the following objectives:

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

The following summarizes the results of the physical, chemical, and toxicological monitoring that was conducted during the pre-construction and construction with the primary focus on sampling at the Coggeshell Street Bridge. The physical data includes: current velocities, tide heights, temperature (air and water), salinity, and total suspended solid measurements. The chemical data included water column levels for: polychlorinated biphenyl (PCBs), cadmium (Cd), copper (Cu), and lead (Pb). Five (5) toxicological testing protocols 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 toxicological assay methods for the following reasons: existing toxicity testing protocol that had been previously developed and evaluated; existing in depth 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 biologists; short turnaround time for

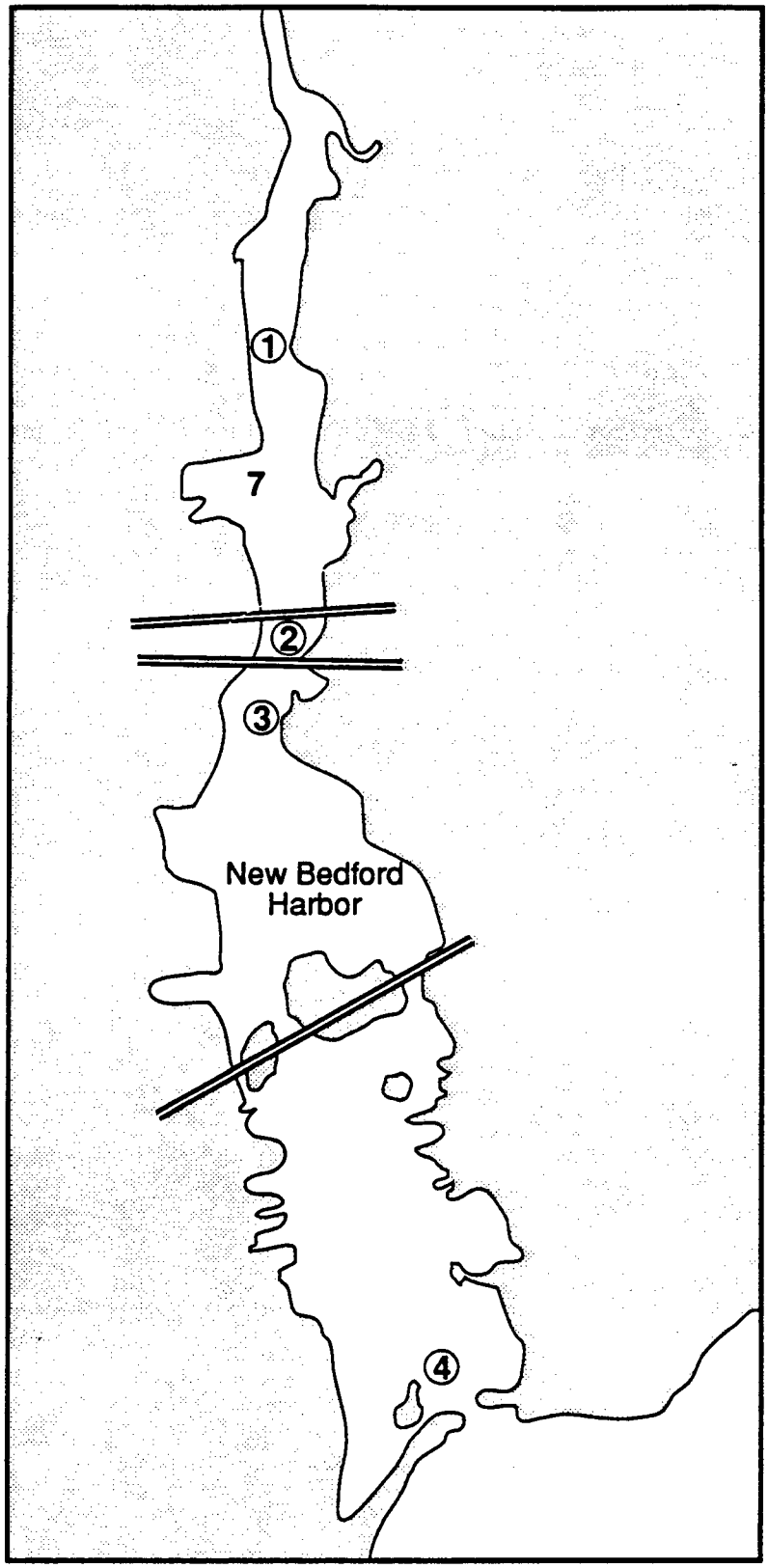


Figure 4-1 Locations of Harbor Monitoring Stations

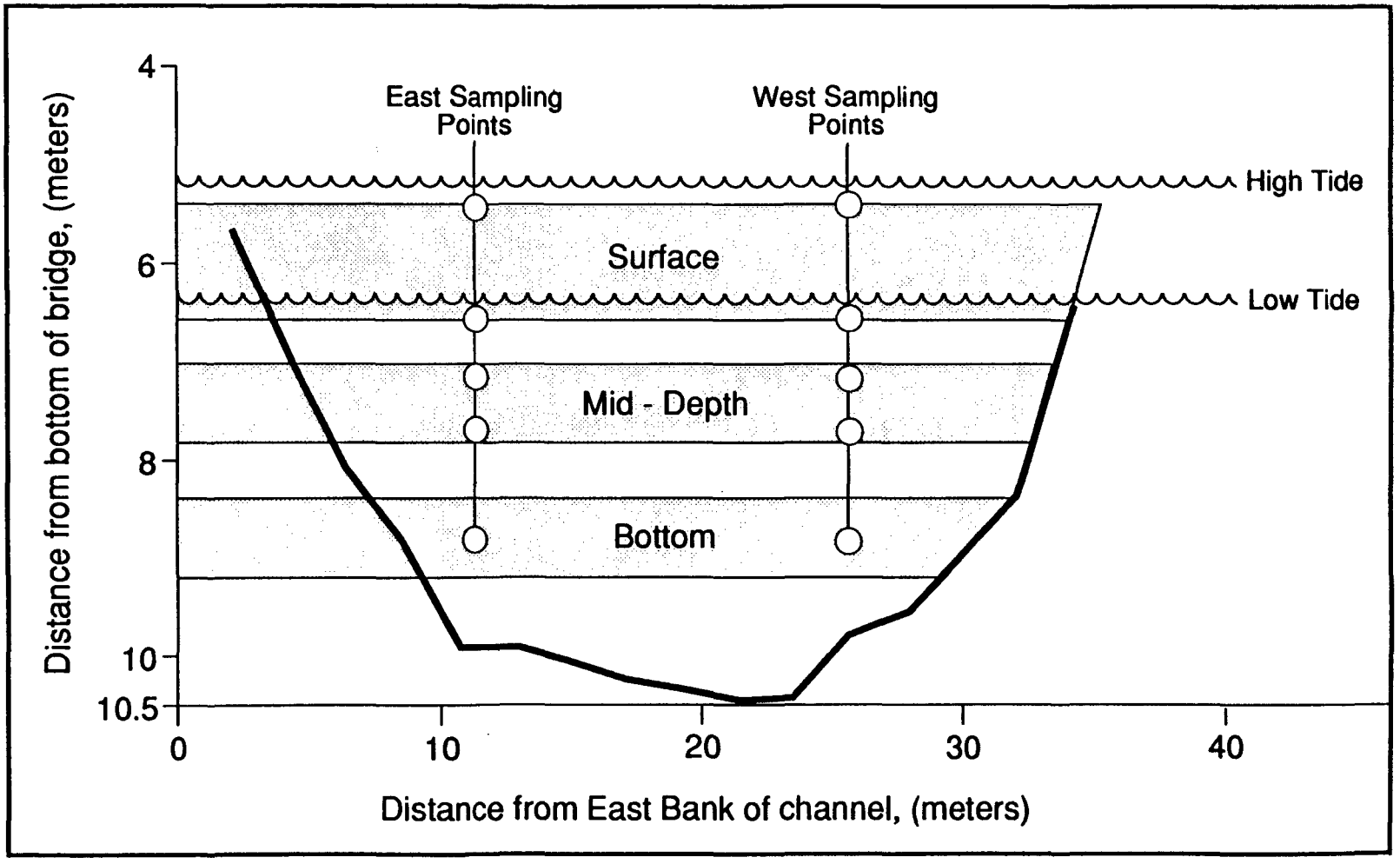


Figure 4-2 Channel bottom profile, (Coggeshall St. Bridge) at ERLN Station 2 with approximate sampling locations

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 toxicological 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. Dinnel et.al. (18) 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 toxicological testing to monitor human-induced changes is well documented in the literature (27, 28). Physiological changes in marine toxicological organisms have been used to demonstrate effects of pollutants for decades. There presently exist numerous toxicological 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 indices have also been used, and, in some situations make a better prediction of pollution effects (30). Log-normal plots (30a), expected species (31, 32), canonical correlation analysis (33), principal components analysis, and multi-dimensional scaling, among other methods, have been used for years to detect pollutant impacts along gradients at the community level. All these assessment methods have their specific uses for the monitoring of pollution effects. Testing protocols other than those used during the pilot study may be appropriate for a full scale clean-up effort in 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 using the same protocol undertook monitoring during construction 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 in appendices 1-3. Only physical, chemical, and toxicological results of harbor water quality monitoring efforts 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 pass these points during construction activities would be unacceptable. At stations 1, 2, 4, and 7 daily ebb and flood tide com-

posite samples (5/day) were collected by pumping 2 liters aliquots each from surface (-.5m), mid-water depth, and bottom (0.5m 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 a station 2 to determine spatial variability using chemical, suspended solids, and sperm cell tests.

Samples taken for chemical analyses at the plume stations and dredge head stations used 1 or 2 liter 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 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 located 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 the harbor. The water for the other toxicological testing was collected at the same time as the chemistry and transported to ERLN where all 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 toxicological testing) are described in Standard Methods (15).

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. All monitoring data is presently at ERLN and will be available at NED. 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.

RESULTS

Physical measurements: Details of results of the hydrographic measurements discussed in this section are available in computer format at ERLN or NED. During the sampling period temperature varied between 18 and 24^{0}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.

A statistical analysis of the TSS data generated during the dredging activities showed the following trends. The horizontal auger dredge produced by far the highest levels of turbidity, followed by the cutter headdredge 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 affect 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).

The particle size analyse (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 dredge head 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. The 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.

The following discussion summarizes a statistical analysis of 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 cutterhead 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 samples 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.

The CDF discharge was monitored for PCBs and TSS during the dredging operations. The PCBs 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 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 highest 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 1

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 reflect only 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 been 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* on both occassions may have been related to other events occurring in the harbor. The fact that station NBH-1 also showed significant effects indicated that an event may have taken place up-stream of the dredging activities. The fact that station NBH-4 showed significant effects indicates that storm run-off may have been a factor.

DISCUSSION

DISCUSSION

Physical: The average tide range during these dredging activities was 1.42 m. with an 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 cutterhead dredge were not significantly different from those collected at the near field stations. However, these samples were significantly higher than those collected at the far field stations. The samples collected during the horizontal auger operation were significantly higher than both the near and far field stations. There were differences recorded among the NBH stations. NBH-7 showed no difference between dredging and no dredging, except during matchbox dredge operations. The PCB levels were significantly higher during matchbox dredge operations when comparisons were made with no dredging and horizontal auger dredge operations. NBH-2 showed that levels recorded during no dredging were higher than during operation of all three dredges. Both the matchbox and cutterhead dredges showed significantly higher levels than the horizontal auger dredge. NBH-1 showed that the cutterhead dredge operations produced PCB levels that were significantly higher than during horizontal auger dredge operations.

Toxicological: The toxicological monitoring results within their limitations appeared adequate to predict and protect existing environmental conditions at the harbor during this pilot study. During future dredging and disposal operations considerations should be given to testing of specific species, with different feeding types, toxicological requirements, and habitat types. This approach may allow for a more sensitive analysis of ecological changes taking place.

These 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 toxicologically 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.

Summary: The monitoring protocol used during this pilot study did not detect an environmentally significant effect that could be attributed to the dredging and disposal operations. These results indicate that any significant environmental impacts from future dredging and disposal in the uppper estuary can be controlled to insure only minor releases of contaminants into the lower harbor.

Table 2

Summary PCB Water Quality Monitoring Results
Harbor Stations

	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
	A	B	A	B	A	B	A	B	A	B
Station 1										
ebb tide	1.7	0.4-3.8	1.5	0.6-3.2	1.4	0.8-2.0	1.1	0.4-1.2	1.5	1.0-2.4
flood tide	1.2	0.8-2.0	1.1	0.6-2.4						
Station 2										
ebb tide	0.6	0.4-0.8	0.9	0.4-1.5	0.7	0.4-0.9	0.5	0.3-1.0	0.9	0.6-1.5
flood tide	0.5	0.3-0.7	0.4	0.2-0.7			0.2	0.2-0.3	0.8	0.6-0.8
Station 4										
ebb tide	0.12	0.05-0.22	0.11	0.05-0.20	0.11	0.10-0.12	0.12	0.06-0.23	0.15	0.09-0.22
flood tide	0.10	0.05-0.13	0.08	0.07-0.09			0.10	0.02-0.21	0.16	0.12-0.19
Station 7										
ebb tide					0.9	0.87-0.94	0.8	0.3-1.9	2.6	0.9-5.4

Notes: values shown are total PCBs in ppb
phases 1-5 are: pre-operational, dike construction, pre-dredging, dredging, and CAD
averages shown in column A, ranges in column B

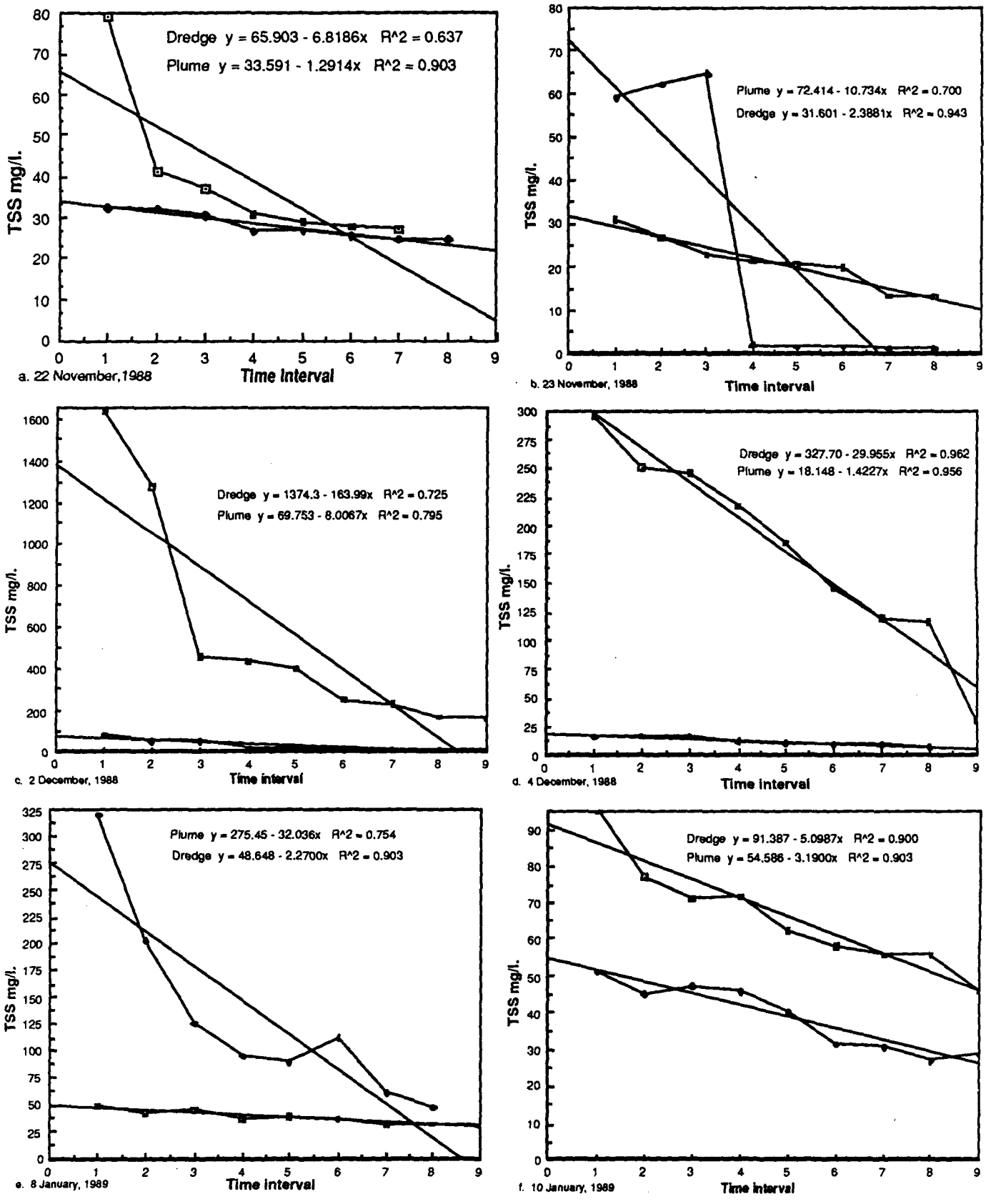


Figure 4-3 Particle Size Analysis by Settling Time

APPENDIX 5

Dredging Sites

Appendix 5 Dredging Sites

Pilot study dredging and contained aquatic disposal (CAD) operations were carried out in a cove located approximately 1500 feet north of the Coggeshall Street Bridge on the New Bedford side of the harbor. Two separate dredging areas were located within the cove. Dredging area 1 was 250 by 250 feet and dredging area 2 was 180 by 180 feet. This appendix provides a detailed description of the physical characteristics of the cove along with the physical and chemical description of the sediment within the dredging area.

Water Depth: Water depths in the cove are generally less than 1.5 feet at Mean Low Water (MLW). Figure 5-1 shows the dredging areas with the water depths indicated.

Tides: The predicted tide range for New Bedford is 3.7 feet with the spring range being 4.6 feet. During the pilot study a tide gage was installed opposite the cove on the east side of the upper estuary. Water levels during pilot study dredging operations (November 18 - February 11) ranged from a low of -2.2 at MLW to a high of +5.10 feet at MLW.

Currents: Current velocities within the cove were measured both prior to and during pilot study operations. These measurements were made using a Mead Velocity Probe (Model HP 302). They were taken at mid-depth in the central portion of the cove at various stages of the ebb tide. Velocities were consistently between 0.1 and 0.3 feet per second. On two occasions during the fall of 1988 efforts were made to determine the route resuspended material would follow when leaving the cove on the ebb tide. The majority of current velocities were measured during this period. Dye (Rhotomine W/T) was pumped into dredging area 1 at a constant rate for one hour at the start of the ebb tide. A grid of stations located within the cove and downstream of dredging area 1 were sampled hourly during the ebb tide. The results of these efforts indicated that resuspended material would leave the cove slowly in a narrow band that followed a straight line path to the Coggeshall Street Bridge.

Salinity: Measurements taken within the cove in September 1988 by the New England Division averaged 30.7 ppt. This level agrees with other measurements made in the upper estuary by both the Waterways Experiment Station (WES) and EPA's Narragansett Laboratory.

Suspended Material: Measurements taken within the cove in September 1988 by the New England Division averaged 4.2 mg/l with a range between 2 and 9 mg/l. WES reported suspended material levels in the upper estuary to be generally less than 10 mg/l (11) and EPA Narragansett reported levels between 5.6 and 8.6 mg/l during pre-operational monitoring at station 1 which is approximately 1000 feet north of the cove.

Sediment

Physical Characteristics: Six sediment cores were taken from each dredging area prior to the start of dredging. These sediment cores were divided into samples representing the 0-24, 24-48 and 48-72 inch horizons. Grain size distribution, water content, specific gravity and plasticity of sediment from dredging area 1 and dredging area 2 are shown in tables 1 and 2 respectively. The sample locations are shown in Figure 5-2. The material in the dredging areas is an organic silt with a sand content of less than 30% in the 0-24 inch horizon increasing to 60% in the 48-72 inch horizon of area 1. The average characteristics for each dredging area are shown below. The range of grain sizes for the 0-24 inch horizon for each dredging area are shown in Figures 5-3 and 5-4. The ranges incorporate curves from 6 samples.

Dredging Area 1

Horizons	% Fines	Water Content(%)	Specific Gravity	Liquid Limit	Plasticity Index
0-24 inch	73.7	135.5	2.49	116.7	54.5
24-48 inch	53.6	74.2	2.56	72.8(1)	31.2(1)
48-72 inch	40.5	46.5	2.60	70.7(2)	30.0(2)

Dredging Area 2

0-24 inch	77.8	158.7	2.46	122.8	45.8
24-48 inch	78.8	117.4	2.55	106.7	51.7

1) Based on 5 samples
2) Based on 3 samples

PCBs: Six sediment cores were taken from each dredging area in the fall of 1987. The top three feet of these cores were divided into samples representing six inch increments and two additional samples were formed to represent the 36-48 and 48-72 inch horizons. These samples were then analyzed for PCBs at EPA's Environmental Research Laboratory in Narragansett, Rhode Island. The results of this effort are shown in table 3 with the sample locations shown in Figure 5-2. PCBs were generally restricted to the top two feet of sediment with the highest levels being detected in the top six inches. PCB levels in the 0-6 inch horizons averaged 226 ppm in area 1 and 385 ppm in area 2.

Metals: The samples discussed above were not analyzed for metals. In 1985 the New England Division (NED) carried out extensive sampling within the upper estuary and a sample core taken during that period fell within dredging area 1. This sample was analyzed by NED and the results are shown in table 4.

Six surface grab samples were also taken from each dredging area in the spring of 1988. The six samples from each area were composited into one sample and used for the elutriate tests discussed in the next section of this appendix. Prior to performing the elutriate test these samples were analyzed for PCBs and metals by NED. These results are shown in table 4.

Elutriate Tests: Elutriate tests are used in making contaminant release estimates for both dredging and disposal operations. The modified elutriate test is used in predicting contaminant loads in the effluent being discharged from a confined disposal facility and the standard elutriate is used in predicting releases at the point of dredging and from contained aquatic disposal operations. Both modified and standard tests were performed by NED using the composite surface samples from dredging areas 1 and 2. The results are shown in tables 5 and 6 respectively.

Table 1
Physical Characteristics of Sediment
Dredge Area 1

Sample	%Fines	Water Content	Specific Gravity	Liquid Limit	Plastic Limit	Plasticity Index
			Horizon 0-24"			
A	77.4	161.9	2.46	134	70	54
B	50.7	90.5	2.55	72	37	35
C	82.7	146.0	2.53	131	76	55
D	79.9	136.3	2.45	126	67	59
E	78.3	146.6	2.47	119	76	43
F	73.1	131.9	2.49	128	47	61
			Horizon 24-48"			
A	83.4	111.3	2.45	99	57	42
B	12.9	26.3	2.63	NP	NP	NP
C	52.8	71.1	2.57	60	39	21
D	49.3	69.9	2.59	54	35	19
E	78.8	106.5	2.54	100	50	50
F	44.2	60.1	2.60	51	27	24
			Horizon 48-72"			
A	57.2	99.7	2.50	92	58	34
B	37.2	13.1	2.65	NP	NP	NP
C	17.4	21.7	2.65	NP	NP	NP
D	13.4	18.8	2.65	NP	NP	NP
E	73.6	104.1	2.50	100	51	49
F	44.0	21.8	2.65	20	13	7

NP - nonplastic (visual)

Table 2
Physical Characteristics of Sediment
Dredge Area 2

Sample	%Fines	Water Content	Specific Gravity	Liquid Limit	Plastic Limit	Plasticity Index
Horizon 0-24"						
A	80.2	161.7	2.47	119	76	43
B	76.0	148.5	2.46	115	72	43
C	79.8	150.4	2.48	114	76	38
D	78.8	175.0	2.44	148	96	52
E	78.5	173.0	2.41	132	74	58
F	73.3	143.3	2.48	109	68	41
Horizon 24-48"						
A	78.3	108.9	2.53	99	45	54
B	77.9	121.4	2.57	101	54	47
C	80.3	109.7	2.55	105	55	50
D	81.9	143.0	2.53	134	72	62
E	80.3	118.9	2.57	112	52	60
F	73.9	102.6	2.56	89	52	37

Table 3
PCB Levels (ppm)

	Sample Depth (inches)					
Sample	0-6"	6-12"	12-18"	18-24"	24-30"	30-36
Dredging Area 1						
A	260	16.2	9.2	2.7	0.4	0.3
B	227	17.2	4.9	3.9	0.5	0.3
C	245	7.6	4.1	7.3	0.6	0.2
D	226	10.1	9.1	2.3	1.4	0.2
E	149	11.2	8.2	2.1	0.2	0.1
F	249	8.9	10.0	4.7	1.9	0.7
Dredging Area 2						
A	585	29.0	3.8	0.5	0.10	ND
B	327	11.2	9.7	1.4	0.10	0.02
C	329	12.5	2.9	2.3	0.10	0.01
D	313	43.1	4.2	0.7	0.30	ND
E	302	92.1	1.9	0.2	0.05	0.01
F	453	14.5	5.3	1.1	0.40	0.04

Table 4
Metals Data (ppm)

	Sample M (Figure 5-2) Depth (inches)		
	0-12"	12-24"	24-30"
Oil & Grease	10,100.0	329.0	50.0
Arsenic	2.4	1.8	1.4
Cadmium	16.0	7.0	<2.0
Chromium	325.0	115.0	<7.0
Copper	897.0	748.0	<6.0
Lead	434.0	539.0	<20.0
Mercury	1.1	<0.1	<0.1
Nickel	57.0	44.0	<24.0
Zinc	1,120.0	1760.0	12.0

	Composite Surface	
	Dredging Area 1	Dredging Area 2
Cadmium	20	30
Chromium	473	591
Copper	1246	1547
Lead	511	532
Nickel	78	103
Zinc	1583	2069

Table 5
Modified Elutriate Test Results
Dredging Area 1

Site Water

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3514 F#1	-0.016	-0.080	-0.040	-0.080	-0.020	0.040	0.06
3515 F#2	-0.016	-0.080	-0.040	-0.080	-0.020	0.020	0.19
3516 F#3	-0.008	-0.040	-0.020	-0.040	-0.010	0.021	0.14
3517 U#1	-0.008	-0.040	-0.020	-0.040	-0.010	0.028	0.52
3518 U#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.026	0.36
3519 U#3	-0.008	-0.040	-0.020	-0.040	-0.012	0.040	0.51

Elutriate

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3532 F#1	-0.008	-0.040	-0.020	-0.040	-0.010	0.094	6.24
3533 F#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.085	8.85
3534 F#3	-0.008	-0.040	-0.020	-0.040	-0.010	0.068	9.38
3535 U#1	-0.016	0.096	0.336	-0.080	0.160	0.464	70.30
3536 U#2	-0.016	0.256	0.760	-0.080	0.478	1.020	87.20
3537 U#3	-0.008	0.120	0.352	-0.040	0.252	0.460	63.90

Suspended Solids Data (mg/l)

Sample	PCBs	Metals
3535	129	263
3536	167	320
3537		276

Bulk Chemical Analysis (ppm)

Cd	Cr	Cu	Ni	Pb	Zn	Total PCB
20	473	1246	78	511	1583	97.5

Note:
1. Negative values are detection limits.
2. Three replicates analyzed.
3. F = Filtered (dissolved)
   U = Unfiltered (total, dissolved and suspended)

Table 6
Modified Elutriate Test Results
Dredging Area 2

Site Water

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3520 F#1	-0.008	-0.040	-0.020	-0.040	-0.010	0.030	0.35
3521 F#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.031	0.20
3522 F#3	-0.008	-0.040	-0.020	-0.040	-0.010	0.024	0.26
3523 U#1	-0.008	-0.040	-0.020	-0.040	-0.010	0.038	0.57
3524 U#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.040	1.08
3525 U#3	-0.008	-0.040	-0.020	-0.040	-0.010	0.040	0.83

Elutriate

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3544 F#1	-0.008	-0.040	-0.030	-0.040	-0.015	0.106	6.77
3545 F#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.044	9.44
3546 F#3	-0.008	-0.040	-0.020	-0.040	-0.010	0.073	9.66
3547 U#1	-0.008	0.118	0.383	-0.040	0.196	0.493	112.00
3548 U#2	-0.008	0.132	0.396	-0.040	0.193	0.470	88.90
3549 U#3	-0.008	0.230	0.618	-0.040	0.295	0.794	94.60

Suspended Solids Data (mg/l)

Sample	PCBs	Metals
3547	196	173
3548	151	207
3549	221	219

Bulk Chemical Analysis (ppm)

Cd	Cr	Cu	Ni	Pb	Zn	Total PCB
30	591	1547	103	532	2069	119

Note:
1. Negative values are detection limits.
2. Three replicates analyzed.
3. F = Filtered (dissolved)
   U = Unfiltered (total, dissolved and suspended)

Table 7
Standard Elutriate Test Results

Dredging Area 1
Elutriate

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3526 F#1	-0.008	-0.040	-0.026	-0.040	-0.010	0.012	8.0
3527 F#2	-0.008	-0.040	-0.020	-0.040	-0.010	0.014	10.1
3528 F#3	-0.008	-0.040	-0.024	-0.040	-0.010	0.024	10.1
3529 U#1	-0.008	0.076	0.184	-0.040	0.104	0.208	100.0
3530 U#2	-0.008	0.074	0.208	-0.040	0.121	0.258	100.0
3531 U#3	-0.008	0.066	0.178	-0.040	0.108	0.218	92.8

Dredging Area 2
Elutriate

Sample	Cd (mg/l)	Cr (mg/l)	Cu (mg/l)	Ni (mg/l)	Pb (mg/l)	Zn (mg/l)	Total PCB (ppb)
3538 F#1	-0.008	-0.040	-0.026	-0.040	-0.010	0.036	3.4
3539 F#2	-0.008	-0.040	-0.023	-0.040	-0.010	0.014	6.2
3540 F#3	-0.008	-0.040	-0.024	-0.040	-0.010	0.012	4.6
3541 U#1	-0.008	0.208	0.466	-0.040	0.237	0.526	34.1
3542 U#2	-0.008	0.158	0.346	-0.040	0.161	0.358	67.0
3543 U#3	-0.008	0.140	0.320	-0.040	0.151	0.342	40.1

Note:
1. Negative values are detection limits.
2. Three replicates analyzed.
3. Refer to tables 5 and 6 for bulk chemical analysis and site water analysis.
4. F = Filtered (dissolved)
   U = Unfiltered (total, dissolved and suspended)

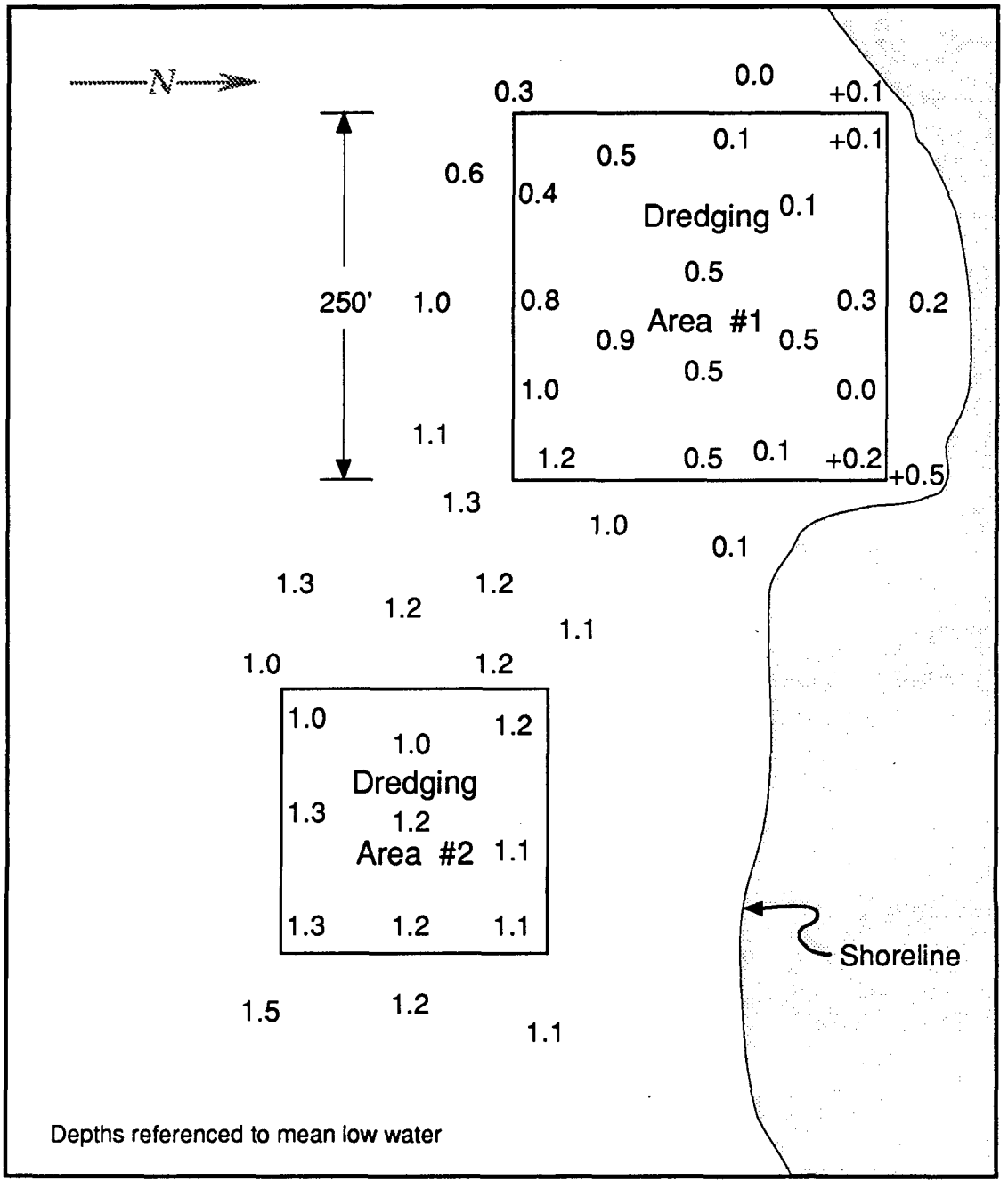


Figure 5-1 Water Depths

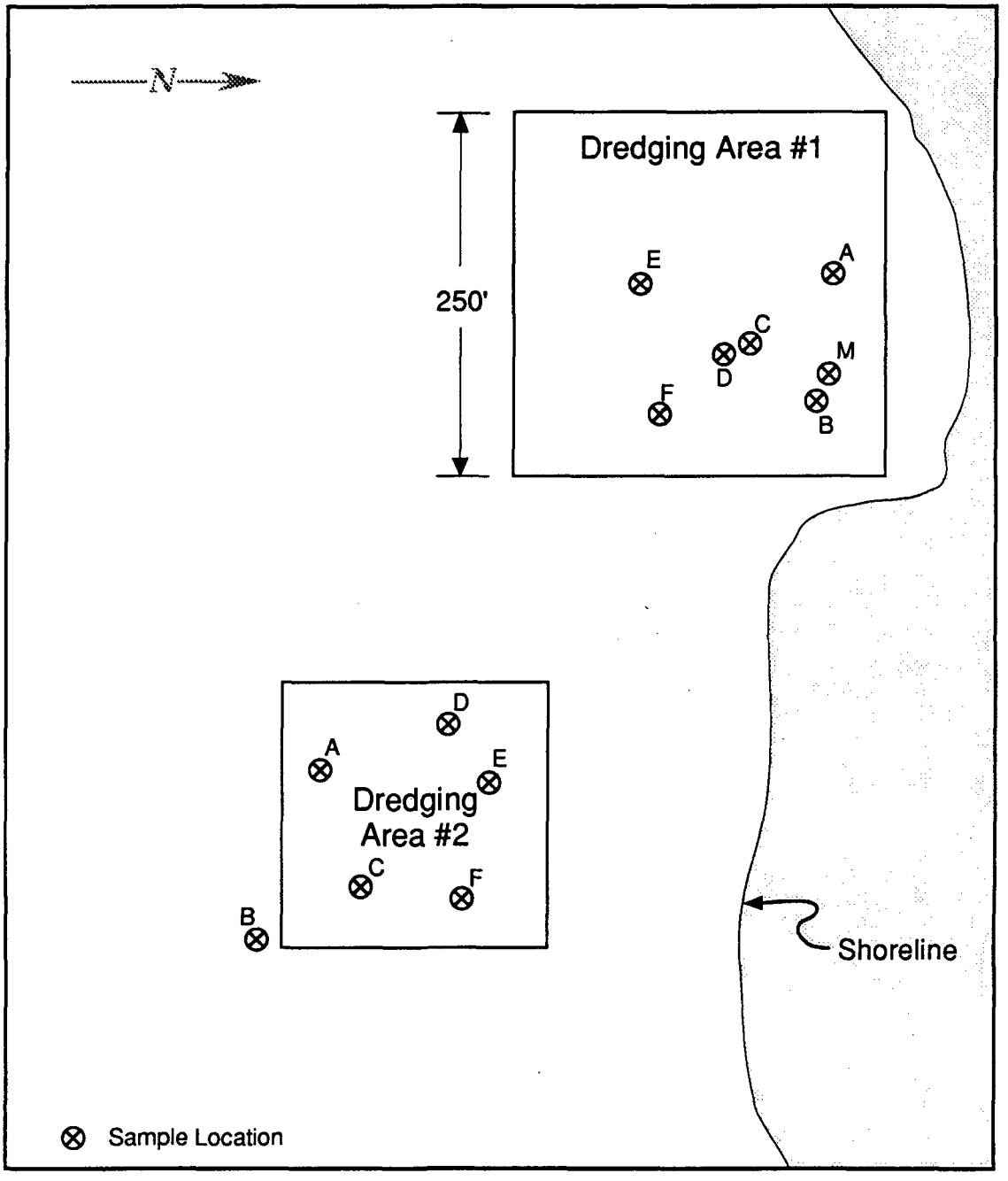
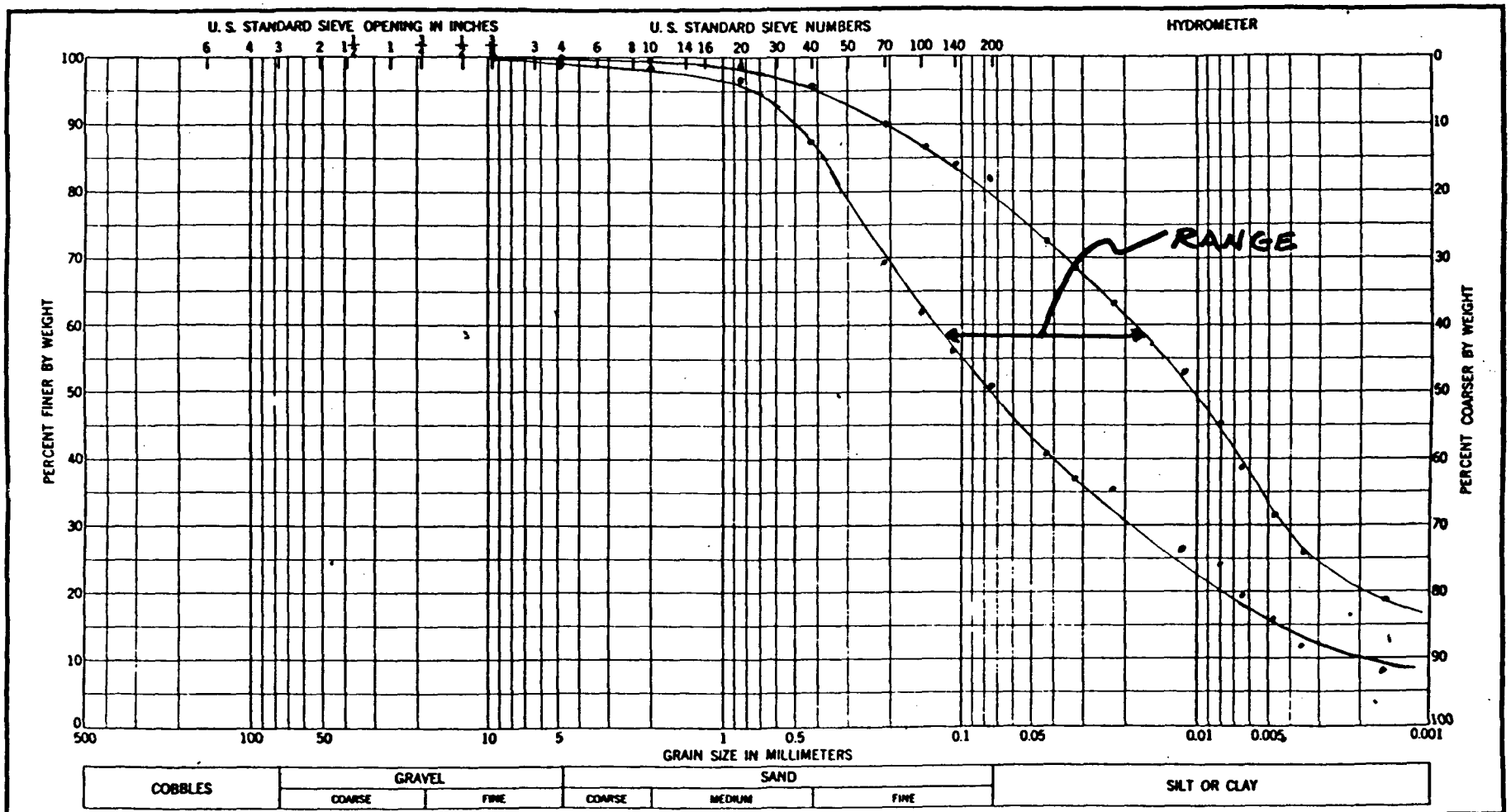


Figure 5-2 Sample Locations



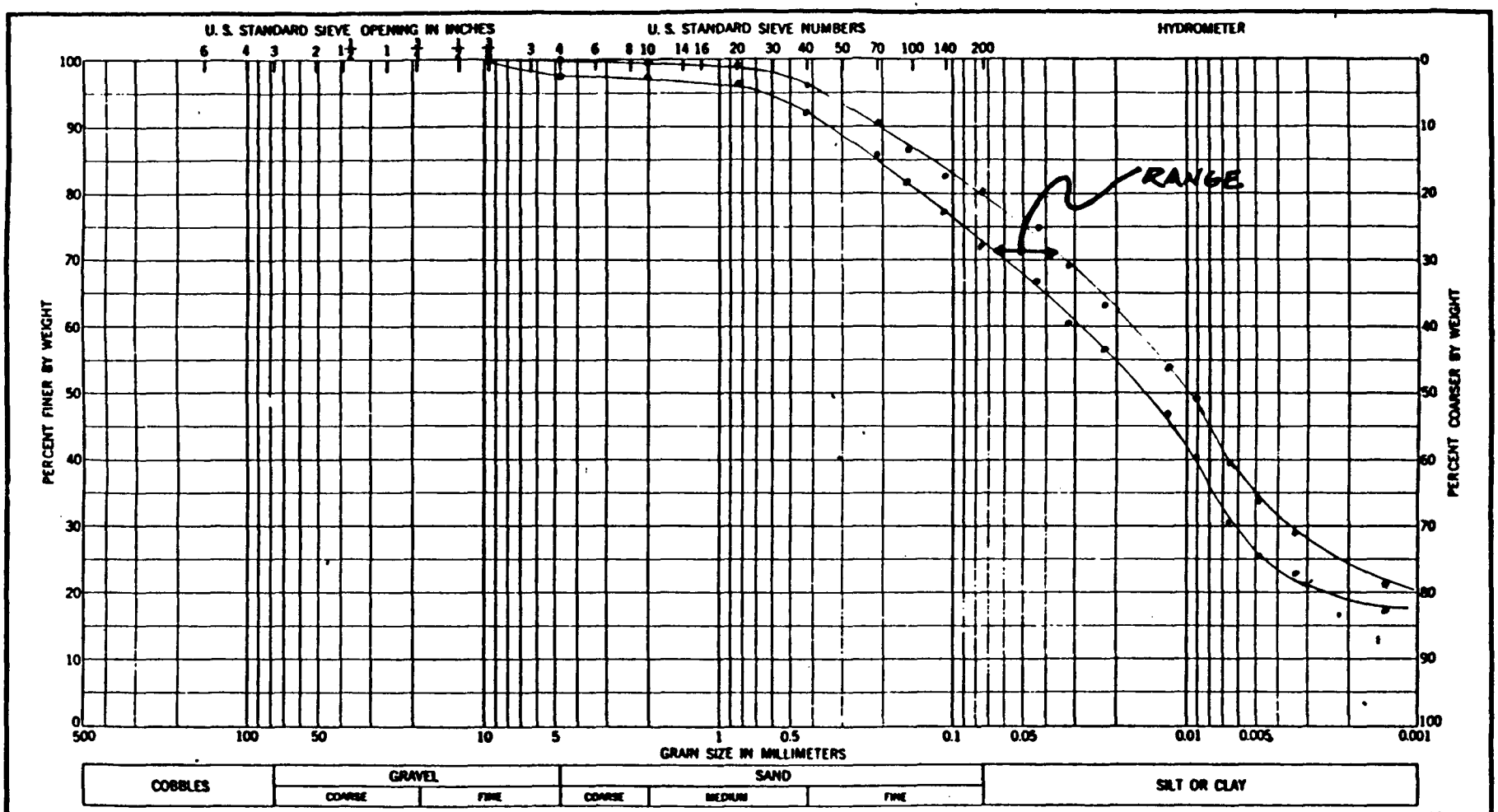
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project NEW BEDFORD HARBOR
PILOT STUDY DREDGING AREA 1
Area 0-24 inch horizon
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE 5-3



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project NEW BEDFORD HARBOR
PILOT STUDY DREDGING AREA 2
Area 0-24 inch horizon
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

FIGURE 5-4

APPENDIX 6

GEOTECHNICAL STUDIES

APPENDIX 6 GEOTECHNICAL STUDIES

INTRODUCTION

Project Description: New Bedford Harbor, as shown in Figure 6-1, is a tidal estuary at the south end of the Acushnet River which separates New Bedford to the west from Fairhaven to the east. Studies of the harbor sediments and water column which have been performed since 1974 indicate the harbor is contaminated with elevated levels of polychlorinated biphenyls (PCBs), copper, chromium, lead, and zinc. The Environmental Protection Agency (EPA) published a Feasibility Study for the Upper Acushnet Estuary (north of the Coggeshall Street Bridge) in 1984 which recommended five alternatives to reduce the elevated levels of the contaminants (12). The Corps of Engineers was contracted by EPA to perform additional pre-design studies on the recommended alternatives due to the large number of unresolved questions. A pilot study to evaluate dredge equipment and dredged material disposal options was executed as part of the pre-design studies. Features of the Pilot Study which required significant geotechnical input were design and construction of a Confined Disposal Facility (CDF) on soft ground, evaluation of the side slopes for two Contained Aquatic Disposal (CAD) areas, physical characterization of the dredge materials, and installation of geotechnical monitoring equipment for the CDF. A sketch of the Pilot Study site plan is shown in Figure 6-2.

General: Subsurface investigations and geotechnical studies were performed to aid in the planning, design, construction, monitoring, and evaluation of the pilot study. The subsurface investigations included research of available information, geological studies, subsurface explorations, and laboratory testing. The subsurface investigations were performed to determine the distribution, description, and properties of the foundation materials for the CDF and the nature of potential dredged materials. Geotechnical engineering studies, based on the data collected from the subsurface investigations, were conducted to develop safe and economical dike designs, dredge cut side slopes, and a subsurface monitoring plan.

Elevations: All elevations in this appendix are referenced to mean low water (MLW). The mean low tide elevation is 0 feet MLW and the mean high tide elevation is 3.7 feet MLW at the project site.

GEOGRAPHY, GEOLOGY AND SEISMICITY

Geography: New Bedford Harbor is the tidal estuary of the Acushnet River which originates in north Acushnet, Massachusetts and flows generally south approximately four miles to the north edge of the estuary at the Wood Street Bridge. The tidal estuary consists of the upper harbor (Wood Street Bridge to the Coggeshall Street Bridge), the inner harbor (Coggeshall Street Bridge to the New Bedford Hurricane Barrier), and the outer harbor (south of the New Bedford Hurricane Barrier).

The pilot study was conducted in and adjacent to a small cove situated on the west side of the upper harbor. The cove is located approximately 2000 feet north of the Coggeshall Street Bridge. Water depths in the cove vary from 0 to 10 feet but were typically 0 to 4 feet where work was performed. The land adjacent to the cove is primarily used by industry. The land is of low relief and marshes exist in the lower areas that are immediately adjacent to the cove.

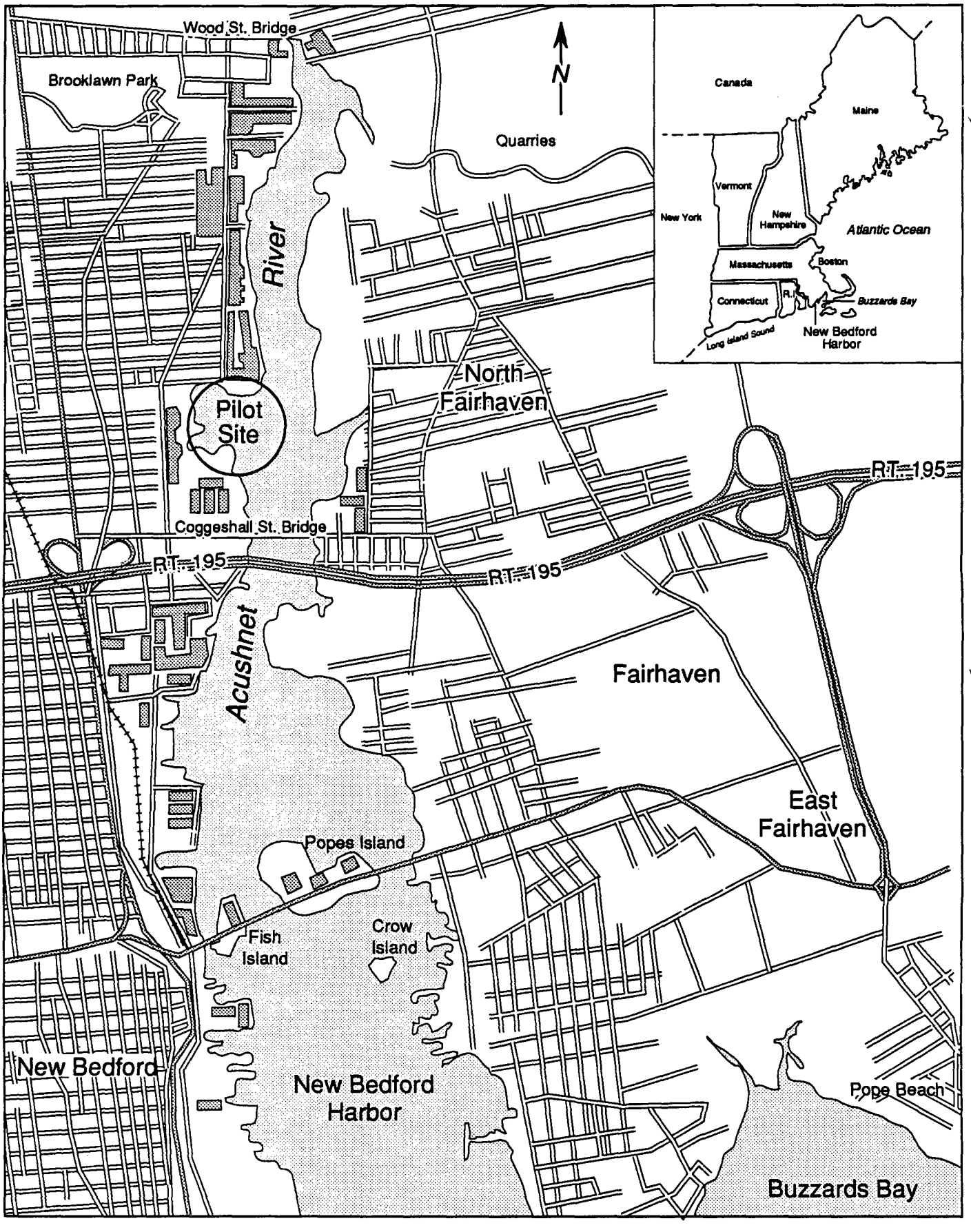


Figure 6-1 New Bedford Harbor

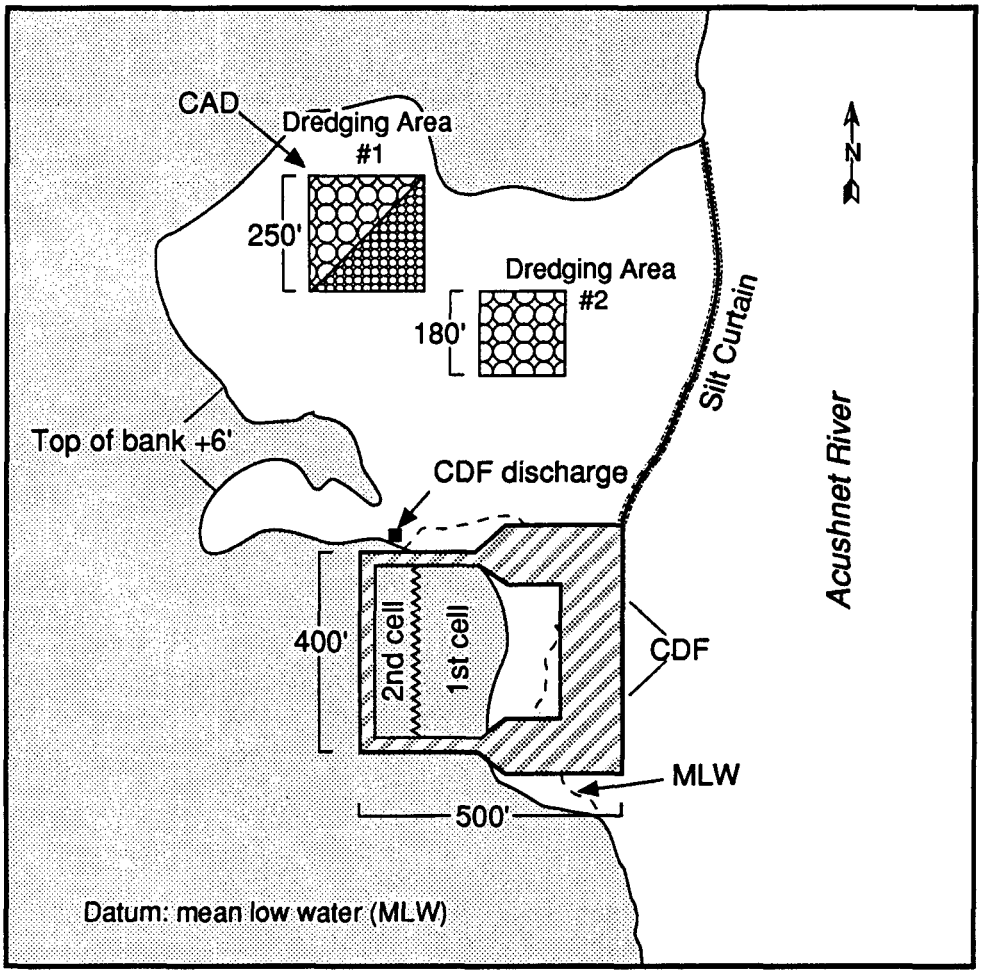


Figure 6-2 Pilot Study Site Plan

Geology: The project site lies on a large flat seaboard lowland which is partially submerged. Bedrock at the site is granitic gneiss and lies more than 35 feet below the surface. The bedrock is overlain by sands and fill (on shore only) or organic clay (offshore only). The sands are typically fine to medium with up to 50 percent silt content and up to 30 percent gravel content. They are alluvial materials that originally were glacial sediments. The organic clay lies above the sand and contains as much as 30 percent fine to medium sand. The fill consists mainly of granular materials mixed with debris.

Seismicity: The project site lies in seismic zone 2 according to the seismic zone map of the United States (17). The foundation materials at the site were not judged to be susceptible to liquefaction or excessive deformation in the event of a significant earthquake.

SUBSURFACE EXPLORATIONS

Presentation of Data: Six subsurface exploration and five laboratory test programs provided information for the planning, design, construction, and monitoring of the pilot study. The portions of the programs pertinent to the pilot study are described below. Locations of the subsurface explorations performed and the monitoring devices installed are shown in Figures 6-3 to 6-5. Exploration logs are presented in Appendix 6-A. Laboratory test results are presented in Appendix 6-B.

Subsurface Explorations: The New England Division's (NED's) Materials and Water Quality Laboratory supervised and performed the first subsurface program from July 1985 to October 1985 (3). The purpose of the program was to characterize the physical and chemical properties of the sediments in the upper harbor. Twenty-nine push core samples were taken at 26 locations in the pilot study area as part of the program. Each sample was taken by pushing and then driving a three inch diameter polyvinyl chloride (PVC) pipe to refusal from a barge. The samples varied from 4 to 84 inches in length. The average sample length was 50 inches. NED Water Quality Laboratory personnel logged the explorations. Only the locations of the push tube samples which were opened and tested in the pilot study area are shown in Figures 6-3 and 6-4.

Woodward-Clyde Consultants (WWC) undertook a more extensive upper harbor exploration program from October 1986 to November 1986 (26). Goldberg-Zoino Drilling was subcontracted by WWC to perform the explorations. The purposes of the program were to characterize the physical and chemical properties of the sediments in the upper harbor to a greater depth (Phase I work) and provide preliminary design input for the dike construction and dredging to be accomplished during the pilot study (Phase II work). Phase I work performed in the pilot study area included: 2 water borings (19 and 31.5 feet deep), 1 land boring (22 feet deep), 2 water probes (30 feet deep each) and 1 land probe (19 feet deep). Phase II work performed in the pilot study area included: 4 water borings (16 to 32 feet deep), 2 land borings (32 feet deep each), 13 push core samples (60 inches in length) and 13 Van Veen samples. Splitspoon samples and standard penetration tests were generally taken at five foot intervals in the boreholes and also were taken immediately beneath six of the push core samples. WWC engineers and geologists observed and logged the explorations.

The NED Materials and Water Quality Laboratory supervised and executed a second subsurface exploration program during the spring of 1987. Twelve push core samples were taken in the proposed dredging areas for the pilot study. Samplers were pushed a minimum of 72 inches in proposed dredging area #1 and a minimum of 48 inches in proposed dredging area #2. The purpose of the pro-

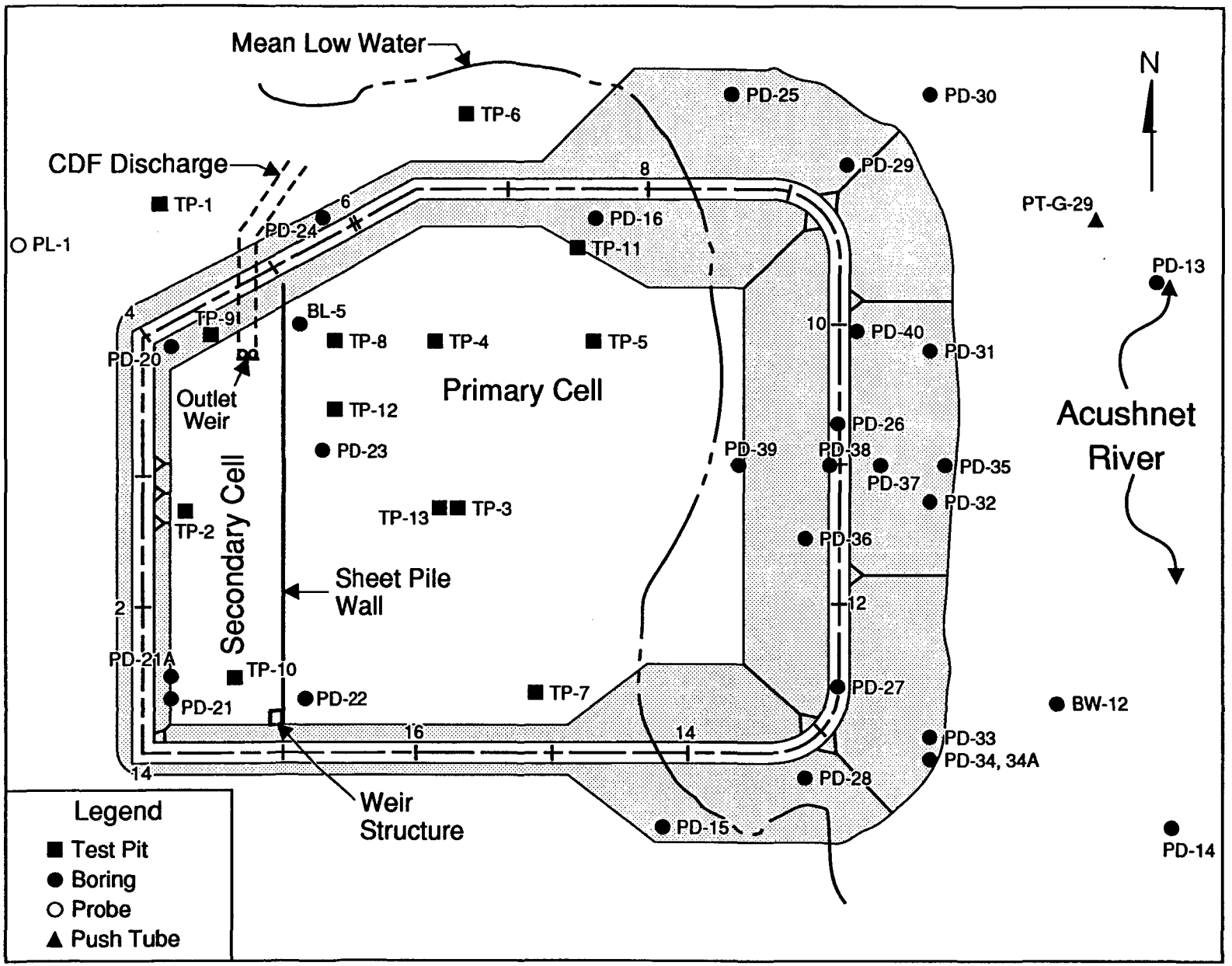


Figure 6-3 Exploration Plan - CDF Area

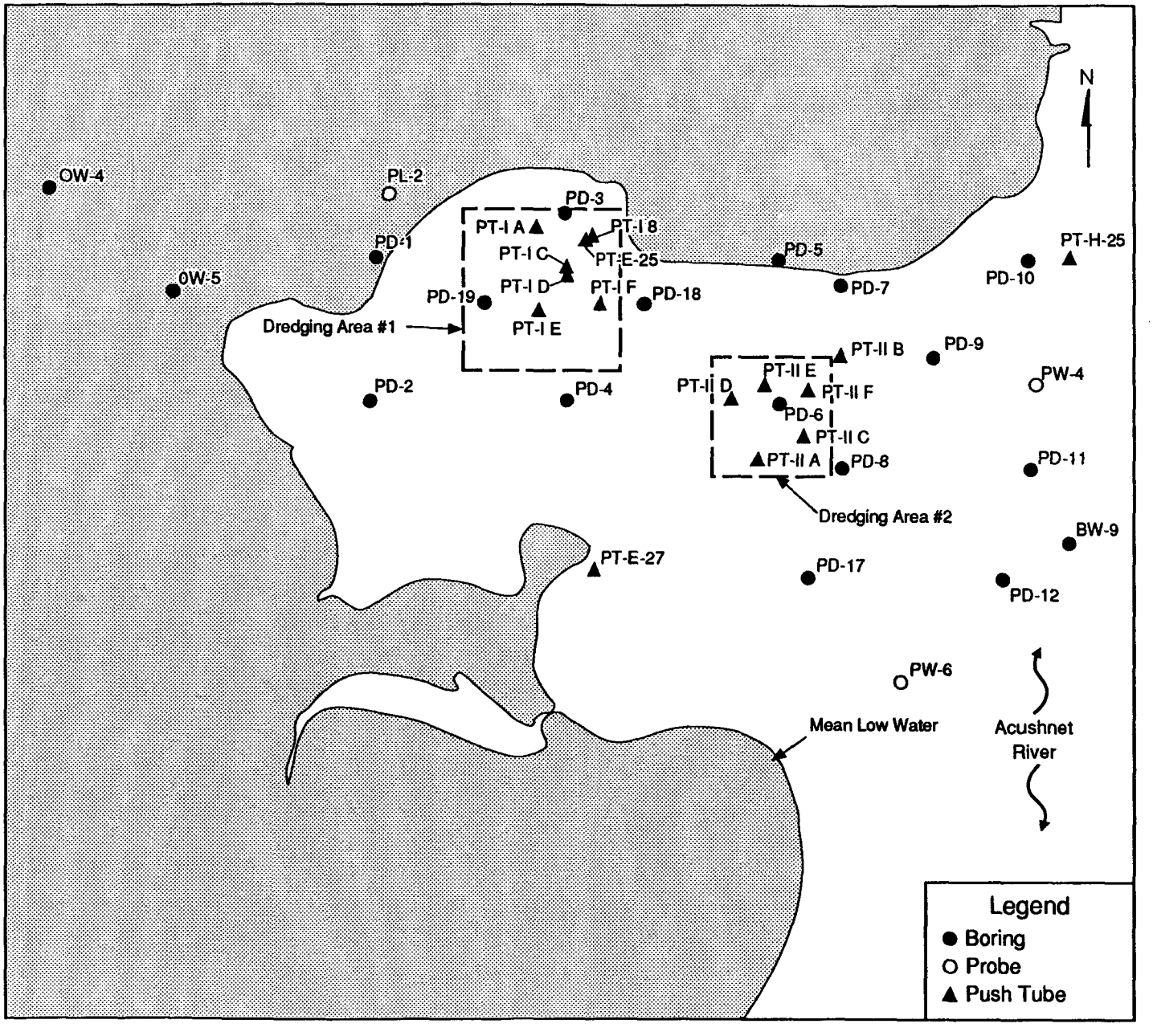


Figure 6-4 Exploration Plan - CAD Area

gram was to better characterize the materials in the proposed dredging areas. NED Water Quality Lab personnel logged the explorations.

Geotechnical Engineers Inc. (GEI) executed the final design explorations for the Confined Disposal Facility in September 1987 (8). Guild Drilling was engaged by GEI to execute the explorations. The purpose of the program was to better define the subsurface profile and material properties along the CDF alinement. The exploration program included: 6 land borings (4 to 40 feet deep), 11 water borings (8 to 32 feet deep), and 13 test pits (4 to 8 feet deep). Standard penetration tests and split-spoon samples were taken at five foot intervals in the land borings and below the organic soils in the water borings. Field vane shear tests were performed at 1.8 foot intervals through the organic soils in the water borings except in the four boreholes where undisturbed samples were taken below four feet of depth. All explorations were observed full time by a GEI field representative.

NED supervised an exploration program in September 1988, during construction of the confined disposal facility. The drilling of six borings was performed by Environmental Drilling, Inc. The purpose of the work was to gain additional information about the strength of the organic silty clay beneath and below the proposed dike. Thirty-nine hand turned vane shear tests were executed in the organic silty clay. Standard drill and wash techniques were used to advance the boreholes through the stage I dike embankment before performing the vane shear tests in four of the borings. The boreholes were observed and logged by USACE personnel.

The final exploration program was performed in August 1988 and November 1988 as part of the construction contract for the confined disposal facility. Goldberg-Zoino Drilling was subcontracted by R. Zoppo Company to advance the boreholes for geotechnical and groundwater monitoring devices. The work included installation of: 2 inclinometers, 5 piezometers, and 7 monitoring wells. The devices were used as indicators of dike performance and movement of groundwater and contaminants through the dike. The boreholes were logged by the driller and R. Zoppo Company personnel.

Laboratory Soil Testing: The NED Materials and Water Quality Laboratory executed laboratory tests on the upper harbor subsurface materials from October 1985 to December 1985 (3). The materials tested were obtained from their July 1985 to October 1985 exploration program. Four samples were tested from the 29 push core explorations performed in the pilot study area. Combined Analysis (mechanical and hydrometer), Water Content, Percent Volatiles, Atterberg Limit, and Specific Gravity tests were run on each of the four samples. The procedures in "Laboratory Soil Testing" (20) were generally followed except for Percent Volatiles tests which were executed with a modified version of Method 209D from the "Standard Methods for the Examination of Water and Wastewater" (1).

WWC coordinated laboratory testing on samples taken during their October 1986 to November 1986 exploration program (26). Tests on contaminated samples were performed by Earth Technology Corporation and tests on uncontaminated samples were performed by WWC in November 1986 and December 1986. Phase I testing in the pilot study area included: 10 Moisture Content determinations, 1 Atterberg Limit test, 3 Specific Gravity determinations, 8 Mechanical Analyses, and 5 Combined Analyses. Phase II testing included: 34 Moisture Content determinations, 12 Atterberg Limit tests, 25 Specific Gravity determinations, 26 Mechanical Analyses, and 25 Combined Analyses. All tests were generally performed in accordance with American Society for Testing and Materials (ASTM) procedures (2).

The NED Materials and Water Quality Lab performed 38 Combined Analyses on the push core samples taken in the study area during the October 1986 to November 1986 WWC exploration program. The testing was executed in August 1987 and September 1987, generally following the procedures in "Laboratory Soil Testing (20).

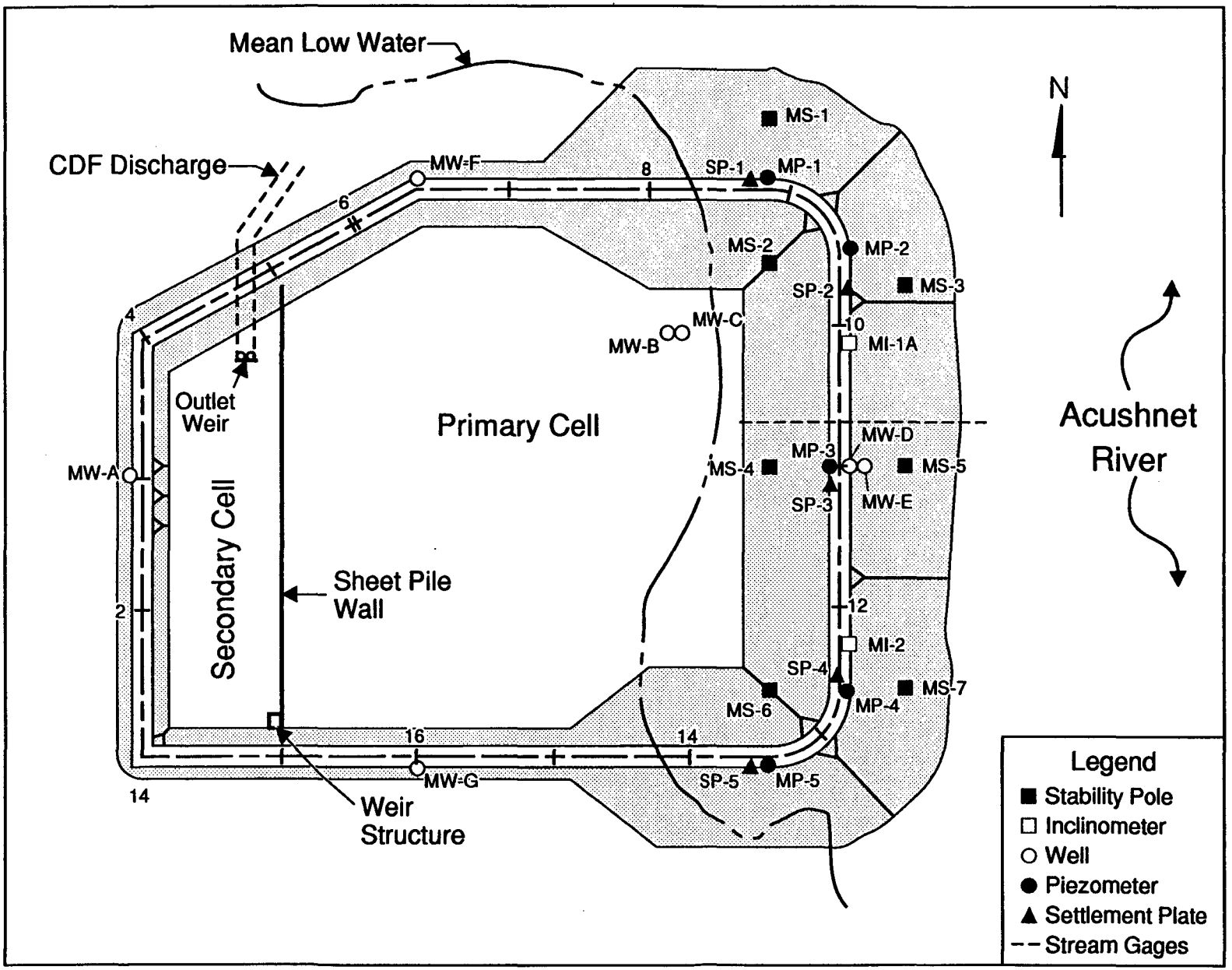


Figure 6-5 Monitoring Plan - CDF Area

Law Environmental, Inc. executed laboratory tests on samples taken during the spring 1987 NED Water Quality Laboratory exploration program. The testing was accomplished during November 1987. It included: 30 Moisture Content determinations, 30 Specific Gravity determinations, 26 Atterberg Limit tests, and 30 Combined Analyses. The tests were generally performed in accordance with ASTM procedures (2).

The final laboratory testing program was performed by GEI during October 1987 and November 1987 (8). The material tested was sampled during GEI's September 1987 exploration program. Testing of samples in the pilot study area included: 2 Combined Analyses, 2 Mechanical Analyses, 8 Moisture Content determinations, 6 Atterberg Limit tests, 3 Specific Gravity determinations, 2 Consolidation tests, 4 Unconsolidated Undrained Triaxial tests, and 2 Consolidated Undrained Triaxial tests. The triaxial tests were performed in accordance with the procedures outlined in "Laboratory Soil Testing" (20). All other tests were generally performed in accordance with ASTM procedures (2).

SUBSURFACE CONDITIONS

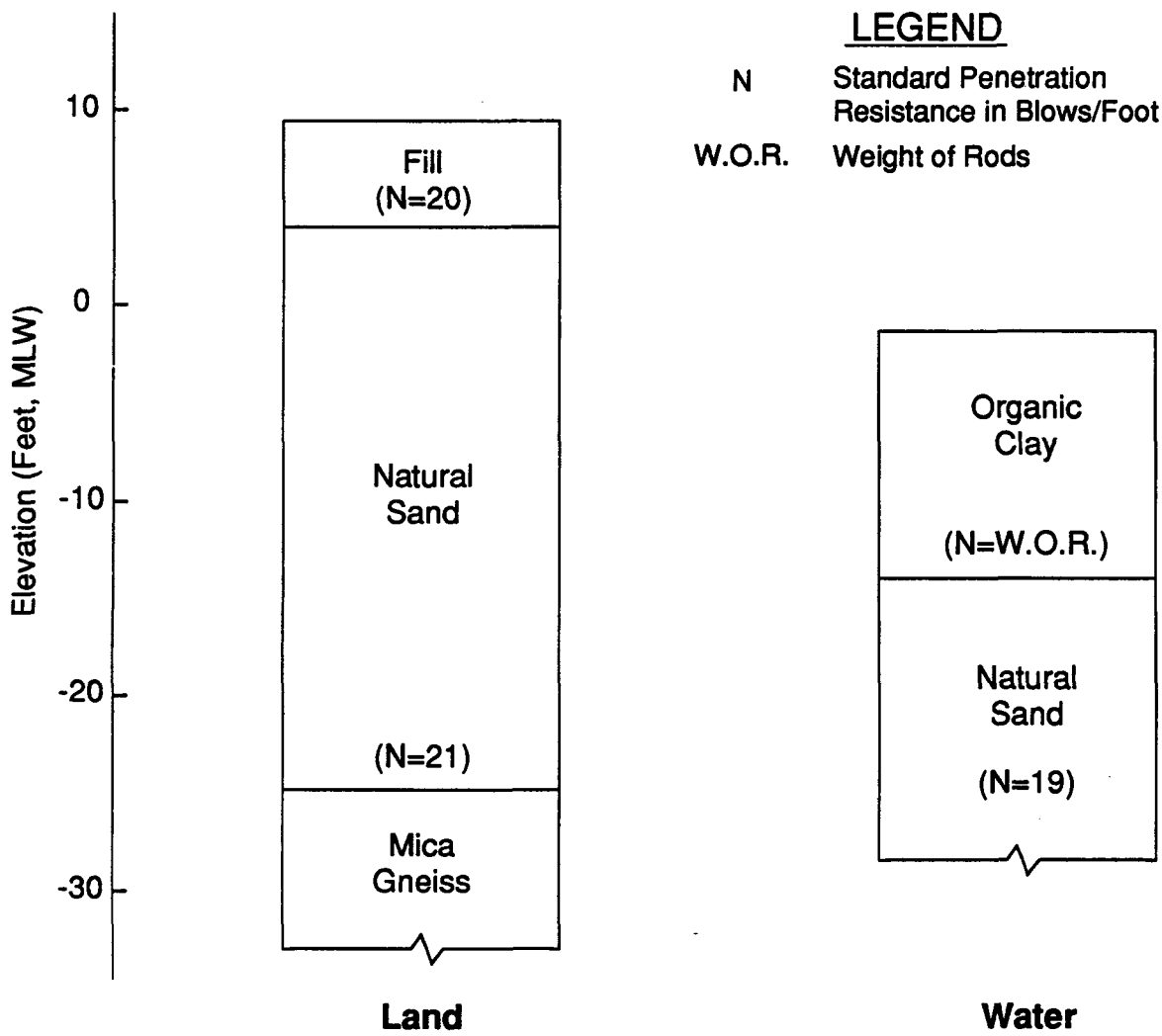
The nature of subsurface conditions was studied using geologic maps, observations from site visits, exploration logs, and laboratory test results. Typical profiles which were developed from the land and water explorations are shown in Figure 6-6. The typical soil profile on land is fill underlain by sand and bedrock, except for boring PD-20 where organic clay was observed between the fill and the sand. Organic clay underlain by sand and bedrock is the typical soil profile offshore, except for boring BW-9 where no organic clay was observed.

Soil Stratum Descriptions: Three major soil types were encountered in the explorations. They are described below.

FILL: A surficial granular fill was observed in all the land borings and test pits. The fill typically consisted of a silty, gravelly sand matrix mixed with bricks, ashes, cinders, concrete, wood, and metal. The fill thickness varied from 3 to 10 feet. Typically, the sand content varied from 50 to 75 percent, the gravel content from 10 to 40 percent, and fine content from 10 to 15 percent in the fill matrix. It appeared that the superstructures of mill buildings which once existed at the site were demolished and then mixed with the matrix. The mixture was dumped into the foundations of the mill buildings which were left in place

ORGANIC CLAY: A layer of organic clay with sand was encountered in all the offshore borings, except for boring BW-9, and one of the land borings (PD-20). The organic clay contained about 20 to 30 percent fine to medium sand by weight and occasionally shells and roots. The organic clay varied in thickness from 4 feet to 17 feet in the boreholes where it was fully penetrated. Field Vane Shear tests turned in the organic clay before construction indicated that it had a peak undrained shear strength from approximately 25 to 240 pounds per square foot.

SAND: Natural sands were encountered below the organic clay or surficial fill. The sands varied from well graded silty sands to clean narrowly graded sands. The sand layer was only fully penetrated in one boring (PD-23) and was 29 feet thick. However, 48 feet of sand was observed in boring PD-12 and the layer had not been fully penetrated. Standard Penetration tests executed in the sand varied from 3 to 80 blows per foot. They indicate the sand is loose



Note: The typical soil profiles are intended to convey trends in subsurface conditions. The land profile is based on 9 borings and 13 test pits. The water profile is based on 16 borings. The surface boundary elevations are averages and vary considerably between individual explorations. Standard penetration values are averages for a particular stratum and may vary considerably within the stratum.

Figure 6-6 Typical Profiles

to very dense in consistency. Standard Penetration test results greater than 50 blows per foot are probably caused by the presence of cobbles and boulders in the sand.

Groundwater: Groundwater was generally observed between the mean high tide level (elevation 3.7 feet MLW) and the mean low tide level (elevation 0.0 feet MLW). The groundwater levels noted on the logs vary from approximately 0 feet MLW to approximately 8 feet MLW at the time that the explorations were performed. It should be noted that fluctuations in the groundwater level may occur due to variations in tide, rainfall, snow, temperature, ice, wind, or other factors which differ from the conditions at the time that the observations were made.

DESIGN

Design Criteria: The principles and procedures discussed in "Design and Construction of Levees" (16) were used to develop the dike sections for the CDF. A typical design section is shown on Figure 6-7. Layer thicknesses and stone sizes for the dike were determined using procedures in "Hydraulic Design of Flood Control Channels" (19), "Additional Guidance for Riprap Channel Protection" (19) and the "Shore Protection Manual" (21). High-strength geotextile design was accomplished using the draft USACE Technical Manual "Engineering Use of Geotextiles" (18), "The Mechanics of Reinforced Embankments of Soft Soils" (9), and the "UTEXAS2 Slope-Stability" package (24). Vertical drain spacing was calculated using information provided in "Designing with Geosynthetics" (10). The sheet pile embedment length was determined using the USACE Computer Program entitled "Design and Analysis of Sheet Pile Walls by Classical Methods" (23).

Embankment Materials: The material from the required demolition, stripping and excavation operations was not suitable for the proposed embankments. The contractor supplied all embankment materials, due to the high potential cost of developing government furnished borrow areas and the difficulty involved in acquiring the land for borrow areas. The embankment materials which were specified are described below.

GRANULAR FILL: Granular fill shall consist of clean, tough, inert grains of quartz or other hard durable rock, free from loam or clay, surface coatings and deleterious materials. The material shall contain no organic matter or soft friable particles in quantities considered objectionable by the contracting officer. It shall be a material which can support construction equipment yet have a fairly low permeability. The fill particles shall be reasonably well graded within the limits listed below.

Sieve Size (U.S. Standard)	Percent Passing by Dry Weight
1/2-inch	100
No. 10	30-95
No. 40	10-75
No. 200	0-15

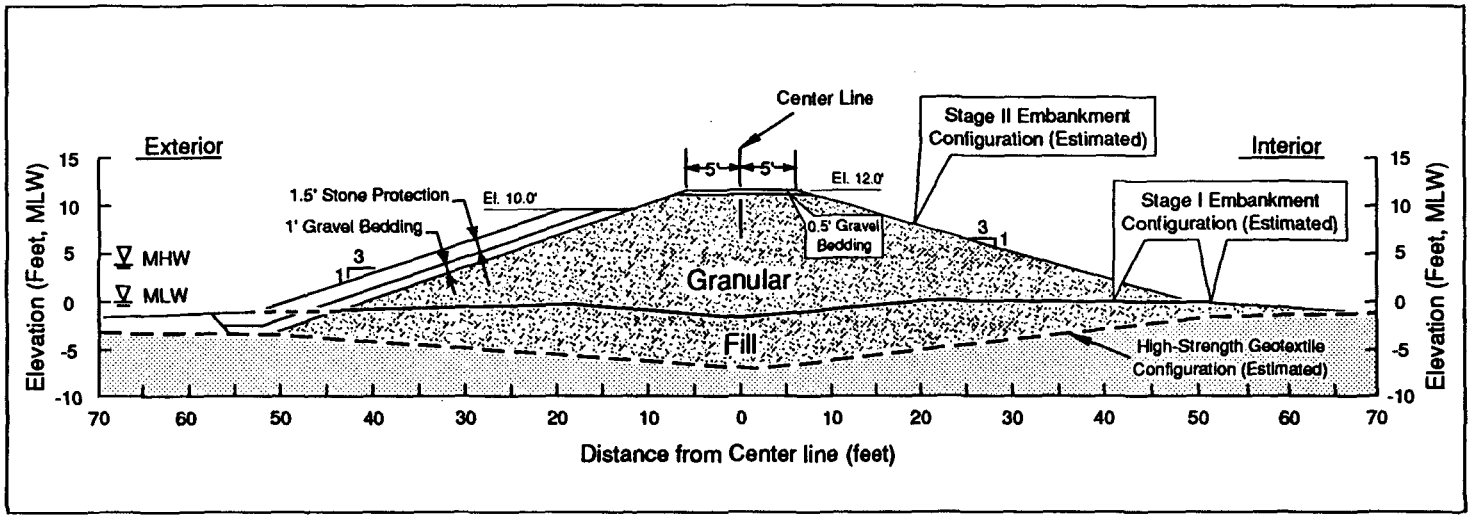


Figure 6-7 Typical Design Section

GRAVEL BEDDING Gravel Bedding shall consist of sand, gravel, and crushed stone. It shall be composed of tough, durable particles. It shall be reasonably free of thin, flat and elongated pieces. The materials shall contain no organic matter or soft friable particles in quantities considered objectionable by the contracting officer. The materials shall be reasonably well graded within the limits listed below.

Sieve Size (U.S. Standard	Percent Passing by Dry Weight
8-inch	100
4-inch	75-100
1-1/2-inch	50-80
No. 4	15-50
No. 40	3-20
No. 200	0-5

In addition, not more than 10 percent by dry weight of the component passing the No. 4 sieve shall pass the No. 200 sieve.

STONE PROTECTION Stone protection materials shall consist of hard, durable, angular, irregular, and sound quarried rock fragments. Each stone shall have a density of not less than 162 pounds per cubic foot based on the saturated surface dry specific gravity (SSD). Stones in the material shall not have long dimensions which exceed 3 times their short dimension. The gradation and size requirements for the subject project are listed below.

Limits of Stone Weight (Pounds)	Percent Lighter by Weight (SSD)
Between 120 and 300 (Max.)	100
Between 60 and 90	50
Less than 50	15
2 (Min.)	0

Sources Of Materials: Producers of granular fill, gravel bedding and stone protection materials were contacted during the spring and fall of 1987 to identify sources which could provide the quantities required for the proposed project. One producer could supply all the materials and was within 4 miles of the project site. More than 10 other possible producers were identified within 50 miles of the project site.

Atterberg Limit Tests: Woodward-Clyde Consultants, Law Environmental, Inc., Geotechnical Engineers Inc., and the USACE performed Atterberg Limit tests on the organic clay in the pilot study area. The test results are summarized in Figure 6-8. Geotechnical Engineers Inc. noticed approximately a 40 percent reduction in the liquid limit values of organic clay samples which were oven-dried versus the ones which were not oven-dried during their laboratory testing program (8). ASTM procedures (2) require that samples are not dried prior to executing liquid limit tests. It appears that the Woodward-Clyde Consultant and Law Environmental, Inc. samples may have been dried prior to running their liquid limit tests.

Design Values: Laboratory tests were performed on the organic clay foundation materials but not the existing granular fill and natural sand foundation materials nor the granular fill, gravel bedding and stone protection embankment materials. Design values were conservatively estimated from

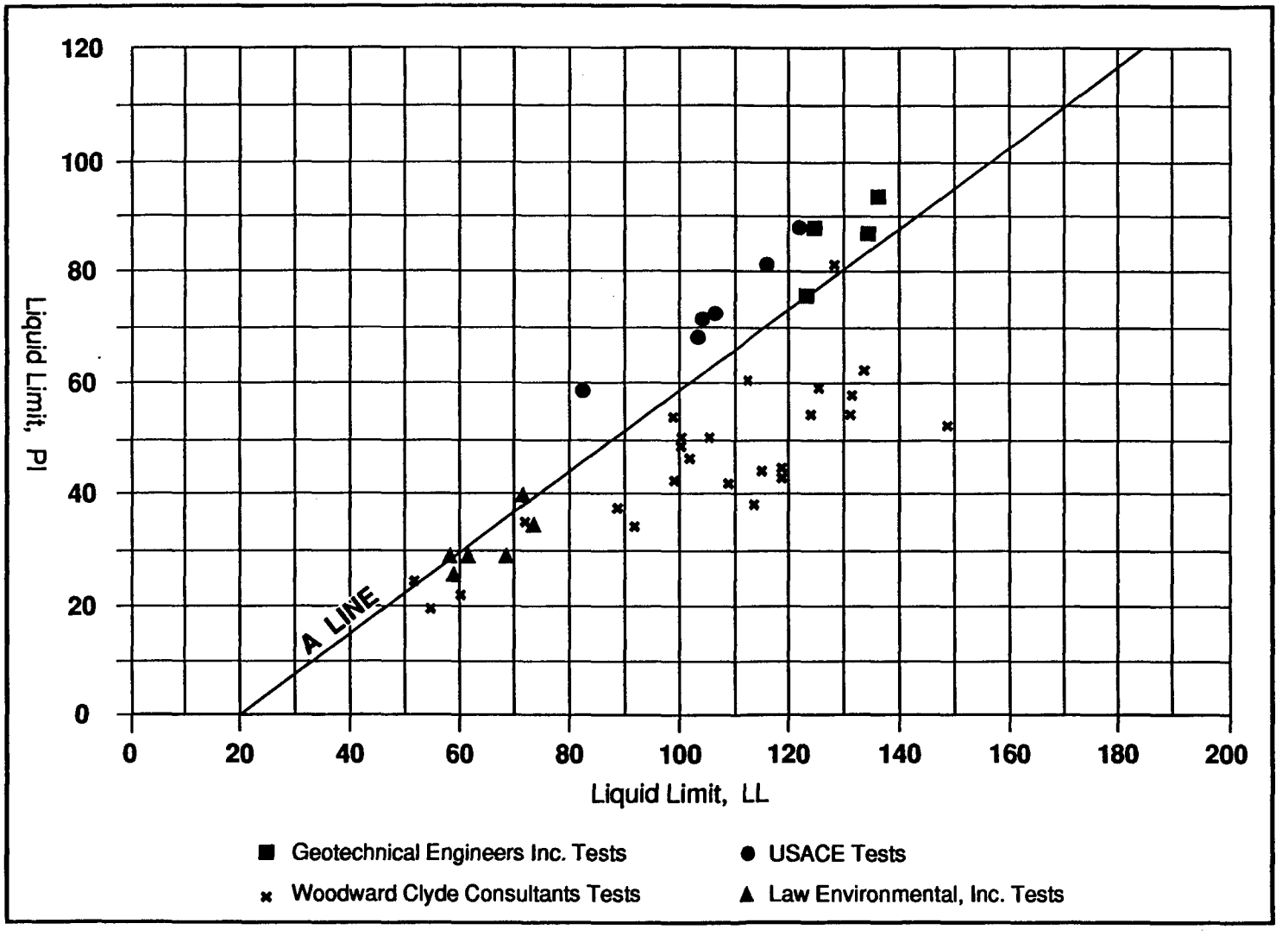


Figure 6-8 Plasticity Comparison - Organic Clay

exploration log data, experience with similar materials, and laboratory test data where available. The laboratory and field test results performed on the organic clay are summarized in Figures 6-9 and 6-10. The estimated design values used in the pre-construction stability, dredge cut, and seepage analyses are listed below.

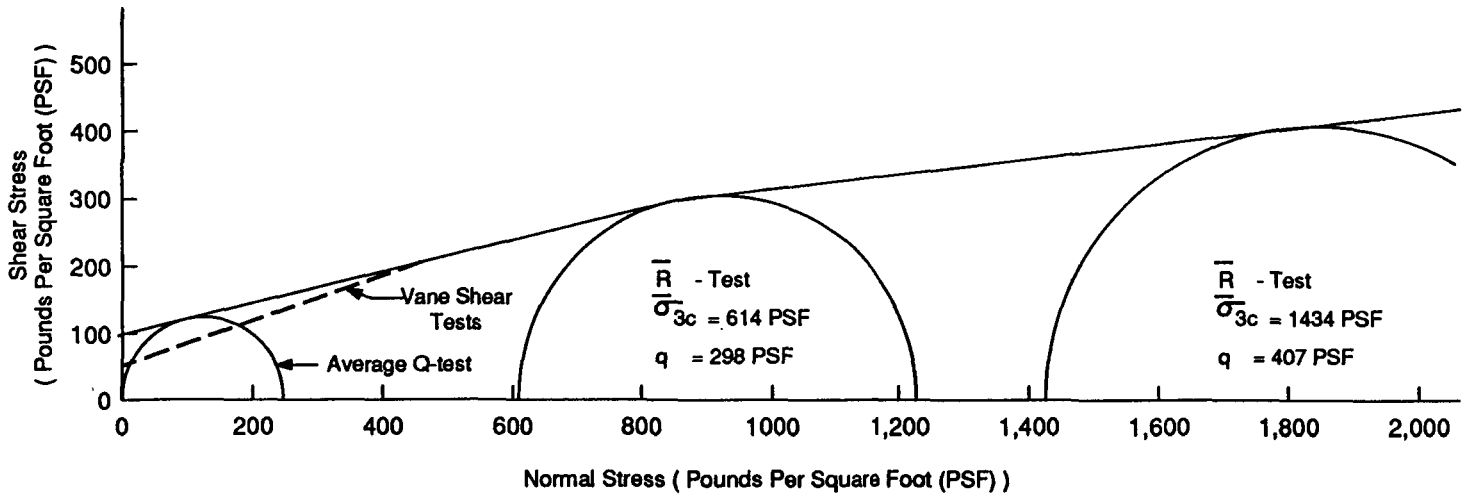
Table 6-1
Design Values

Material	Location	Saturated Unit Weight (LBS/FT)	Strength c (LBS/SF)	Strength ø (DEG)	Permeability (cm/s)
Organic Clay	Foundation	92	65-175	0	$<10^{-6}$
Sand	Foundation	120	0	30	10^{-2} to 10^{-3}
Granular Fill	Foundation	120	0	30	10^{-2} to 10^{-3}
Granular Fill	Embankment	110	0	30	10^{-2} to 10^{-3}
Gravel Bedding	Embankment	130	0	32	10^{-1} to 10^{-2}
Stone Protection	Embankment	120	0	35	$>10^{-1}$

Embankment Stability: The "in water" dike section shown in Figure 6-11 was chosen for stability analysis because it combined maximum embankment heights with minimum foundation strengths. The UTEXAS2 Slope Stability package and the strength values listed in the Design Value paragraph were used to analyze the End of Construction condition. The Sudden Drawdown from Maximum Pool, Intermediate Flood Stage, and Steady Seepage from Maximum Pool conditions were judged to be much less critical because it was judged that the organic clay foundation soils would gain substantial strength due to the embankment loading before filling of the dike would occur. An analysis of earthquake conditions was not judged to be necessary due to the low height of the dike, the low magnitude of earthquakes that have occurred in the vicinity of the site in the past, and the characteristics of the dike materials.

Circular and non-circular searches using the Spencer procedure were used to find the critical shear failure surface for the "in water" dike section. The initial search using one vertical on three horizontal side slopes for the dike and an organic clay shear strength which was 65 pounds per square foot (psf) at the high-strength geotextile (approximately -3 feet MLW) and increased 9 psf/foot of depth, as shown in Figure 6-10, yielded a factor of safety of 0.6. Since it was necessary to increase the factor of safety without substantially increasing the width of the dike section, reinforcement was introduced. It was found by using 50 percent of the ultimate strength (a typical value recommended for polyester) of the strongest high-strength geotextile that had been manufactured in the United States at the base of the proposed dike in the analysis that the factor of safety could be increased up to 1.7. A factor of safety from 1.1 to 1.4 was calculated using 50 percent of the ultimate tensile strength of the selected high-strength geotextile (1,667 pounds per inch ultimate tensile strength). The variation in factor of safety reflects the three available options to the user in the UTEXAS2 Slope Stability package to designate how reinforcement force will be applied. It should be noted the strength of the high-strength geotextile was reduced fifteen percent in the analysis to account for the holes punched in it during vertical drain installation.

A second analysis was performed after stage I construction on the section shown in Figure 6-12 to see if stage II construction could be safely started before the stage I primary consolidation period



Note: Vane Shear test results reflect best fit line of the tests performed before start of construction.

Figure 6-9 Shear Test Results

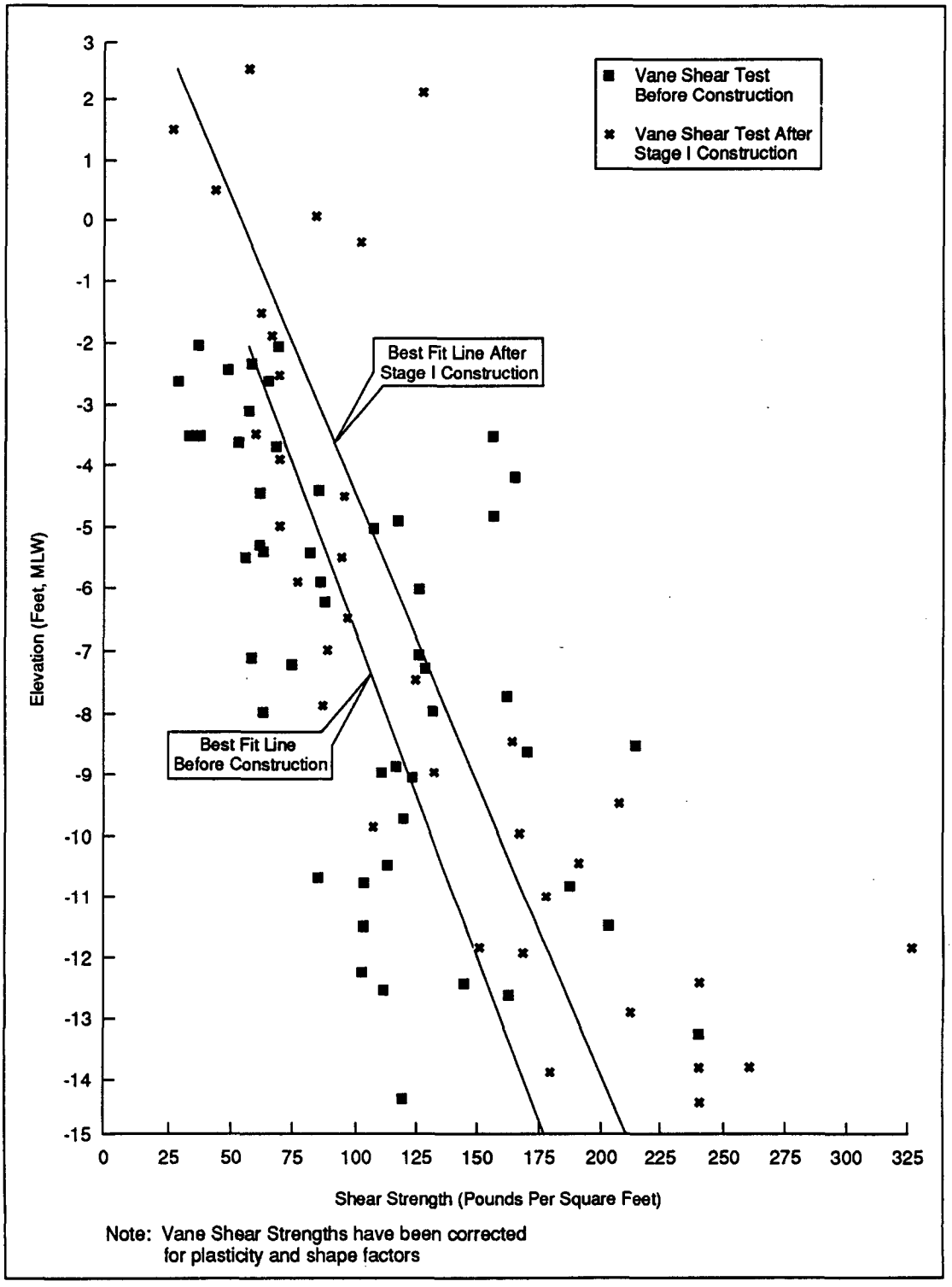
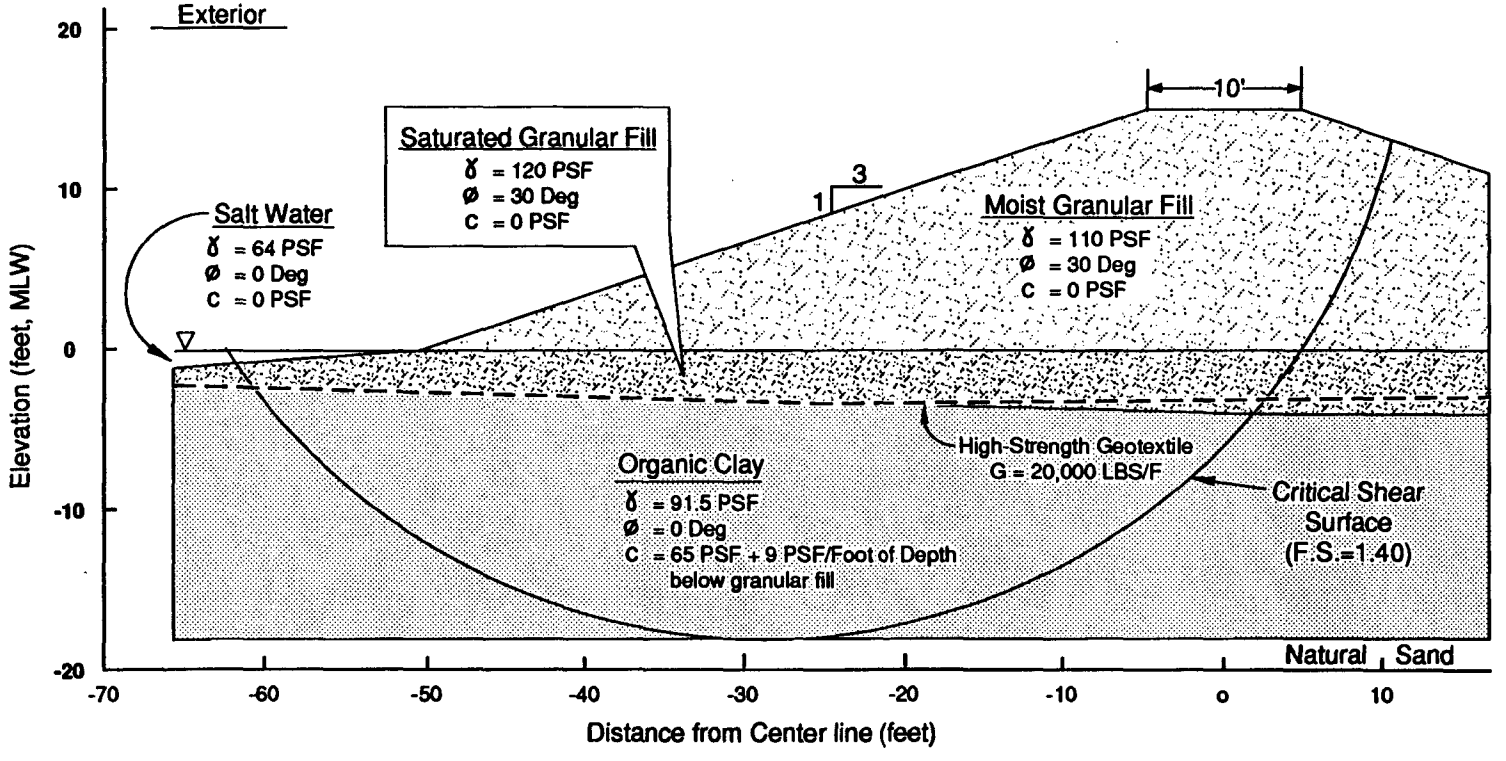


Figure 6-10 Vane Shear Test Results



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Note: Full force of high-strength geotextile was applied to base of the slice in the direction of the geotextile

Figure 6-11 Critical Shear Surface - Before Construction

ended. It was observed during vertical drain installation that the high-strength geotextile elevation varied from 3 feet MLW to -12 feet MLW instead of the approximately -3 feet MLW originally assumed. Additional vane shear tests (The results are shown in Figure 6-10.) which were performed below the in-place high-strength geotextile indicated that the strength of the organic clay was approximately 25 psf at elevation 3 feet MLW and increased 10.4 psf/foot with depth. The tensile strength of the high-strength geotextile used in the analysis was 2500 pounds per inch, which corresponded to 50 percent of the in-place high-strength geotextile's ultimate tensile strength (11). It was applied tangential to the circle or wedge at the base of the slice where the high-strength geotextile crossed the assumed failure surface. The tensile strength was reduced 30 percent to account for the orientation and size of the vertical drain holes. The net result due to the changed input was that the factor of safety decreased from 1.3 to 1.2.

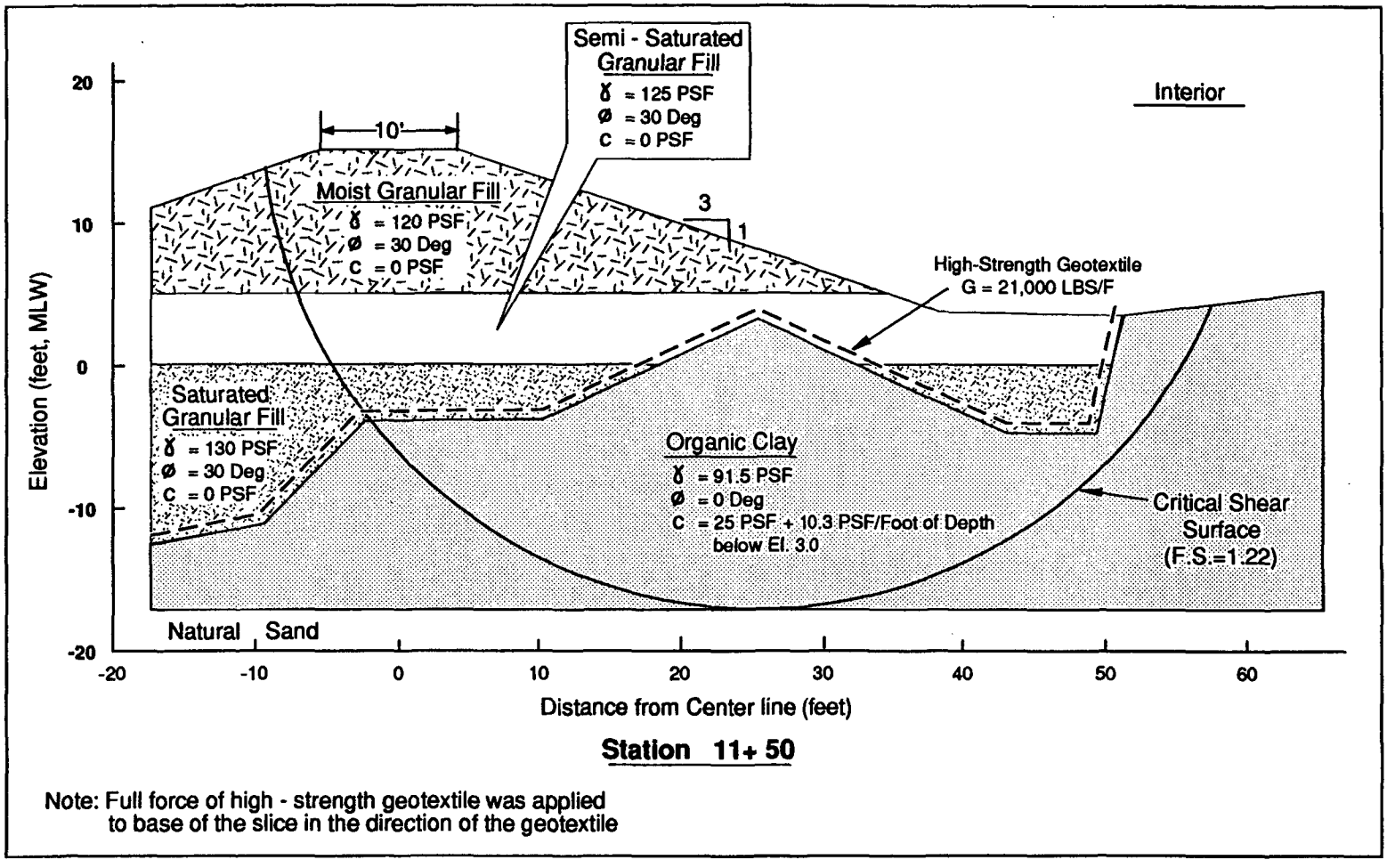
Settlement: The organic clay foundation soils described in the exploration logs and tested in the laboratory are highly compressible. A virgin compression ratio of 0.35 was selected based on one dimensional laboratory consolidation tests to perform a settlement analysis for the proposed dike section shown in Figure 6-7. The analysis indicated that the proposed dike might settle from 5 to 6 feet due to primary consolidation. A concern arose that, if the large amount of estimated settlement occurred, there might be some large cracks in the dike. Therefore, it was decided to construct the dike in two stages so cracks that developed in the base of the dike (stage I) could be repaired before the crest of the dike (stage II) was constructed. The estimated primary consolidation for each stage was still slightly larger than 2.5 feet.

Seepage Control: The design hydrostatic head for the dike is the difference between the maximum height of dredge fill (10 feet MLW) in the interior of the dike and low tide level (0 feet MLW) outside of the dike. Seepage through the dike was controlled by the relatively long seepage path through the semi-impervious dike material. Foundation seepage was controlled by the long seepage path through the impervious organic clay foundation soils. A shallow estuary side toe was not judged to be necessary nor practical to construct.

Placement And Compaction: The specified procedures for placement and compaction of dike materials for the base (stage I) of the "in water" dike were somewhat atypical. A specific fill sequence where the fill was placed in a concave shape in the direction of advancement as shown in Figure 6-13 was specified so all the wrinkles were removed from the high-strength geotextile. The initial loose lift was to be 24 to 36 inches thick followed by loose lifts 12 inches thick. Placement and compaction of the first four feet of loose fill material was to be accomplished with crawler-type tractor equipped with low ground pressure treads that exerted a unit track pressure of not more than 3.0 pounds per square inch.

The specified procedures for placement and compaction of dike materials for the "land" dike and the crest of the "in water" dike (stage II) were conventional. Loose fill material was to be placed in lifts approximately 12 inches thick. Each lift was to be placed and compacted with at least six passes of a crawler-type tractor weighing more than 25,000 pounds. Due to the nature and location of the project, requirements for restricted areas were not necessary.

Slope Protection: Coastal and hydraulic engineering analysis of wave conditions at the project site indicated that the maximum wave heights are approximately one foot. The procedures in the "Shore Protection Manual" (21) were used to calculate the minimum stone layer thicknesses and stone sizes based on the maximum wave height. The minimum stone layer thicknesses and stone sizes were relatively small so they were increased to provide protection from vandalism. The specified sections are shown on Figure 6-7.



Note: Full force of high - strength geotextile was applied
to base of the slice in the direction of the geotextile

Figure 6-12 Critical Shear Surface - After Stage 1 Construction

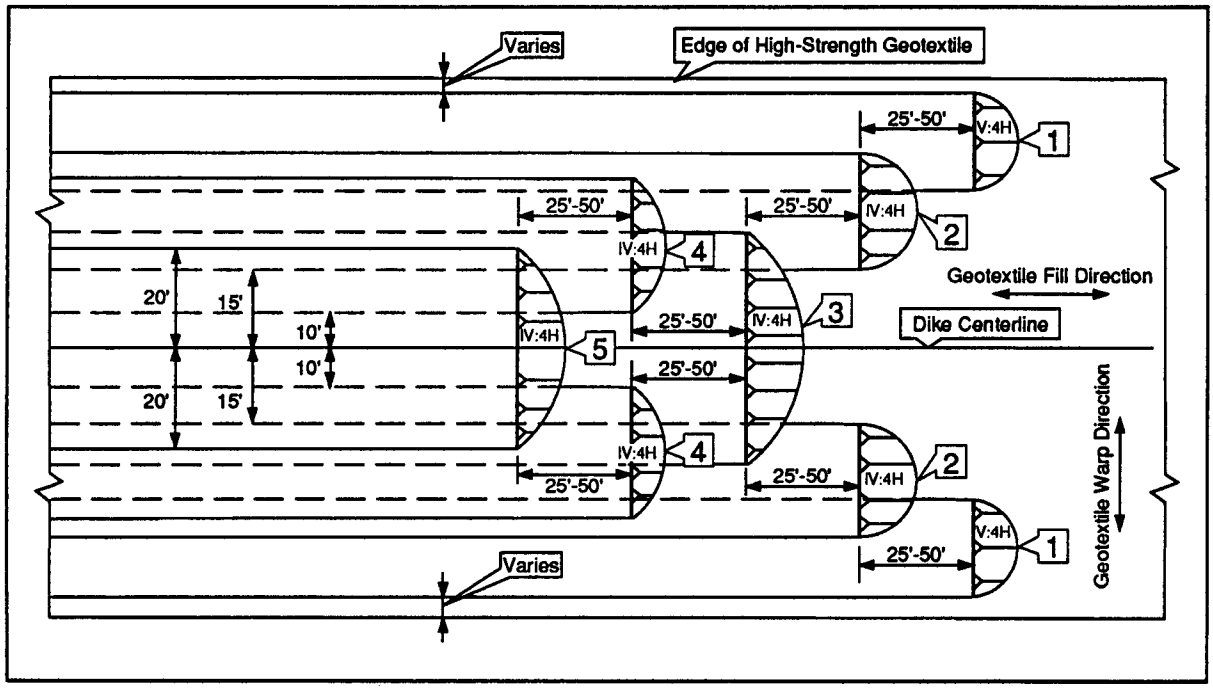


Figure 6-13 Embankment Fill Sequence

Sheet Pile Wall: A sheet pile wall was needed to separate the primary cell of the CDF from the secondary cell of the CDF rather than a dike due to space limitations. "Design and Analysis of Sheet Pile Walls by Classical Methods" (23) was used to design the sheet pile wall. The design hydrostatic head for the wall was the difference between the maximum height of dredged fill in the primary cell (10 feet MLW) and the bottom of the secondary cell (5 feet MLW). It was assumed that the dredged material would have a cohesion of 45 pounds per square foot, a friction angle of 0 degrees and a saturated unit weight of 90 pounds per cubic foot, and the sand foundation soils would have a cohesion of 0 pounds per square foot, a friction angle of 30 degrees, and a saturated unit weight of 120 pounds per cubic foot. The analysis indicated that for a Factor of Safety of 1.5, PZ-22 steel sheet piles were required, and they should be driven to elevation -13 feet MLW.

High-strength Geotextile: The purposes of the high-strength geotextile were to provide reinforcement in the proposed dike, separate the organic clay foundation soils from the granular fill embankment materials, and improve mobility of construction equipment during initial granular fill placement. The guidance in the draft "Engineering Use of Geotextiles" (14) was used to specify the requirements of the high-strength geotextile. The ultimate tensile requirements of the high-strength geotextile in the warp direction were previously discussed in the Embankment Stability paragraph. The bearing capacity considerations due to the use of the high-strength geotextile are discussed in the Bearing Capacity paragraph below. In addition, the pullout resistance, sliding failure resistance and tensile requirements in the fill direction of the high-strength geotextile were studied. It was found that at least 28 feet of embedment of the high-strength geotextile was required beyond the critical failure circle to resist pullout of the geotextile, the effective interface friction angle of the high-strength geotextile must be greater than 12.5 degrees to resist sliding of the granular fill on the geotextile, and the ultimate tensile strength and seam strength of the high-strength geotextile must be greater than 600 pounds per inch in the fill direction to resist active earth pressures and construction forces.

Sediment Control: Two different methods of controlling the sediment disturbed during the high-strength geotextile placement and "in water" dike construction operations were considered. The first method was to use an impermeable geomembrane which would extend from the top of the water column down to a point approximately two feet above the estuary bottom. The geomembrane would be supported by driven wood poles or steel pipes. The second method was to use a permeable geotextile which would extend from the top of the water column to the estuary bottom. The geotextile would be supported by moveable floats and wood poles, if necessary, and the bottom of the geotextile would be anchored with weights. The second method was selected because the geotextile could be moved more easily and it was feared that the sediments which were stopped by the impermeable geomembrane needed for the first method would fall to the estuary bottom and then be carried past the geomembrane by the tidal currents.

Vertical Drains: The estimated consolidation period without vertical drains was from 15 days to 150 days for both Stage I and II "in water" dike construction. Coefficients of Consolidation from 0.273 feet squared per day to 2.73 feet squared per day which were obtained from laboratory test results were used to calculate the consolidation periods. Shorter consolidation periods were needed to meet the project schedule so vertical drains were considered. The procedures in "Designing with Geosynthetics" (10) were used to calculate consolidation times for various vertical drain spacings. The estimated consolidation periods were from 3 days to 30 days with the selected vertical drain spacing of five feet.

Environmental: A preliminary judgement was made that the proposed project would not adversely impact the geology, topography or soils in the project area. The following concerns were raised: the proposed dredging and "in water" dike construction activities would elevate the PCB lev-

els in the estuary water column and other parts of the estuary bottom, surface water runoff would erode significant amount of fill in the soccer field area before grass was established, and PCBs would leach through the unlined dike. A sediment fence was specified around the dredging and "in water" dike construction areas to reduce migration of PCBs in the estuary water column and into other parts of the estuary bottom. Hay bale barriers were specified around the soccer field area to retain soil eroded by surface water runoff while grass was being established. A monitoring system was set up to determine whether PCBs were leaching through the unlined dike. A bentonite slurry cut-off trench was envisioned as the contingency plan if it was found that leaching was a problem.

Access: Access to the project is good. Land vehicles can access the south side of the project site along Sawyer Street. Small boats and barges can access the east and north sides of the project site from the Acushnet estuary.

Construction Sequence: A construction sequence was developed to construct a safe dike as well as to minimize the construction time. An outline of the basic steps follows:

1. Construct the north and south legs of the stage I "in water" dike before constructing the east leg of the stage I "in water" dike.

2. Place high-strength geotextile immediately prior to placement of granular fill along each leg of the stage I "in water" dike.

3. Place and compact the granular fill for each leg of the stage I "in water" dike using the fill sequence shown in Figure 6-13.

4. Allow the stage I "in water" dike to consolidate until the rate of settlement and pore pressures subside.

5. Construct the north, south and west legs of the "land" dike using conventional fill procedures while stage I "in water" dike is consolidating.

6. Place and compact the fill for each leg of the stage II "in water" dike using conventional fill procedures.

7. Allow the stage II "in water" dike to consolidate until the rate of settlement and pore pressures subside.

8. Place gravel bedding and stone protection on the "in water" dike (stage III construction).

Bearing Capacity: The predicted bearing capacity factor of safeties were approximately one for stage I construction and below one for stage II construction using classical theories. Recent theories involving plasticity concepts (9) for use with high-strength geotextiles were studied and applied to the proposed dike section. The reevaluated bearing capacity factor of safeties were greater than one for both stage I and II construction.

Weirs: Two variable weirs were needed in the CDF during dredging operations. The larger weir was situated at the south end of the sheet pile wall and allowed water to pass from the primary cell to the secondary cell. It could be adjusted between elevation 6 feet MLW and elevation 10 feet MLW using a stop log type structure. The smaller weir was situated in the northeast corner of the secondary cell and released water back into the cove. It could be adjusted between elevation 5 feet MLW

and elevation 9 feet MLW using a stop log type structure.

Instrumentation: Settlement plates, piezometers, stability poles, and inclinometers were specified to monitor dike settlement and stability. Monitoring wells were specified to monitor possible flow of PCBs and heavy metals through and below the dike. Strain gages were designed and installed by Waterways Experiment Station on the east leg of the high-strength geotextile to monitor high-strength geotextile elongation. The monitoring instruments were modified to resist deterioration due to exposure to PCBs and heavy metals to the extent practicable. The locations of the proposed monitoring instruments are shown in Figure 6-5. Details of the monitoring instruments are shown in Figures 6-14 to 6-18.

Dredge Cuts: The specified dredge cuts for the pilot study were studied using the UTEXAS2 Slope Stability package (24), slope stability charts (25), and the guidance of Dr. Jack Fowler (Waterways Experiment Station). The shear strengths shown in the Design Value paragraph were used in the analysis. The slope stability package and slope stability charts indicated that dredge cuts as steep as 1 vertical on 2 horizontal would be safe. However, Dr. Fowler felt that due to disturbance to the organic clay caused by the proposed dredging operations, and his observations of dredge cuts on similar materials that a more realistic dredge cut slopes were in the 1 vertical on 3 horizontal to 1 vertical on 5 horizontal range. Since the nature of the project was experimental, dredge cuts with 1 vertical on 3 horizontal slopes were specified. Provisions to flatten the dredge cuts were made in case the 1 vertical on 3 horizontal slopes were unsafe. In addition, it was specified to step the dredge cuts and allow them to slough in order to reduce the disturbance of the dredging operations.

CONSTRUCTION

Demolition: Demolition was required along the proposed "land" dike and steel sheet pile alignments where reinforced concrete foundations and one smoke stack foundation existed. Large pieces of the reinforced concrete foundations were broken up with a pneumatic jack hammer which was attached to the arm of a hydraulic excavator. Once the foundations were reduced to reasonable sized pieces, they were loaded on trucks with a Koehring 666 hydraulic excavator and placed in the on site berms. Work progressed smoothly except for removal of the smoke stack foundation which required an extreme amount of effort, because it was quite massive and it had a large amount of steel reinforcement in it.

Sheet Pile Installation: Existing foundations were removed along the steel sheet pile alignment as described in the Demolition paragraph. The steel sheet piles were then driven into the natural sands with a vibratory pile driving hammer. The steel sheet piles were driven very easily and no difficulties or obstructions were encountered during the driving operations according to Construction Division representatives. Records of the driving operations, driving equipment, templates used, protective caps used (if any), driving equipment performance data, top and bottom elevations and pile penetration rate which required contractor submittals are not available.

Sediment Control: The contract specifications required that the contractor submit a sediment fence design for approval, then fabricate and maintain the fence during construction of the "in water" dike. The purpose of the fence was to reduce the flow of sediments into the estuary which were disturbed during the high-strength geotextile installation and placement of dike fill operations. Figure 6-19 is a cross section of the sediment fence which was used. It performed exceptionally well (no major delays due to sediment migration or interference with construction activities).

High-strength Geotextile Testing: Three sets of laboratory strength tests were executed on the high-strength geotextile which was delivered to the project site (5) (6) (11). The test results are in-

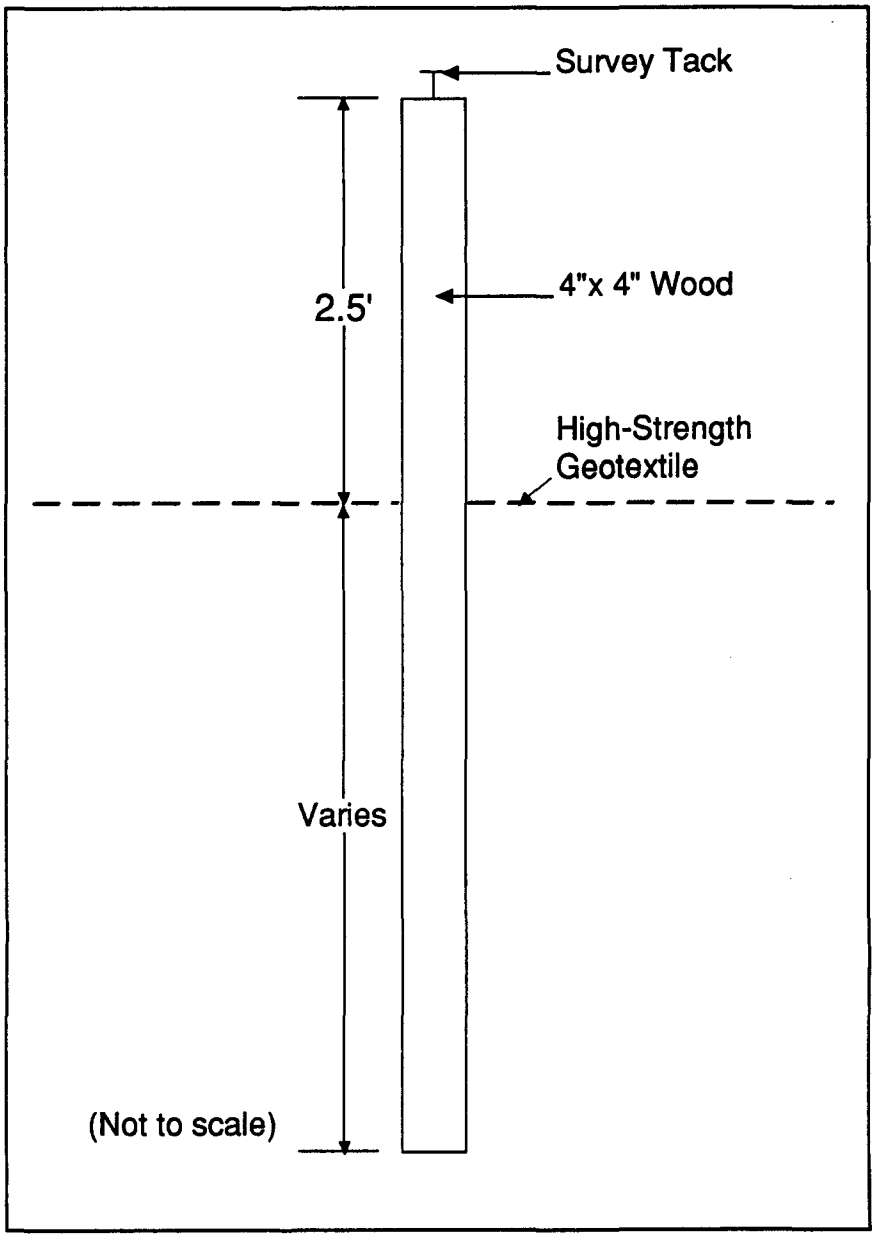


Figure 6-14 Typical Stability Pole

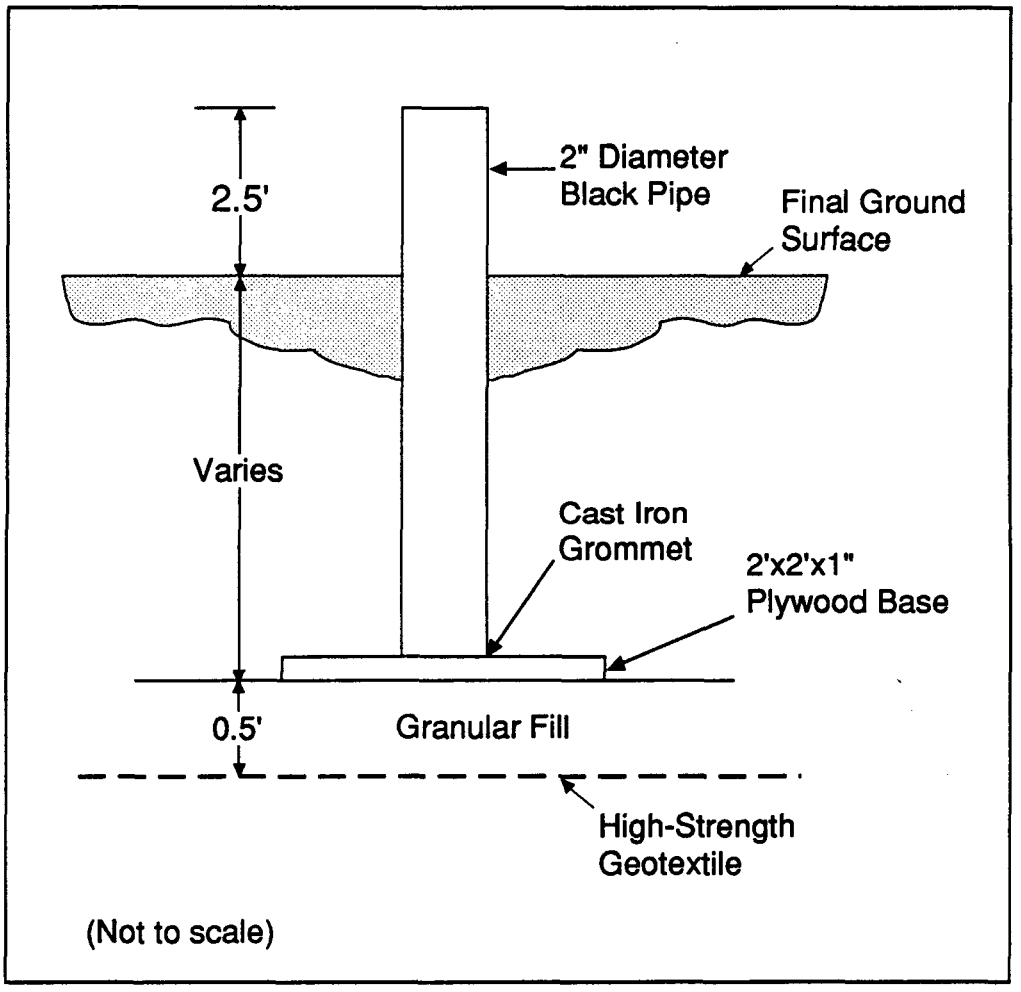


Figure 6-15 Typical Settlement Plate

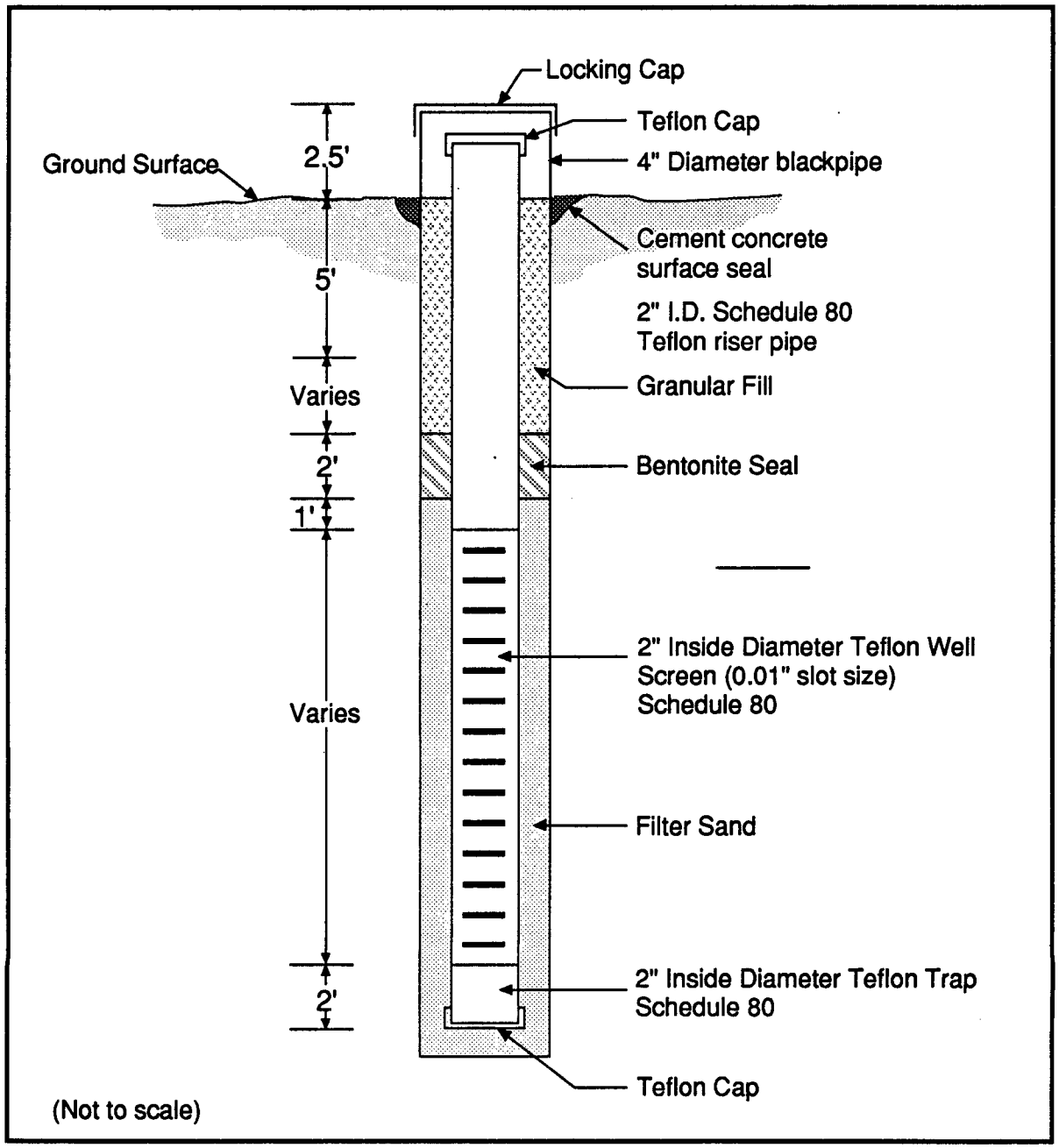


Figure 6-16 Typical Monitoring Well

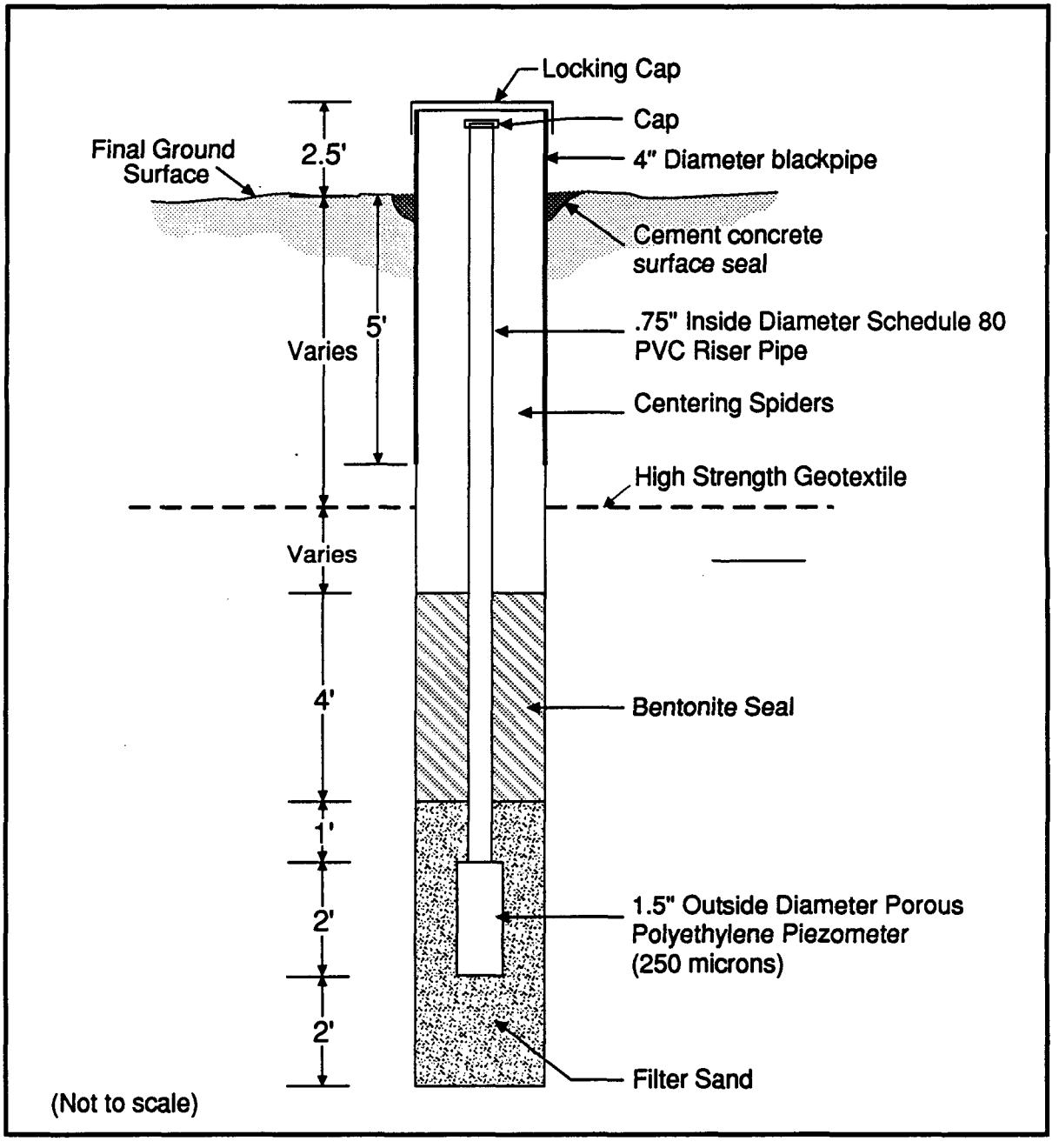


Figure 6-17 Typical Piezometer

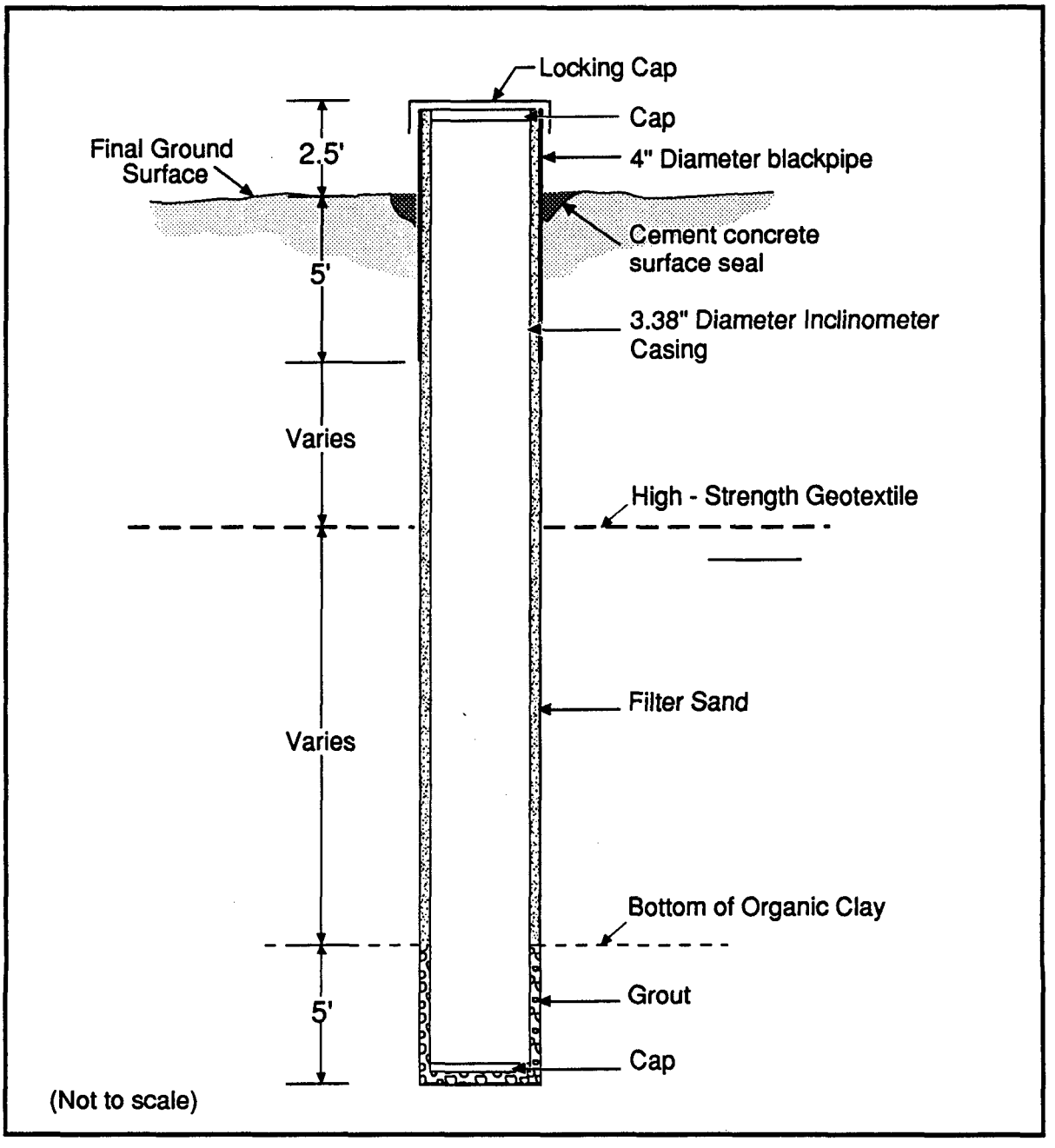


Figure 6-18 Typical Inclinometer

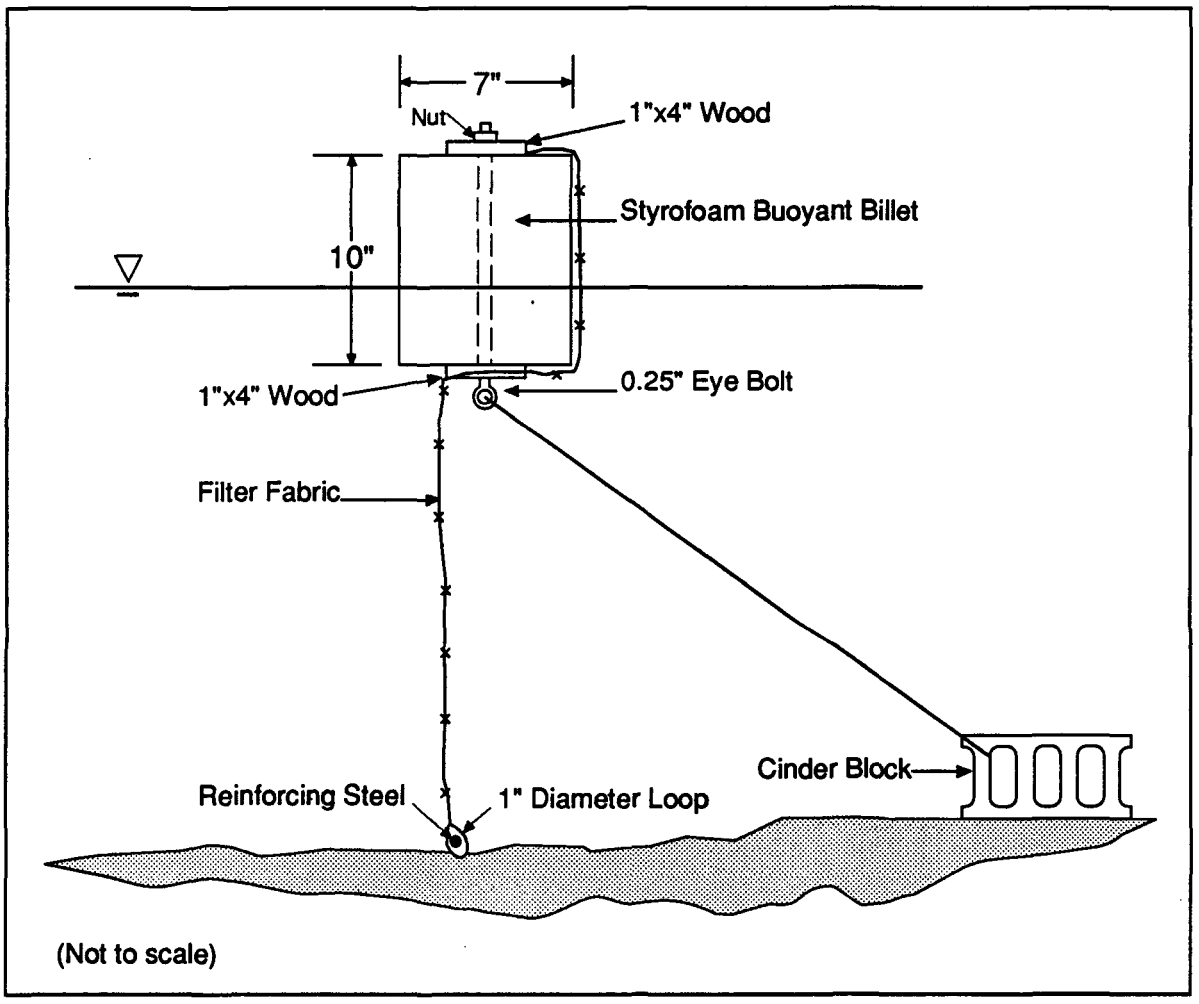


Figure 6-19 Sediment Fence Section

cluded in Appendix 6-C. The high-strength geotextile tested consisted of 100 percent polyester tenacious yarns that were woven by Nicolon Corporation in the United States. Approximately 26 yarns per inch and 4 yarns per inch were measured in the warp and fill directions, respectively. It weighed 65 ounces per square yard. Using ASTM D-4595, it was determined that the high-strength geotextile's ultimate tensile strength was about 5,000 pounds per inch and 1,150 pounds per inch in the warp and fill directions, respectively. Tear developed at 10 to 15 percent elongation. The secant modulus of the high-strength geotextile at 5 percent elongation was about 50,000 pounds per inch and 11,500 pounds per inch in each of the principle directions. The individual panels of the high-strength geotextile were sewn together with a "butterfly" type seam which has an ultimate tensile strength of approximately 700 pounds per inch (14).

Chemical compatibility tests were performed on samples of the high-strength geotextile during construction of the dike (5). The test results are included in Appendix 6-C. The samples of the high-strength geotextile were immersed in a slurry of Acushnet River bottom sediments and seawater for periods of 30, 60, and 120 days. The slurry had a PCB concentration of approximately 500 parts per million and was maintained at 23 degrees celsius. Tests on the immersed samples were compared to a control sample which was not immersed. The average ultimate tensile strength, secant modulus at five percent strain, and strain at failure of the immersed samples at 120 days were 15.1 percent, 10.2 percent, and 31.5 percent less, respectively. Most of the reduction in test values was noted in the first 30 days.

Strain Gage Installation: Fifty-two strain gages were attached by Waterways Experiment Station personnel to a panel of the high-strength geotextile at Nicolon's plant in Georgia (13). Gages type EP-08-40CBY-120, manufactured in the United States by Micro-Measurements Division, were used. Their nominal length is four inches. The following is a step-by-step procedure which was used to attach the gages to the high-strength geotextile:

1. The high-strength geotextile was rolled out in a building onto a flat surface and the gage locations were laid out on five foot and three foot spacings, respectively. Each gage location was offset about six inches transverse to the longitudinal axis of the high-strength geotextile roll starting from the centerline of the proposed embankment. This precaution was taken so that if high-strength geotextile yarns were inadvertently damaged only a minimum number of gages would be lost.

2. The gages were oriented parallel to the alignment of the warp and fill yarns. Each location had gages in the warp direction and every other location had gages in the fill direction. This was accomplished by positioning the fabric so that the warp and fill yarns were perpendicular to each other. A steel straight edge and felt tip pen were used to mark the desired gage alinement.

3. A 3/8-inch diameter bead of silicone, made by Teroson GmbH, West Germany, called 33 Silicone Sealant, was first applied to the high-strength geotextile at the desired gage location and orientation. The strain gage and terminal strip was placed on this bead with a pair of tweezers. A strip of teflon, two inches by seven inches, was placed over the gage and carefully smoothed with one's fingers, keeping it in alignment with the fabric yarns.

4. A flat smooth plywood block, two inches by seven inches, was placed over the Teflon covering both the strain gage and terminal strip. Weights varying from 20 pounds to 100 pounds were placed on the plywood strip for a curing time of about 5 to 10 minutes. The curing time is controlled by the amount of moisture in the air. The weights force the silicone bead to spread out. The magnitude of weight depends on the high-strength geotextile thickness. The thicker and heavier high-strength geotextiles require larger weights to force the silicone into

the high-strength geotextile. The silicone does not cement itself to the high-strength geotextile yarns but is held by impregnation into the high-strength geotextile structure. This impregnation acts simply as a small foot print with little stubs of silicone penetrating the high-strength geotextile. Most high-strength manufacturers apply a light manufacturing lubricant to the yarns to facilitate the weaving process and this prevents the silicone from adhering to the high-strength geotextile yarns. Attempts to completely remove the lubricant failed.

5. The strain gage and terminal strip were wired and soldered together leaving a small two inch loop of wire for strain relief between the gage and the terminal. An eight-inch pigtail consisting of two 18 gauge stranded wires and a piece of shrink tubing about four inches long and 1/4-inch diameter was connected to the terminal strip. A heat gun was used to shrink the tubing at the terminal leaving two four-inch long wires exposed. The pigtail was oriented in a direction perpendicular to the long axis of the gage to provide strain relief. The pigtail was tied down with a self locking plastic tie.

6. The wire terminal, wires, and shrink tubing were carefully cleaned with nonresident free solvent TF or Isopropyl alcohol to remove any finger prints, oil, and soldering residue. Before waterproofing the gaged area, the gage was checked for continuity, and all solder joints were checked for soundness.

7. Waterproofing was accomplished by placement of about 4 to 5 beads of silicone (1/4-inch diameter) in the longitudinal axis of the strain gage and terminal strip. A strip of Teflon, two inches wide and seven inches long, was placed over this area, and the silicone was smoothed out to prevent any voids or air pockets inside the waterproofing cover. The cover was formed to a thickness of about 1/4-inch to 3/8-inch above the strain gage and terminal strip. The silicone was carefully placed around the terminal strip wires and about two inches of the shrink tubing. The silicone should be tapered or flared out only over the original area of silicone that spread out when the weights were applied to the strain gage. Otherwise, the additional silicone will have a tendency to peel off the fabric. This entire operation of placing the strain gage, wiring the strain gage, and placement of the water proofing layer should be accomplished as soon as possible, preferably in a 4 to 8 hour period. If this is not done, cold joints may develop between the first and second layer of silicone, and the second layer may peel off during fabric shipment and installation.

8. It generally requires about 2 to 4 hours for the waterproofing layer to cure at which time the gage continuity is checked again. The exposed wire ends of the pigtail are clipped off and dipped in the silicone to protect them from absorbing moisture during subsequent sewing and shipping operations.

9. The pigtail wires are stripped back at the site and the strain gages are checked to see if they survived the sewing and shipping operations. All the strain gages were functioning properly. Prior to soldering 1/4-inch diameter Belden four conductor cables to the strain gages, an eight-inch long by 3/8-inch diameter piece of shrink tubing was placed over the cable. After the cables were soldered and taped, the shrink tubing was placed over the original 1/4-inch diameter shrink tubing and cable splice, and it was shrunk using a heat gun. Then the cables were wired and the exposed ends were protected with a pile national pipe enclosure to prevent moisture from entering the cable ends.

10. Once the high-strength geotextile had been placed in the final designed position and approximately three feet of fill had been placed on it, the cable ends were threaded through six-inch diameter PVC pipes. The pipes were attached in a vertical position to steel scaffolds that were constructed to an elevation higher than the proposed dike. Finally the excess cable

was cut and the cable ends were attached to multiple dial switches so that the gages could be rapidly read.

High-strength Geotextile Installation: Individual panels (15 feet wide), including the strain gage panel, of high-strength geotextile were sewn together to form three segments (the north, east, and south legs of the "in water" dike) at Nicolon's plant. The seams were sewn with a high-strength polyester thread using a double needle sewing machine. Each segment was folded in "accordion" fashion at the plant and shipped by truck to the project site.

The leading edge of each folded segment was attached to a 12 inch diameter by approximately 400 foot long PVC pipe with nylon ropes at the site. Larger nylon ropes were attached to the pipe and threaded around a cathead. The cathead was mounted on an anchored spud barge which was situated in the Acushnet River Estuary several hundred feet ahead of the leading edge of the high-strength geotextile segment being installed. Each segment of the high-strength geotextile was pulled in place by engaging the larger ropes alternately with the cathead.

The high-strength geotextile installation procedure worked well except for the east segment of the "in water" dike. Apparently the contractor had difficulty pulling the folded high-strength geotextile segment into place because one-half of the east segment became unfolded and twisted. When the contractor attempted pulling the unfolded and twisted segment using the method described above, portions of this segment ended up as much as 20 feet from the required location. The contractor spent two days pulling cables he had attached to the edges of the high-strength geotextile with the cathead on the spud barge and several different types of land based vehicles to pull this segment to the specified location. Several tears up to 10 feet developed along the edges of the high-strength geotextile during the repositioning operation.

"In Water" Dike Construction: Stage I "in water" dike construction started 23 June 1988 on the north leg of the proposed dike immediately after installation of the high-strength geotextile segment. A light gray, fine to coarse sand with 15 to 20 percent silt was pushed from the land with approximately 4.6 pounds per square inch ground pressure dozers in approximately a four foot lift. The leading edge of the fill was advanced forming a concave shape in the direction of the fill. At the start, the outer edges (approximately 75 feet right and left of the dike centerline) of the initial lift of dike fill proceeded the central portion by approximately 100 feet. It was found that approximately a 30 foot difference between the outside edges and central portion of the initial lift of granular fill worked best, as fill placement progressed. A mud wave formed around the granular fill which reached approximately four feet in height and 60 feet in width at the completion of the north leg of the "in water" dike on 27 June 1988 (three working days).

Stage I construction of the south leg of the proposed "in water" dike started 7 July 1988. Granular fill was pushed eastward with one dozer that had a contact pressure of approximately 2.6 pounds per square inch. The initial lift thickness was maintained at approximately two feet. Five working days later stage I construction of the south leg was complete. It was found that the mud wave which developed around the south leg was smaller than the north leg (1.5 feet in height and 30 feet in width versus 4 feet in height and 60 feet in width) and the amount of granular fill used per foot of the south leg of the "in water" dike was approximately 60 percent less than per foot of the north leg of the "in water" dike as shown in Figure 6-20. The differences could be attributed to the fact that the specified construction procedures and low ground pressure equipment were used to construct the south leg.

Stage I construction of the east leg of the "in water" dike started 27 July 1988 and ended 5 August 1988. The following construction practices which were not in compliance with the project plans and

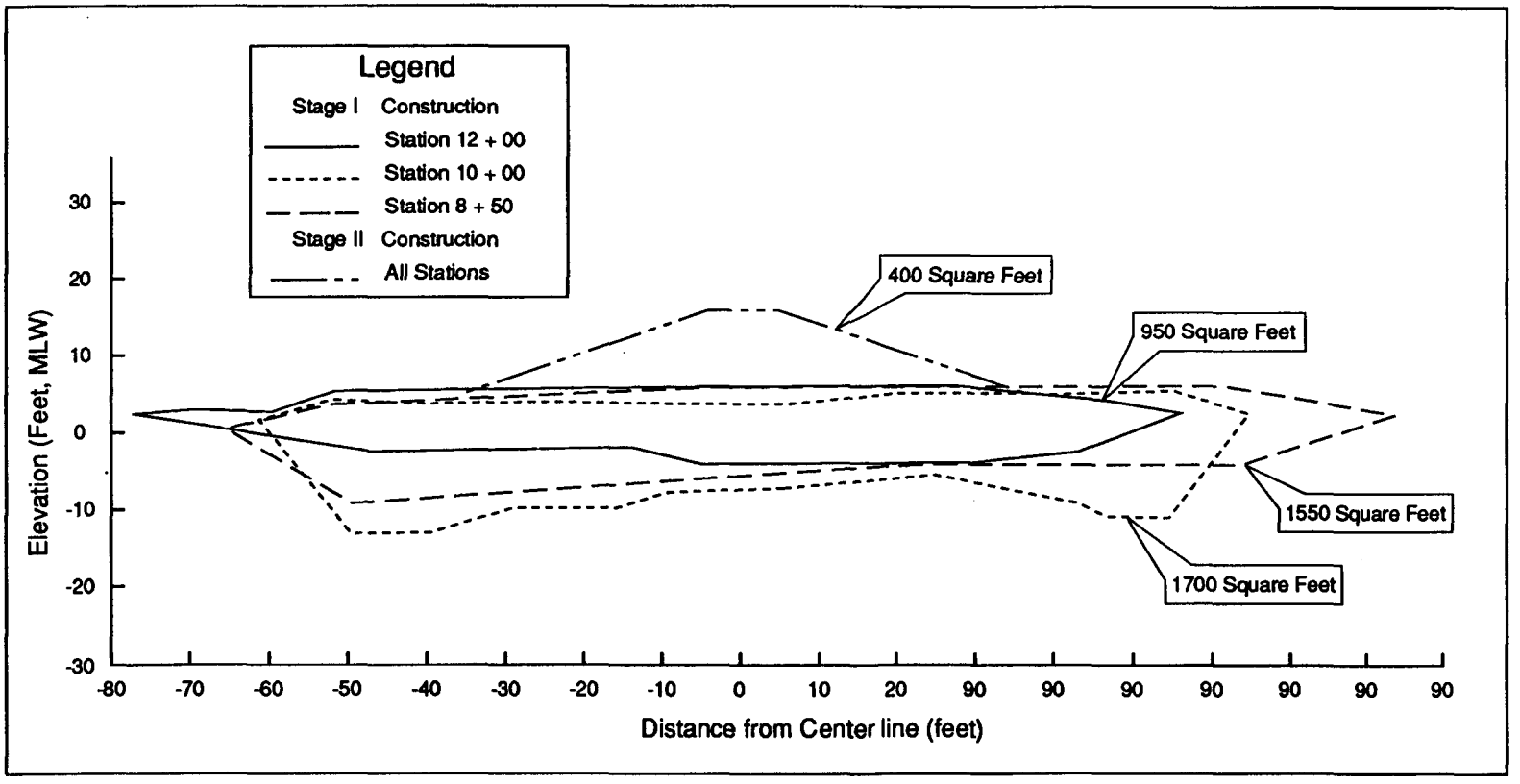


Figure 6-20 Fill Section Comparisons

specifications occurred: equipment with contact pressures greater than three pounds per square inch was extensively used to place the first four feet of granular fill, the leading outside edges (approximately 75 feet right and left of the dike centerline) of the granular fill were not placed concurrently to balance the loads on the high-strength geotextile, the initial lift of granular fill was frequently greater than three feet, back dumping of trucks at the leading edge of the granular fill was permitted throughout the work, and equipment was frequently allowed to operate directly on the high-strength geotextile. The following problems were attributed to the construction practices: the west edge of the high-strength geotextile segment was pulled approximately 50 feet out of position, an approximately 15 foot long transverse tear developed along the west edge of the high-strength geotextile segment about 15 feet south of the strain gage panel, placement of granular fill directly on the organic clay was required along the west edge of the high-strength geotextile segment, mud waves up to 10 feet high developed during granular fill placement, and mud waves up to six feet high and 75 feet wide remained to the east and west of the leg after completion of stage I granular fill placement. A comparison of typical "as built" sections of the in water dike is shown in Figure 6-20.

Stage II granular fill placement and compaction of the in water dike was accomplished in November 1988 and December 1988 with a standard ground pressure dozer. Occasionally water had to be added to the granular fill to reduce dust which emanated during the placement and compaction operations. Stage II "in water" dike construction proceeded according to schedule. A soft area (approximately 2000 square feet) was observed between inclinometer MI-1A and the strain gage panel on the east leg of the "in water" dike. The soft area stabilized after three lifts of granular fill were placed and is not a cause for concern.

"Land" Dike Construction: Granular fill for the land dike was end dumped then placed and compacted with conventional construction equipment. Occasionally water was added to the granular fill to reduce dust which emanated during the placement and compaction operations. Land dike construction proceeded according to schedule and no unusual problems occurred.

Vertical Drain Installation: A subcontractor installed approximately 63,000 linear feet of vertical drains (approximately 2,700 drains) from 3 August 1988 to 8 August 1988 using the stage I embankment as a working mat. The drains extended from the top of the stage I "in water" dike, through the granular fill and organic clay, to a point approximately two feet into the natural sands. Each drain consisted of a polypropylene wick wrapped in a polypropylene geotextile sock. The drains were installed with a vibrating mandrel mounted on a specially fabricated low ground pressure (4.3 pounds per square inch) pile driving rig.

Initially, the subcontractor had problems penetrating the two layers of the high-strength geotextile at the northeast and southeast corners of the dike but overcame the problem by welding a point to the mandrel. Throughout vertical drain installation the subcontractor had problems penetrating the granular fill in areas where the granular fill was much thicker due to poor stage I construction practices. Vertical drains were not successfully installed at the following in water dike locations: the central section of the east leg (6 drains) because the rig could not work safely on the thin layer of granular fill (less than 2 feet), the west edge of the east leg (8 drains) because the top of the stage I embankment was not constructed wide enough to allow the rig access, the north leg (8 drains in random locations) because the rig could not penetrate the thick layer of granular fill, and the southwest corner of the north leg (12 drains) because an apparent obstruction was encountered.

Slope Protection: The required gravel bedding and stone protection for the "in water" dike was placed with a small dozer and backhoe. Construction difficulties were not encountered during the placement operations. A reasonably uniform appearance was achieved. However, laboratory tests performed by the contractor (two tests) and the NED materials and water quality lab (one test) indicate that the gravel bedding is finer than specified and is not reasonably well graded as shown in Fig-

ure 6-21. Erosion of the gravel bedding and dike core may occur due to the nature of the gravel bedding material placed.

Instrumentation (General): Stability poles, piezometers, settlement plates, and inclinometers were installed immediately after completion of stage I of the "in water" dike. Monitoring wells were installed immediately after completion of stage II of the "in water" dike. The locations of the instruments are shown of Figure 6-5. More detailed information about the "in-place" locations and the elevations at the time of installation of the instruments is presented in table 6-2 below. Additional installation information is contained in the following paragraphs.

Table 6-2 Instrumentation Details

TYPE AND DESIGNATION	STATION	RANGE	APPROXIMATE ELEVATION (MLW)	
Wells			Bottom of Borehole	Top of Screen
MW-A	3+00	8'L	-4.5	2.5
MW-B	10+01	110'R	-6.5	-0.5
MW-C	10+01	105'R	-2.0	5.0
MW-D	11+01	7'L	-12.0	-5.0
MW-E	11+01	10'L	-3.0	4.0
MW-F	6+16	7'L	-3.0	4.0
MW-G	15+66	7'L	-3.0	4.0
Piezometers				
MP-1	8+66	7'L	-16.0	
MP-2	9+4	7'L	-15.0	
MP-3	11+01	7'R	-15.5	
MP-4	12+41	7'L	-14.0	
MP-5	13+26	7'L	-13.0	
Inclinometers				
MI-1A	10+10	7'L	-24.5	
MI-2	12+16	7'L	-24.0	
Stability Poles			Top of Pole	
MS-1	8+66	55'L	6.2	
MS-2	8+66	55'L	6.4	
MS-3	9+66	45'L	6.3	
MS-4	11+01	45'L	7.7	
MS-5	11+01	40'R	6.3	
MS-6	12+41	55'R	8.1	
MS-7	12+41	40'L	7.7	
Settlement Plates			Bottom of Plate	
SP-1	8+56	7'L	-1.1	
SP-2	9+71	7'L	-0.5	
SP-3	11+06	7'R	-0.4	
SP-4	12+36	7'L	-0.3	
SP-5	13+31	7'L	-1.1	

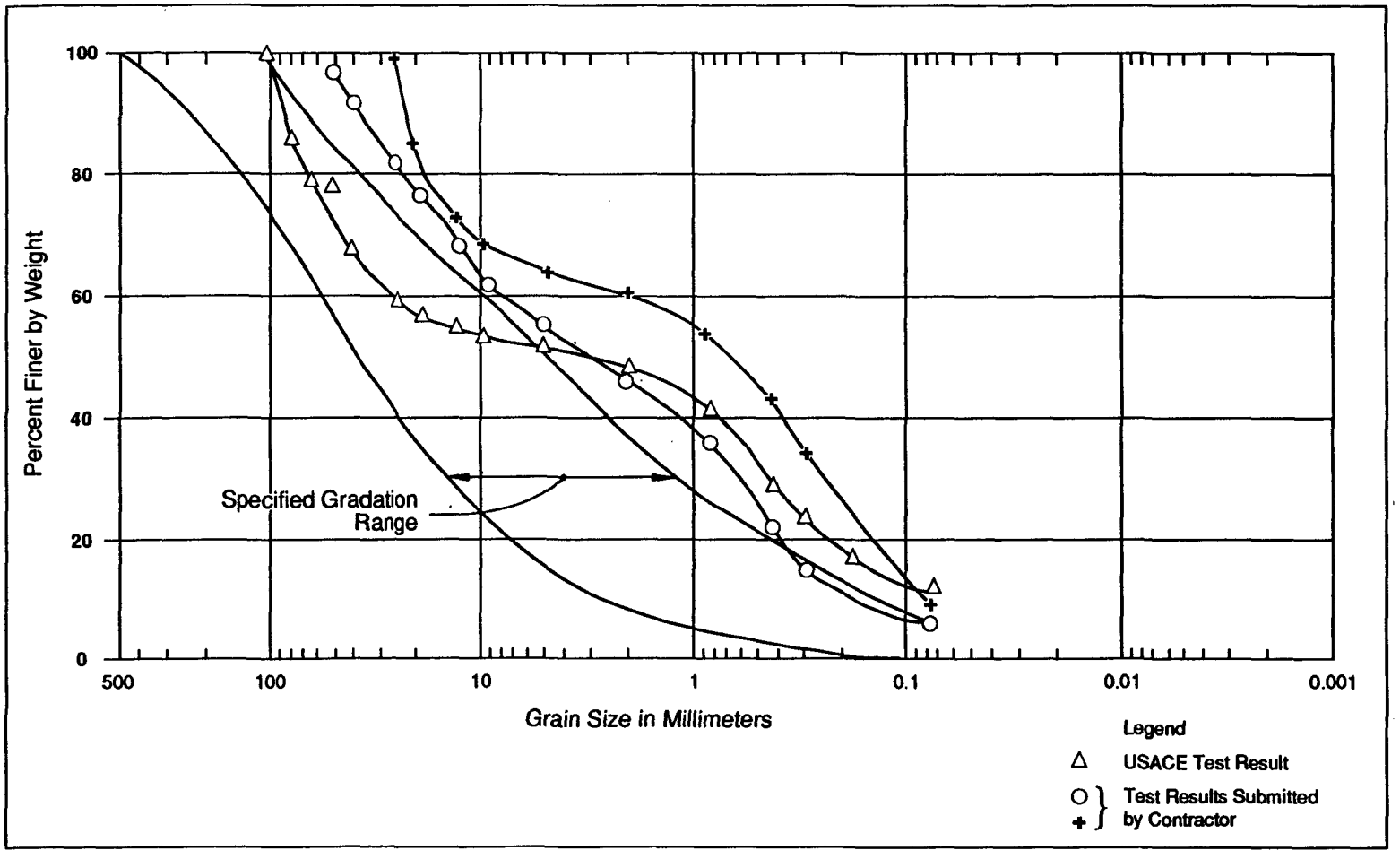


Figure 6-21 Gravel Bedding Gradations

Stability Pole Installation: A subcontractor installed seven 4-inch by 4-inch by 16-foot stability poles 17 August 1988 with the aid of a drill rig. A typical stability pole is shown in Figure 6-14. The stability poles are approximately eight feet longer than specified. Four of the offsets of the poles are different than specified. The use of a drill rig, additional length of the poles, and changes in the offsets apparently were modifications made by the contractor. Apparently, the contractor thought they were needed because the stage I in water dike cross section differed considerably from what is shown on the plans due to his poor stage I construction practices.

Settlement Plate Installation: Settlement plates were installed on 29 June 1988 (SP-1), 12 July 1988 (SP-5), and 9 August 1988 (SP-2, SP-3 and SP-4). In each case, a 6-inch leveling course of granular fill was placed at the proposed settlement plate location. Then, the plate assembly as shown in Figure 6-15 was placed on the leveling course. Finally, additional granular fill was placed on and around the plate to stabilize it.

Well Installation: Seven observation wells were installed 8 November 1988 to 10 November 1988 by a subcontractor. Each well consisted of a two-inch inside diameter schedule 80 teflon trap, well screen and riser pipe. A typical well detail is shown in Figure 6-16. Observation well installation was observed on a part time basis by a representative of the contractor rather than a full time basis by a qualified engineer as specified. Apparently no problems were encountered during observation of well installation.

Piezometer Installation: A subcontractor installed five piezometers from 18 August 1988 to 23 August 1988. Each piezometer consisted of a porous polyethylene tip and a 3/4-inch inside diameter schedule 80 PVC riser pipe. A typical piezometer detail is shown in Figure 6-17. Piezometer installation was observed on a part time basis by a representative of the contractor rather than a full time basis by a qualified engineer as specified.

The subcontractor had problems installing the seal for piezometer MP-3. He attempted to lift the bottom of the casing approximately 0.5 feet above the previously installed sand filter and then dump bentonite pellets down the annular space between the casing and riser pipe to form the seal. Approximately two feet of organic clay blew into the bottom of the casing before the bentonite pellets could be dumped. The subcontractor attempted to pull the casing but was unsuccessful. He was successful in completely washing the hole out and installing the seal with non-stick bentonite balls. The non-stick bentonite balls allowed the subcontractor to dump the bentonite balls down the annular space before pulling the casing. Unfortunately, the elevation of the piezometer dropped approximately one foot during the washing operation which indicated that the sand filter could have been damaged. Therefore, piezometer MP-3 was read more frequently after installation to determine whether it was functioning properly, which it appears to be doing.

Inclinometer Installation: Two inclinometers were installed by a subcontractor 23 August 1988 to 26 August 1988. A typical inclinometer detail is shown in Figure 6-18. Inclinometer installation was observed on a part time basis by a representative of the contractor rather than on full time basis by a qualified engineer, as specified.

The installation of inclinometer MI-2 went well except for the removal of the last ten feet of flush joint casing. The subcontractor attempted to place sand backfill in the annular space between the inclinometer casing and the flush joint casing too quickly. Some of the sand got jammed between the inclinometer casing and the flush joint casing. The flush joint casing could not be pulled without also pulling the inclinometer casing, so water pressure was applied in the annular space. The water forced the jammed sand out the bottom of the annular space and up the outside of the flush joint casing. Then, the flush joint casing was pulled and sand backfill was placed around the inclinometer

casing at a slower rate. It did not appear the application of water pressure damaged the inclinometer casing.

Inclinometer casing MI-1 twisted approximately 40 degrees out of line during removal of the flush joint casing around it. The inclinometer casing could not be twisted into the correct orientation. A new borehole was drilled and a new inclinometer casing was installed without difficulties approximately three feet north of the original location. The new inclinometer was numbered MI-1A.

Inclinometer casing MI-2 was damaged during stage III in water dike construction. The contractor excavated around the damaged casing and replaced the damaged portion of the inclinometer casing. The repair appears to be good. The inclinometer probe can be raised and lowered in the repaired casing. However, the granular fill which fell down the inclinometer casing during the repair operation needs to washed out before the inclinometer can be read.

MONITORING

Wells: The water in each of the monitoring wells is sampled and tested periodically. The wells have performed satisfactorily and there have not been any problems obtaining the samples. The test results do not indicate seepage of contaminated material through the CDF is a problem.

Settlement Plates: Five settlement plates functioned satisfactorily throughout the life of the project. The settlement plates were surveyed daily during periods of granular fill placement and approximately two times per week during consolidation periods. Plots of settlement versus arithmetic time and log time (for both stage I and stage II consolidation periods) are presented in Figures 6-22 to 6-24.

The plots generally follow the theoretical curves shown in most text books. High rates of settlement versus time immediately after granular fill placement (stage I and stage II construction) which gradually slow during the following consolidation periods are depicted on the arithmetic plots. The log time plots indicate that secondary consolidation was not reached during the stage I consolidation period nor as of 12 April 1989 during the ongoing stage II consolidation period. It appears that the actual consolidation periods would have been longer than what was predicted theoretically without vertical drains, if more time and survey were allowed. Possible reasons for the long consolidation periods are reorientation of the organic clay particles due to the construction activities and clogging of the vertical drains.

The downward displacement of the settlement plates as of 12 April 1989 varied from 2.14 feet (SP-2) to 3.35 feet (SP-3). It appears that the final total downward displacement of the settlement plates will be in the 3 feet to 4 feet range which is less than the 5 feet to 6 feet that was predicted. The reason for the difference is that a significant amount (up to 50 percent of the layer thickness in some areas) of the organic clay layer was displaced during the granular fill placement operations.

Piezometers: Two and maybe three piezometers (MP-3, MP-4, and MP-5) functioned satisfactorily throughout the life of the project. If does not appear that the seals was formed properly during installation of the other two or three piezometers (MP-1, MP-2, or MP-5). The piezometers were read daily during periods of granular fill placement and approximately two times per week during consolidation periods. Plots of the readings versus arithmetic time are presented of Figure 6-25. The plots of the piezometers which functioned satisfactorily depict dramatic increases in the piezometric levels during stage II granular fill placement and slow decreases in piezometric levels during

consolidation periods as expected. Calculations performed during the latter days of granular fill placement and based on piezometer readings at that time indicate the porewater pressures near the tips of piezometers MP-3 and MP-4 were approaching the combined effective pressures of the materials above the tips.

Inclinometers: One inclinometer (MI-1A) performed satisfactorily throughout the project. The other inclinometer (MI-2) performed satisfactorily until it was damaged (between 1 November and 7 December 1988) at the end of stage II "in water" dike construction. Inclinometer MI-1A was read ten times including its initial reading. Inclinometer MI-2 was read seven times including its initial reading. Deflection versus depth plots of the inclinometer readings are presented in Figures 6-26 and 6-27.

The plots show that the deflection rates of the inclinometer casings were high during stage II granular fill placement and slowly decreased with time during consolidation periods. Both inclinometer casings deflected large distances to the east (MP-1A approximately 0.36 feet as of 3 May 1989 and MP-2 approximately 0.11 feet as of 1 November 1988). Inclinometer MP-1A deflected a large distance to the north (approximately 0.24 feet as of 3 May 1989) while inclinometer MP-2 did not deflect significantly in the north to south plane. Most of the inclinometer casing movement was observed in the organic clay layer. The magnitude, direction, and location of the inclinometer casing movements appear to be reasonable for a job of this nature.

Stability Poles: All seven stability poles performed well during the construction of the project. Each pole was observed daily by the contractor's and Construction Division personnel. Significant movements of the stability poles were not observed during the project.

Strain Gages: Monitoring of the strain gages' output was performed using a 4-1/2 digit ohmmeter. This technique has been validated by Leshchinsky and Fowler (11). It is a reliable technique that is easy to use in the field by non-technicians. For the strain gages used, the strain elongation in percent equals four tenths times the change in gage resistance in ohms relative to an initial value measured immediately after installation. Consequently, monitoring the change in gage resistance in the field enabled one to determine the corresponding strain.

Early construction operations had significant impacts on the 52 strain gages that were glued to the high-strength geotextile. Sixteen strain gages were lost during installation of the high-strength geotextile. Twenty-one strain gages were lost during stage I in water dike construction. No strain gages were lost during installation of the vertical drains. One strain gage was lost during the stage I in water dike consolidation period. One strain gage was lost during stage II in water dike construction. Two strain gages have been lost since completion of stage II of the in water dike construction, as of 3 May 1989. Approximate locations of the 15 strain gages remaining after stage I construction of the in water dike are presented in Figure 6-28.

Plots of strain versus time for the 15 strain gages remaining after stage I construction of the in water dike are presented in Figures 6-29 and 6-30. The the following strain ranges were noted on the strain versus time plots: high-strength-geotextile installation (0.5 percent to 0.9 percent), stage I "in water" dike fill (0.6 percent to 2.2 percent), vertical drain installation (-0.1 percent to 0.5 percent), stage I in water dike consolidation (0.5 percent to 3.5 percent), stage II in water dike construction (0 percent to 0.8 percent), and stage II "in water" dike consolidation (0.1 percent to 1.5 percent). The strain ranges seem reasonable, except that during stage II in water dike construction and consolidation, low strain ranges were observed in one-half of the strain versus time plots.

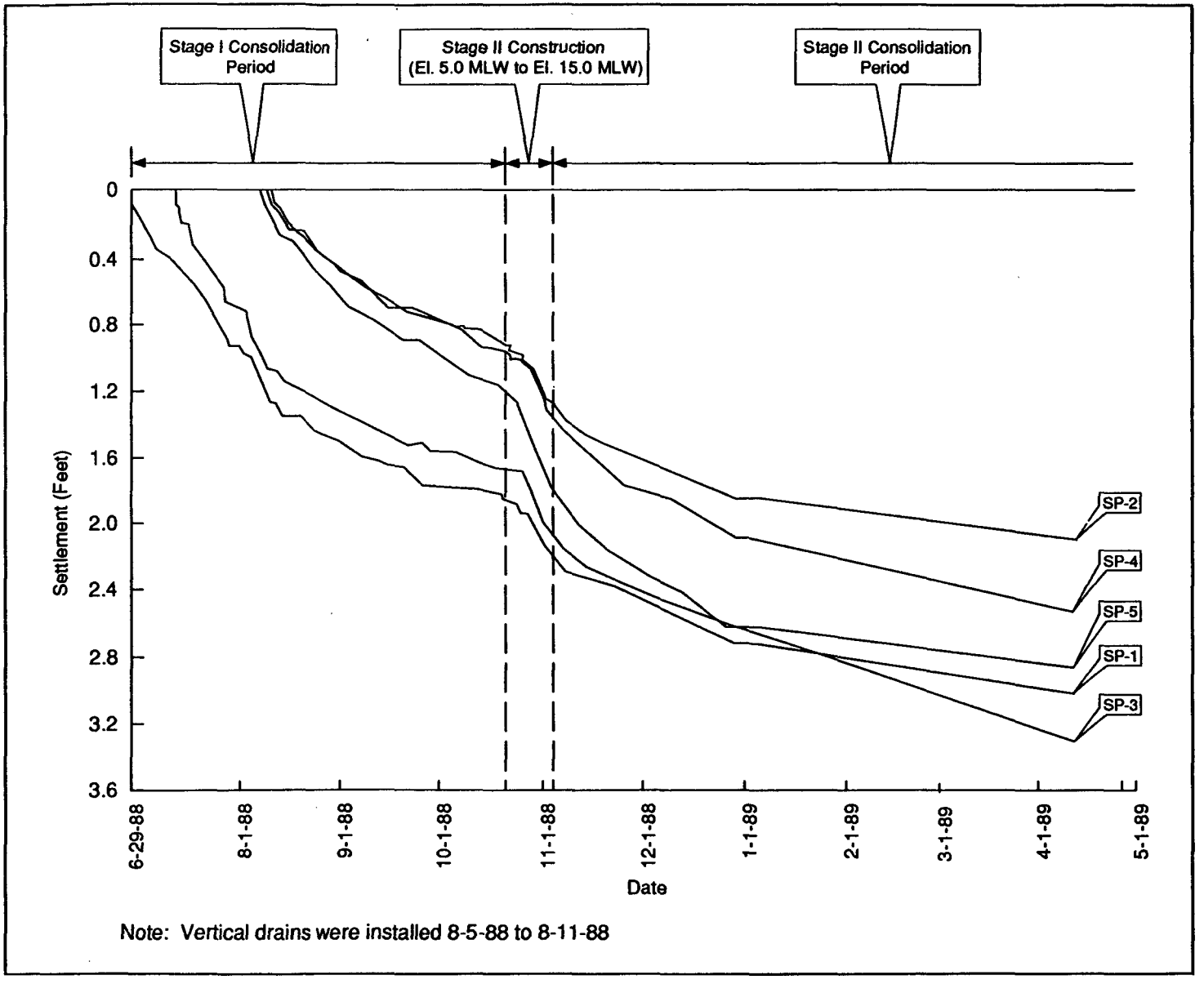


Figure 6-22 Settlement Plate Plots - Settlement Versus Time

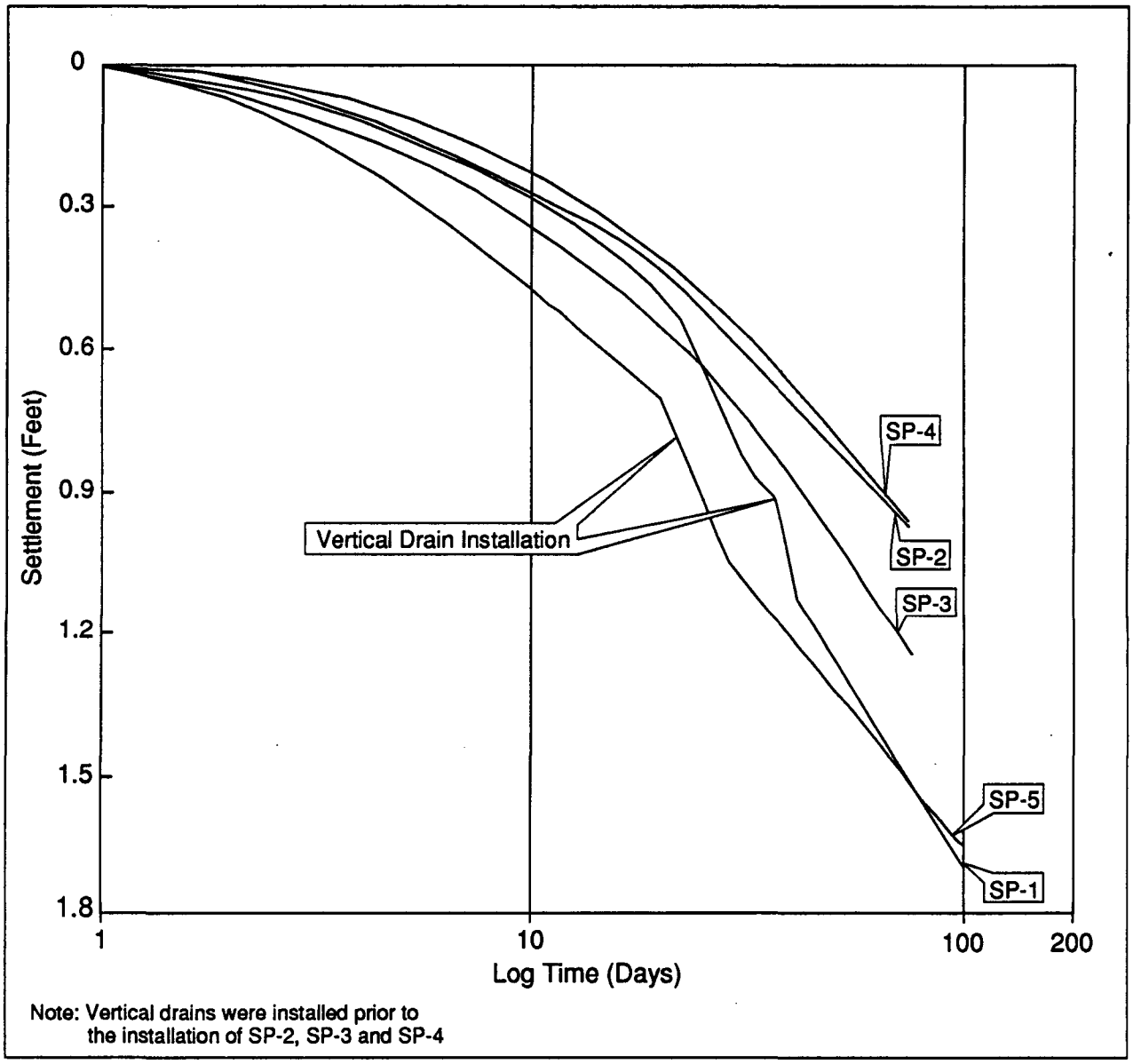


Figure 6-23 Settlement Plate Plots - Settlement Versus Log Time (Stage I Consolidation Period)

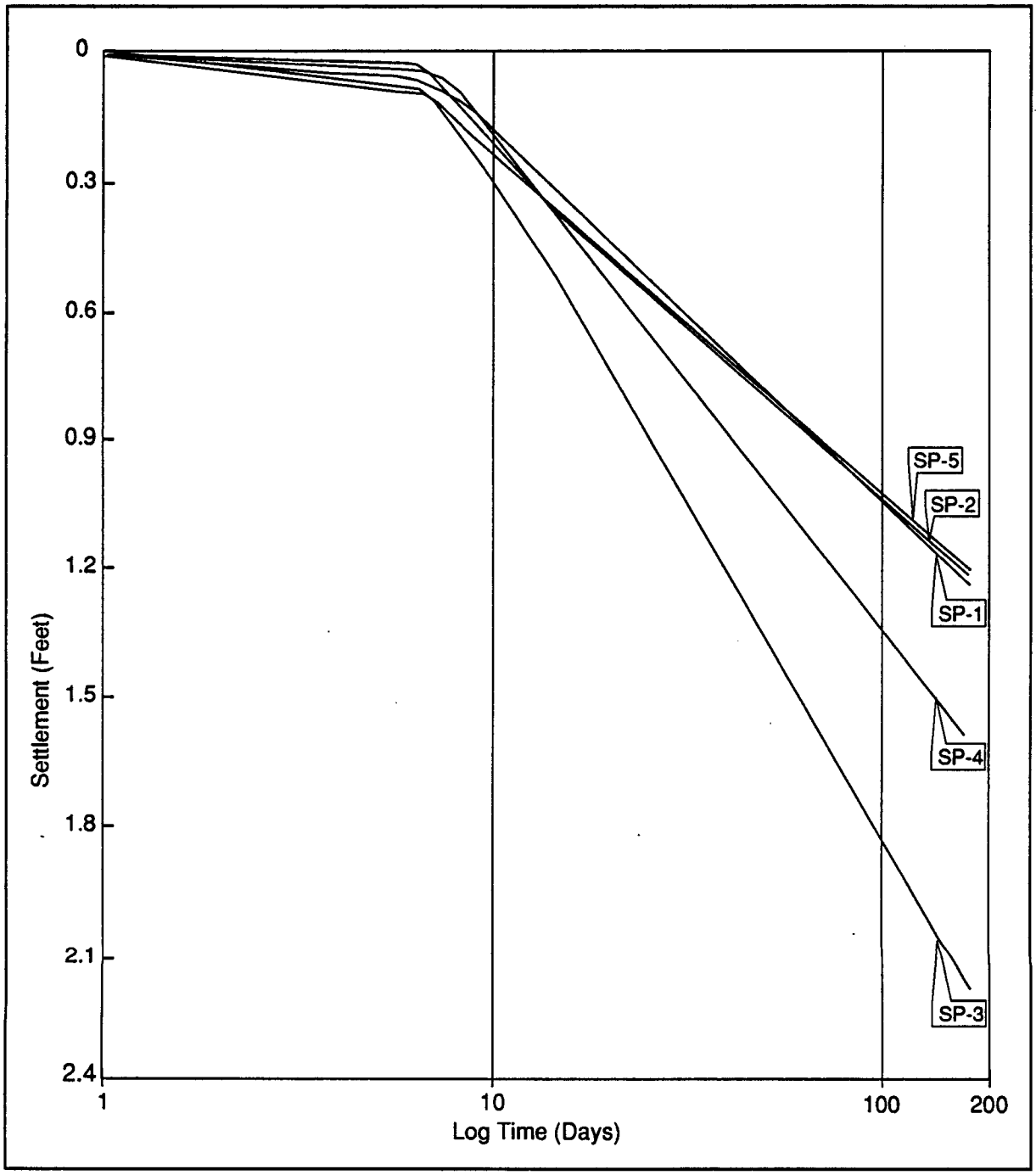


Figure 6-24 Settlement Plate Plots - Settlement Versus Log Time (Stage II Consolidation Period)

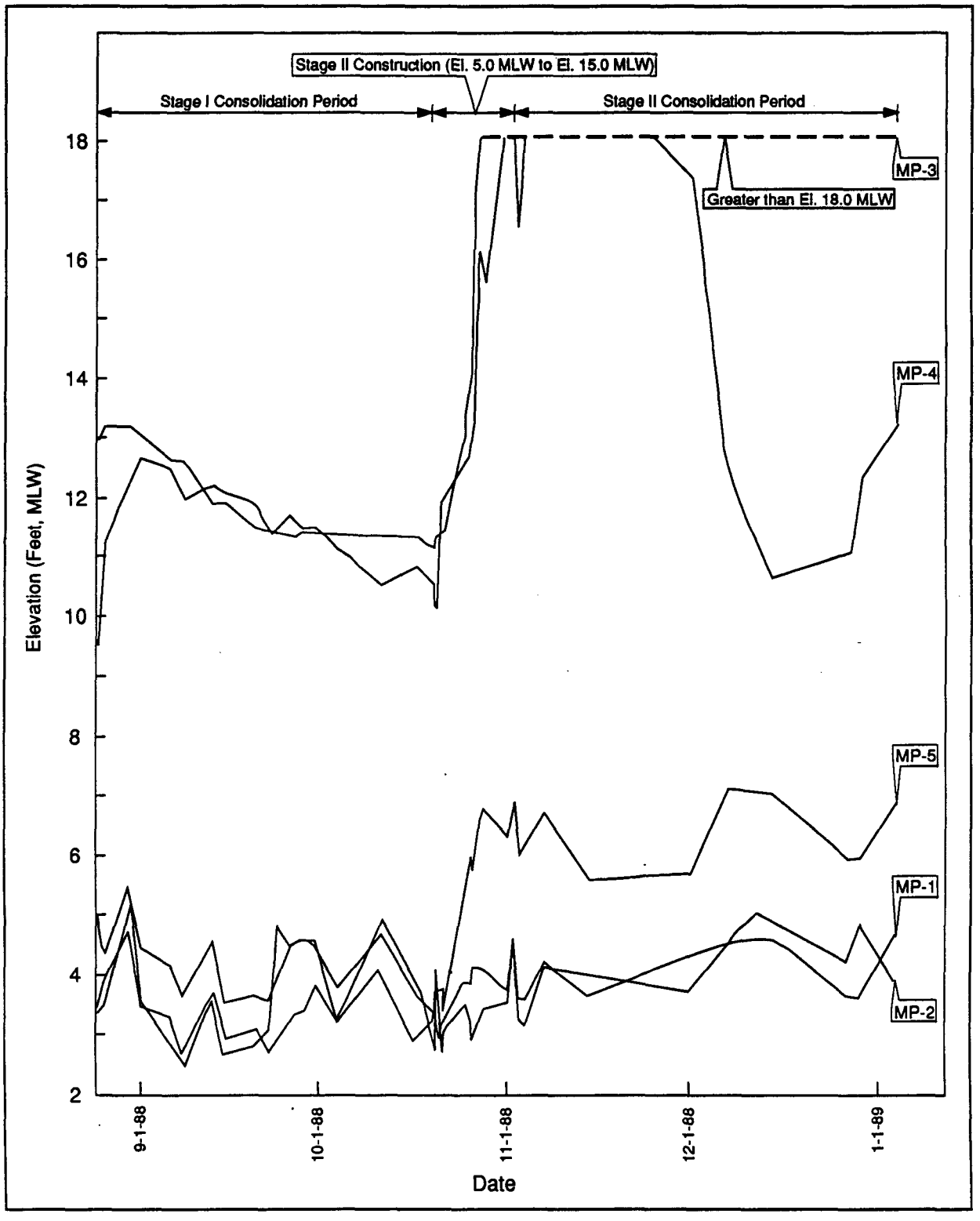


Figure 6-25 Piezometer Plots - Peizometric Level Versus Time

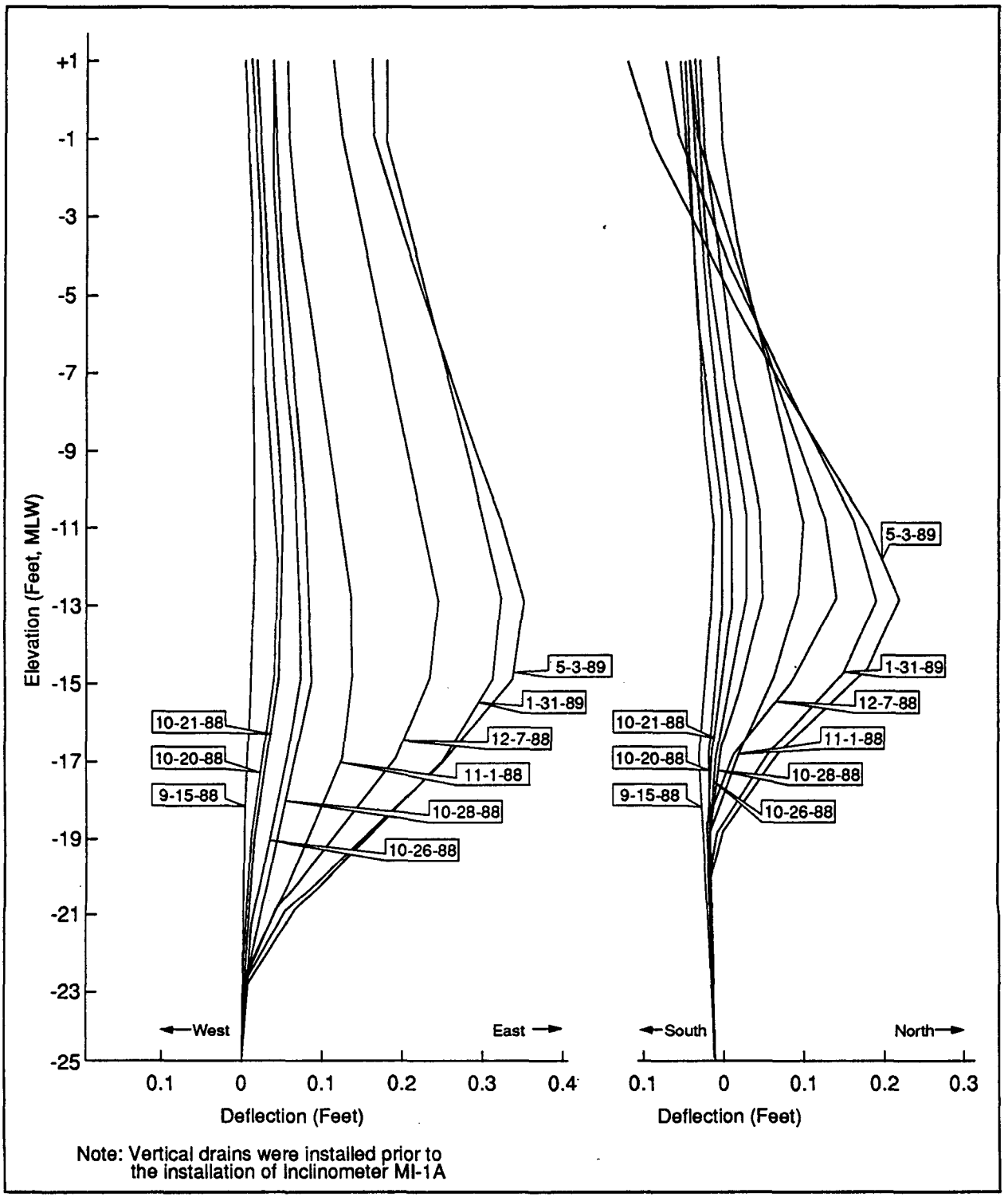
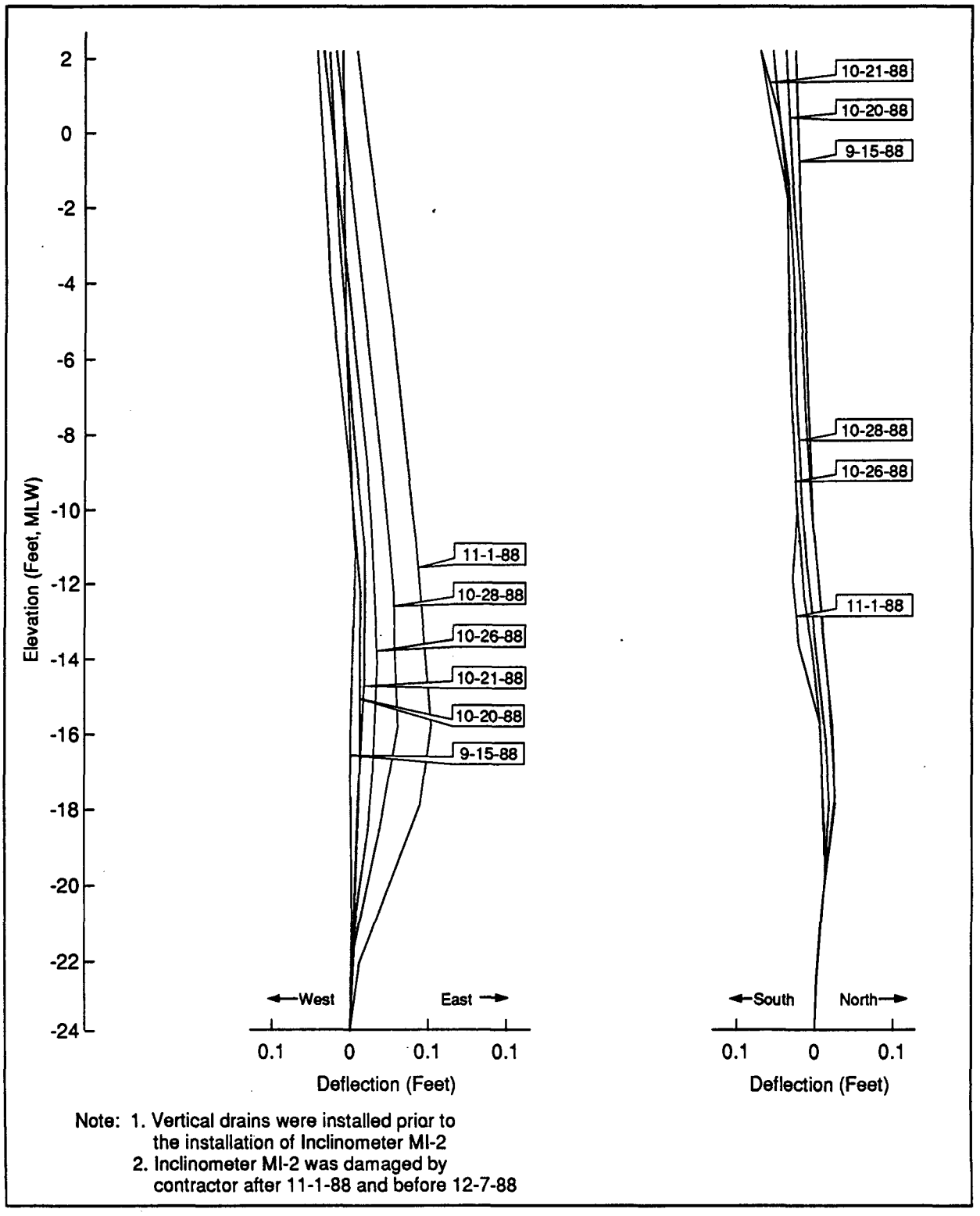


Figure 6-26 Inclinometer MI-1A Plots - Elevation Versus Deflection



Note: 1. Vertical drains were installed prior to the installation of Inclinometer MI-2
2. Inclinometer MI-2 was damaged by contractor after 11-1-88 and before 12-7-88

Figure 6-27 Inclinometer MI-2 Plots - Elevation Versus Deflection

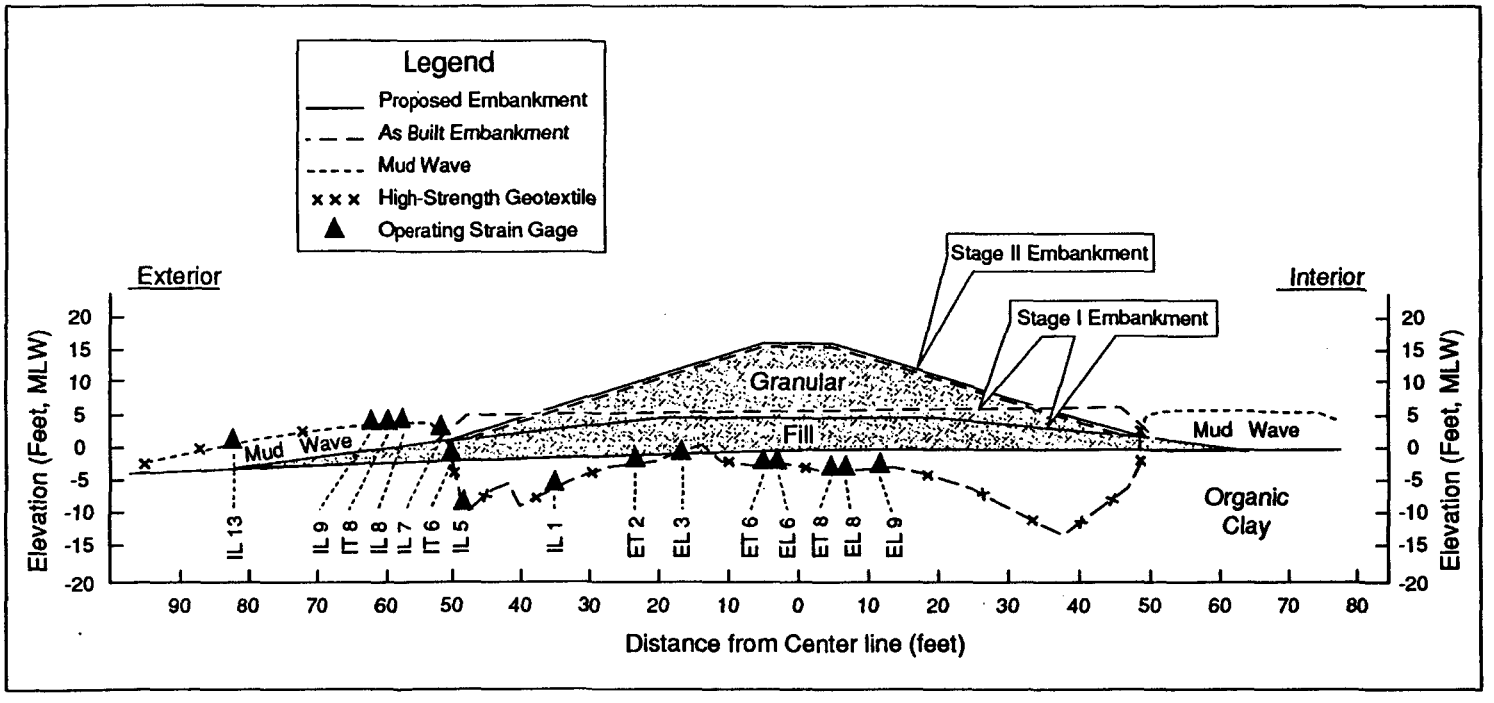
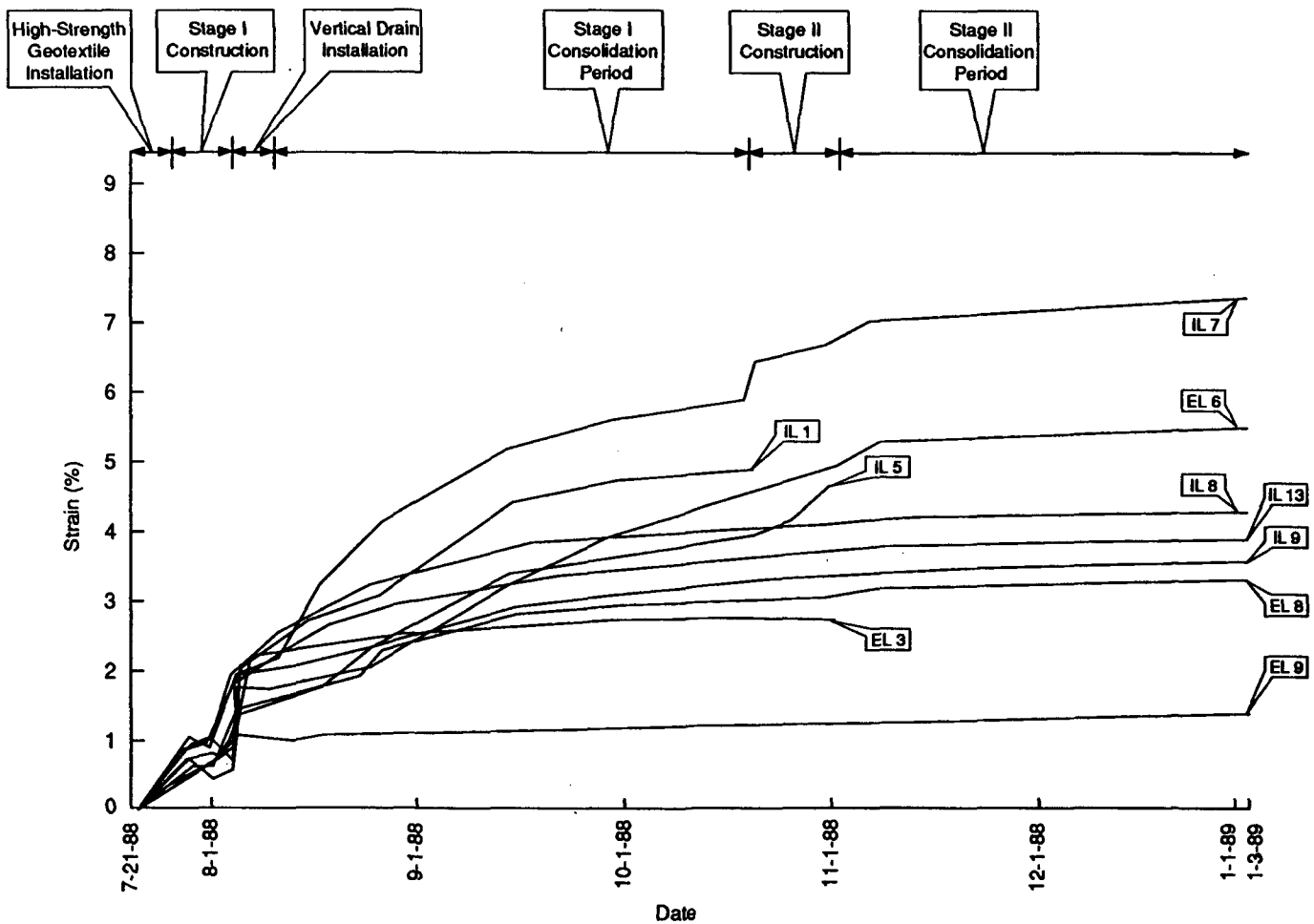
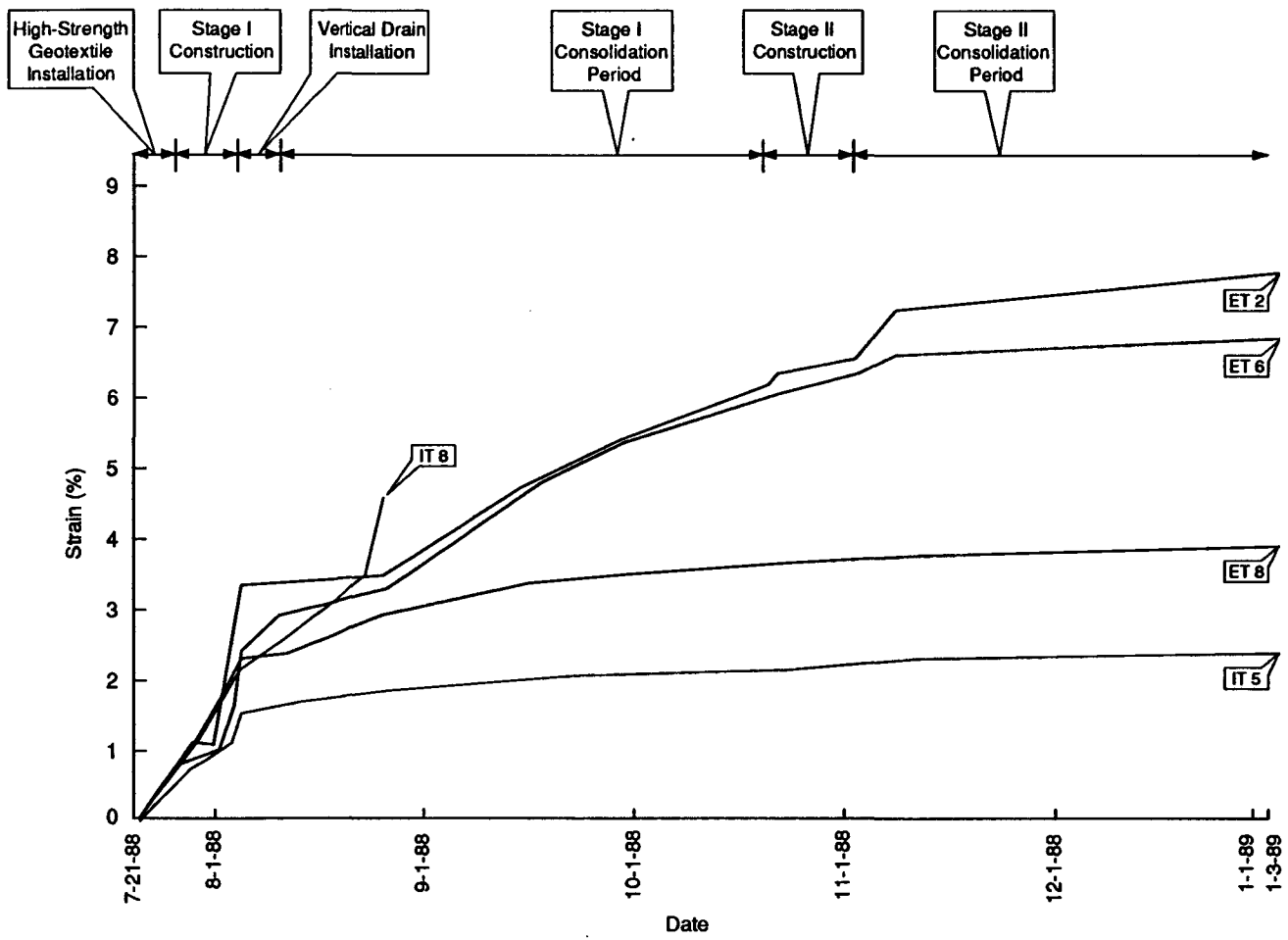


Figure 6-28 Strain Gage Locations



Note: Strain gage locations are shown on Figure 6-28

Figure 6-29 Strain Gage Plots - Longitudinal (Warp) Direction



Note: Strain gage locations are shown on Figure 6-28

Figure 6-30 Strain Gage Plots - Transverse (Fill) Direction

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20) U.S. Army Corps of Engineers. 1970. "Laboratory Soils Testing", Engineering Manual 1110-2-1906, Washington, D.C. 20314.

21) U.S. Army Corps of Engineers. 1984. "Shore Protection Manual", Waterways Experiment Station, Vicksburg, Mississippi 39180.

22) U.S. Army Corps of Engineers. 1960. "Site Geology, New Bedford-Fairhaven Hurricane Barrier, New Bedford Harbor, New Bedford, Massachusetts", Design Memorandum No. 2, New England Division, Waltham, Massachusetts 02254.

23) U.S. Army Corps of Engineers. 1987. "User's Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods", Instruction Report K-81-2, Washington, D.C. 20314.

24) U.S. Army Corps of Engineers. 1987. "UTEXAS2 Slope Stability Package", Instructional Report GL-87-1, Waterways Experiment Station, Vicksburg, Mississippi 39180.

25) U.S. Naval Facilities Command. 1982. "Soil Mechanics", Design Manual 7.1, Alexandria, Virginia 22332.

26) Woodward-Clyde Consultants. 1987. "Field Investigation and Analytical Testing, New Bedford Superfund Site, New Bedford, Massachusetts", Omaha, Nebraska 68154.

APPENDIX 6-A

Exploration Logs

NED Materials and Water Quality Lab

July 1985 to October 1985

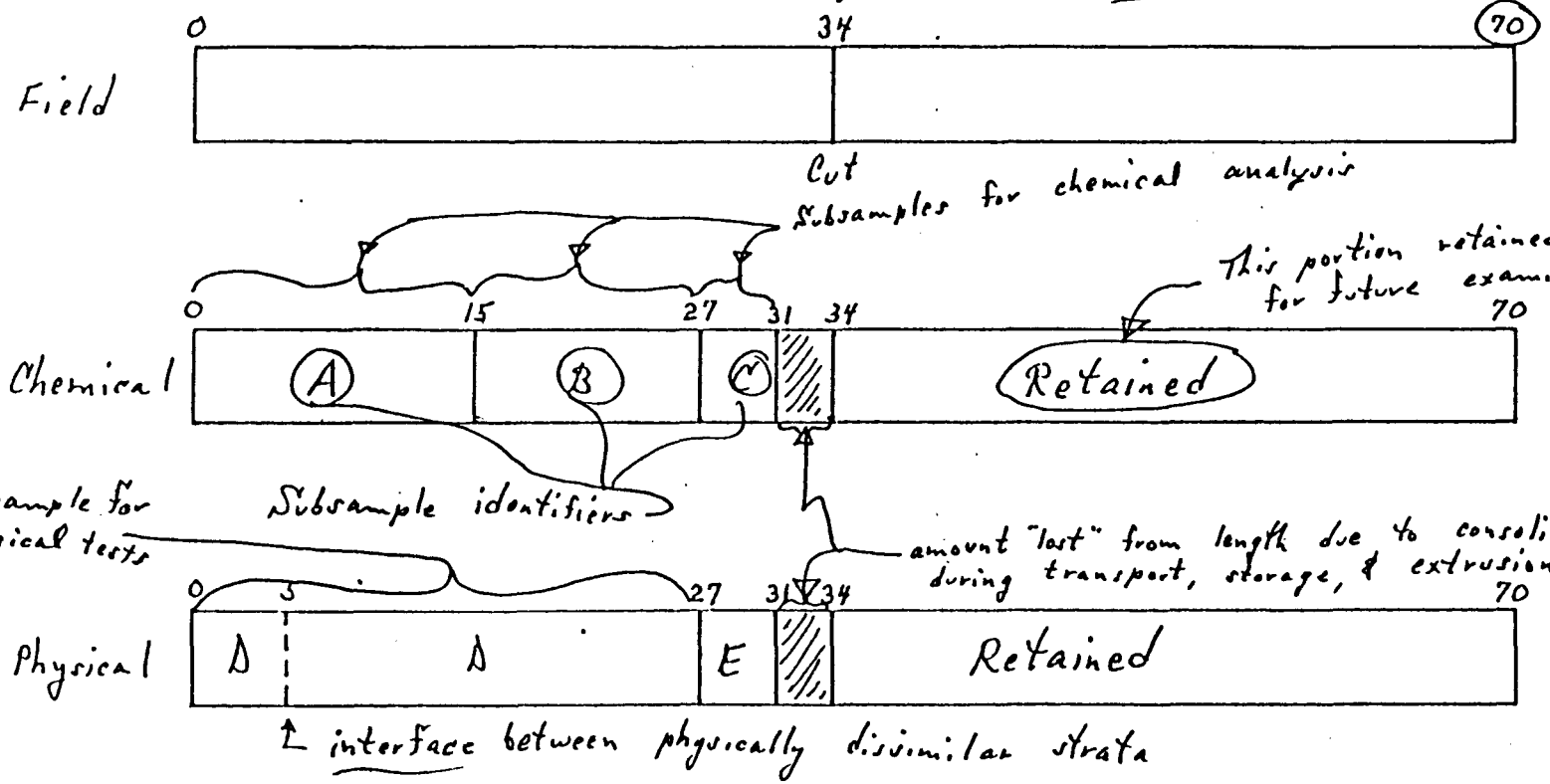
EXAMPLE

Grid No. → G-29-1

Replicate tube number (1 or 2) – if absent, no replicate taken

Field cut made to facilitate handling

Original full length of tube in inches



This portion retained in tube for future examination if necessary

KEY

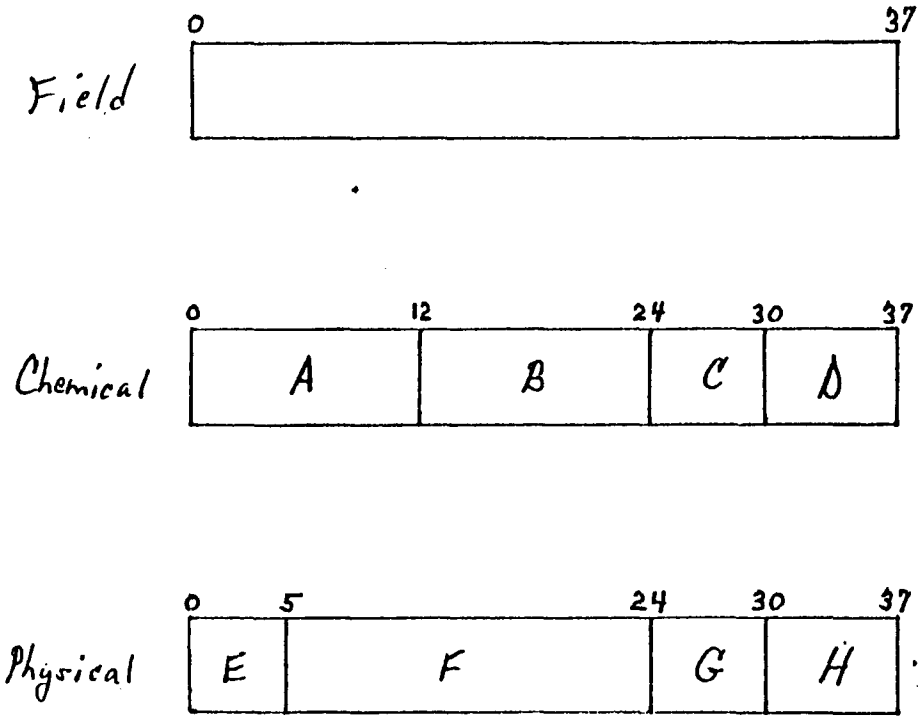
D: 0"-5" Black, loosely packed medium to fine sand w trace of silt & organics (leaves & roots)
5"-27" Olive green silt w trace of sand w shell fragments

E: NOT RETAINED – Olive green, dense, sandy silt with shells

→ at discretion of laboratory representative

E-25-1

9910



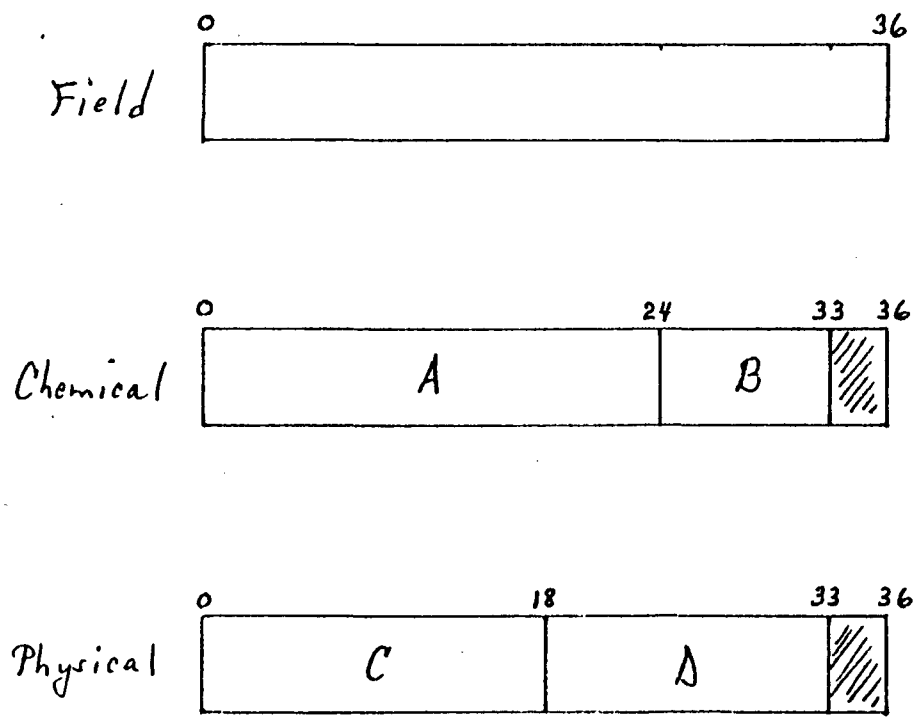
E: Black, loose, soft, peaty silt w̄ marine odor and shell fragments

F: Olive, firm, organic silt w̄ sand and marine odor

G: Olive green, firm, fine silty sand w̄ shell fragments

E-27-1

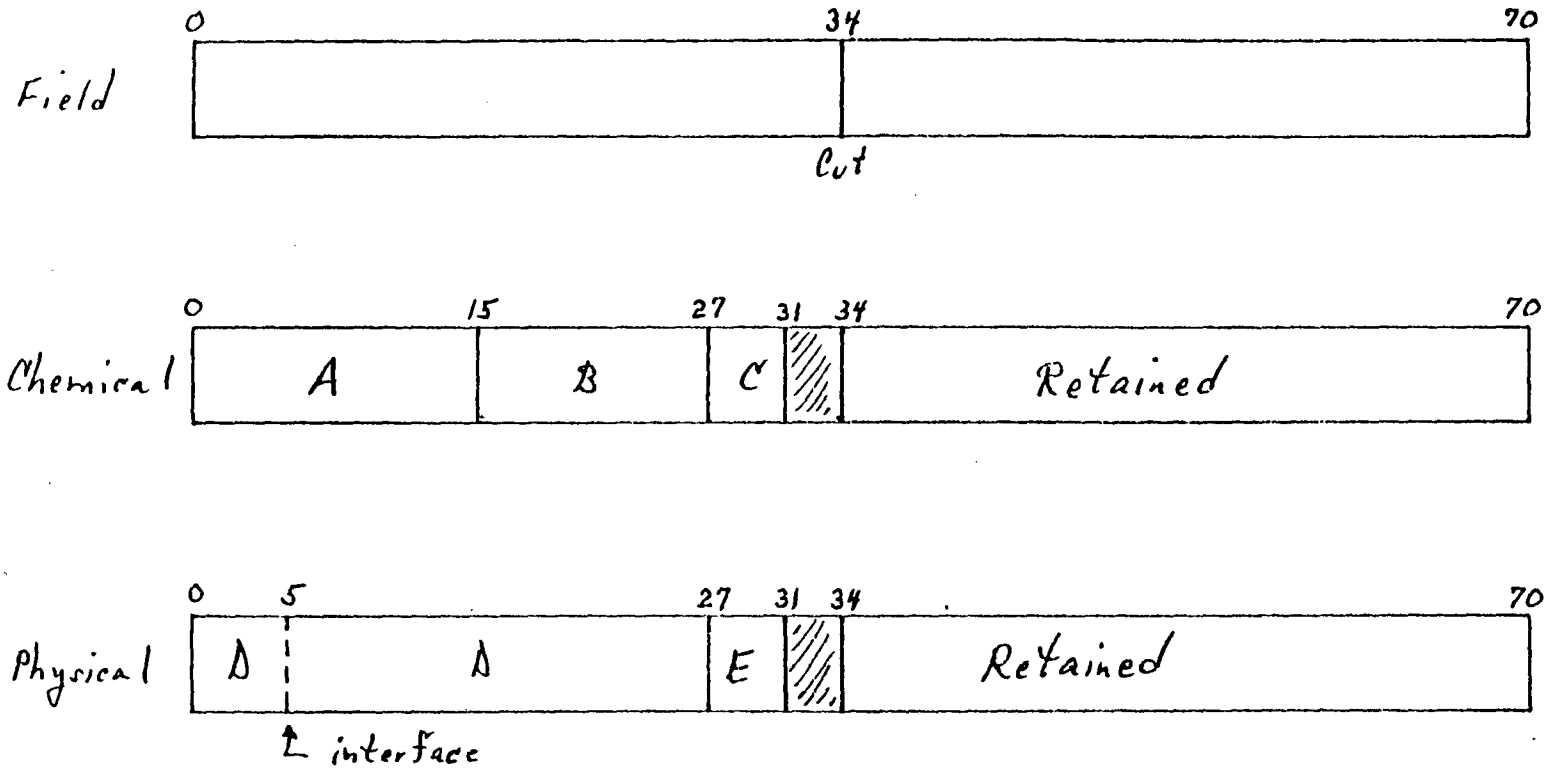
9912



C: Black, firmly packed, fine sandy silt w shells and organics

D: Olive green, loose, soft, medium to fine silty sandy gravel with shells

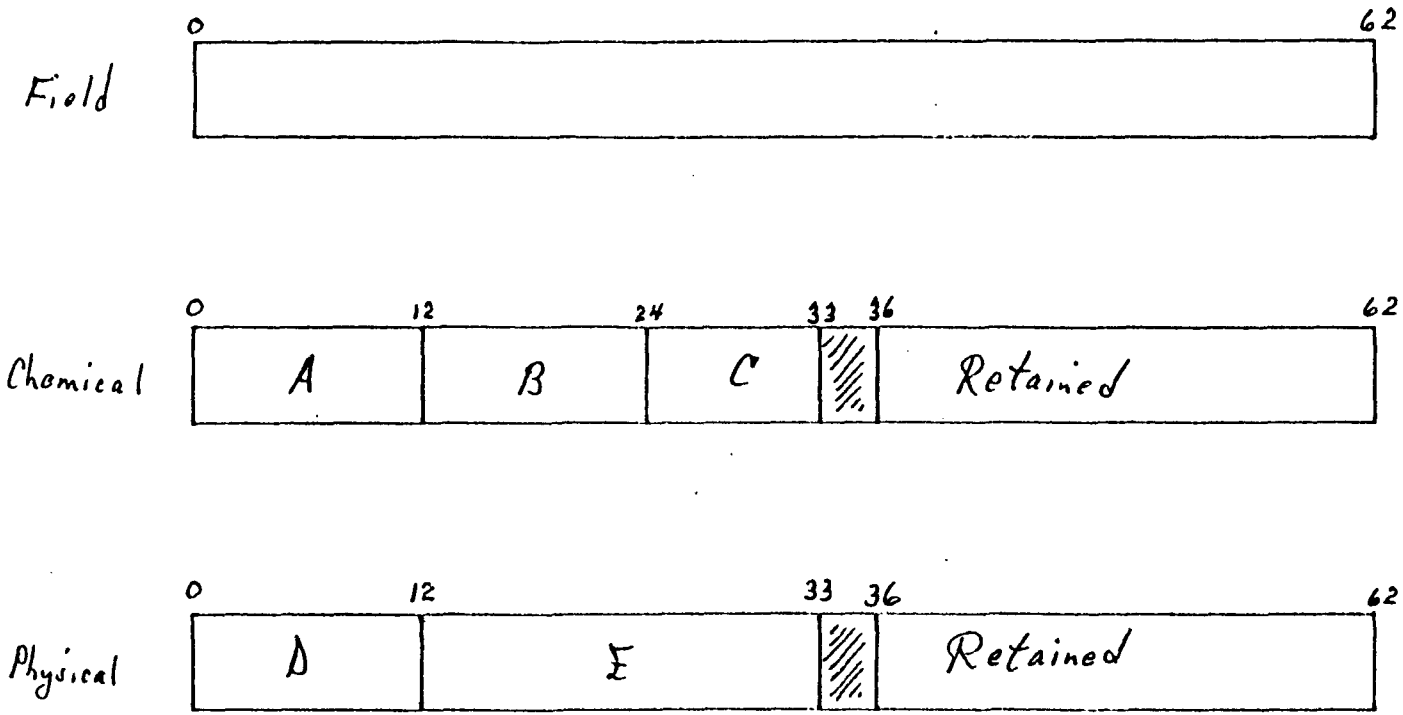
9922 G-29-1



D: 0"-5" Black, loosely packed medium to fine sand w trace of silt & organics (leaves & roots)
5"-27" Olive green silt w trace of sand w shell fragments

E: -NOT RETAINED - Olive green, dense, sandy silt with shells

9907 H-25



D: Black, soft, organic silt w marine odor

E: Olive green, firm, medium to fine organic sandy silt with marine odor

Goldberg - Zoino Drilling

October 1986 November 1986

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-10-86

RIG Barge

WATER El. 6.3± AT

BW-9

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 2.3 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	OVM READINGS	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	5/24	P	Loose, black to dark gray, Silty SAND	On Sampler = 3ppm	SM	Boring advanced by driving a 3 inch dia. casing in 5 foot sections, then wash boring & advancing a 1-3/8" IDSS Sampler with AW rods with a 140 lb. hammer dropping 30 inches or pushing manually.
				Dense, gray to multicolored, poorly graded SAND to Silty SAND		SP-SM	
5	SS	12/24	8 4 5 6		On Sampler = 6ppm		Alluvium
					During Washbore = 1ppm		
10	SS	16/24	6 9 11 14				
					During Washbore = 1ppm		
15	SS	24/24	14 21 42 50				
	SS	0/1	>100				Refusal Blow Count > 100
20							BOTTOM OF BORING 19.0'
25							

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-11-86

RIG Barge

WATER El. 6.1

BW-12

PROJECT LOCATION New Bedford, Mass.

LOGGED BY L. Giannasi DRILLED BY GZA

SURFACE ELEVATION 2.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	4/24	P	Loose, black, low plastic Clayey ORGANIC SILT	OL	Boring advanced by driving a 3-inch dia. casing in 5 foot sections, then wash boring & advancing a 1-3/8" IDSS Sampler with AW rods with a 140 lb. hammer dropping 30 inches or pushed manually.
5	SS	0/24	P			
				Soft to firm, black and dark gray, highly plastic ORGANIC CLAY	OH	Alluvium
	SS	16/24	P			
10						
	SS	6/24	P	Loose, dark brown to black, organic SILT with Sand	ML	Alluvium
				Loose to dense, dark gray to multicolored, Silty SAND	SM	Alluvium
15	SS	24/24	6 5 9 4			
20	SS	18/18	8 13 25	Dense to very dense, gray, poorly graded SAND	SP	Alluvium
25						

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

BW-12

PROJECT LOCATION New Bedford, Mass.

DATE 10-11-86

RIG Barge

LOGGED BY L. Giannasi DRILLED BY GZA

WATER El. 6.1 ± AT

SURFACE ELEVATION 2.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25	SS	18/18	5 6 5	Loose to dense, gray, poorly graded, Silty SAND	SM	Alluvium
30	SS	18/18	2 2 4			
						BOTTOM OF BORING 31.5'

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-27-86

BL-5

PROJECT LOCATION New Bedford, Mass.

RIG Acker 82

LOGGED BY A. Brillinger DRILLED BY GZA

WATER ENTERS El. 3.6 ft

RFACE ELEVATION 10.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	18/24	5, 13, 23, 27	Black SILT, CLAY and Brick fragments Becoming brown to black, poorly graded, Silty SAND with Clay, Gravel and brick fragments	SM	Boring advanced with 3-3/4" augers and a 1-3/8" IDSS Sampler with a 140 lb. hammer dropping 30 inches
						Fill
5	SS	0/25	20, 21, 21, 15	Dense, brown, poorly graded, Silty SAND with shells	SM	Augers grinding at 3-3.5'. Alluvium ← Water Enters ATD
10	SS	24/24	5, 7, 7, 10	Loose to dense, green-gray SILT with Gravel and Sand	ML	Alluvium
15	SS	24/24	6, 11, 15, 21	Becoming dense, poorly graded, Silty SAND	SM	
20	SS	21/24	4, 10, 11, 15	Becoming loose to dense		Hole augered to 20'; sampled to 22'.
						BOTTOM OF BORING 22.0'
25						

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-10-86

RIG Barge

WATER El. 4.8± AT

PW-4

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 2.3 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0			P ↓			Probe consists of AW Rods with flat 1-3/8" tip pushed until resistance is encountered & then driven with a 140 lb. hammer falling 30 inches.
			3			
			5			
5			10			OVM Reading @ 2.5' on rods = 1ppm
			20			
			24			
			26			
			30			
10			35			
			35			
			37			
			40			
			43			
15			51			
			63			
			65			
			60			
			53			
20			50			
			53			
			49			
			52			
			58			
25						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-10-86

PW-4

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 4.

SURFACE ELEVATION 2.3 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25			61			
			64			
			66			
			63			
			58			
30						BOTTOM OF PROBE 30.0'
35						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-10-86

RIG Barge

WATER El. 7.6± ATD

PW-6

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn

DRILLED BY GZA

SURFACE ELEVATION 2.1

ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0			P			Probe consists of AW rods with flat 1-3/8" tips pushed until resistance is encountered & then driven with a 140 lb. hammer falling 30 inches.
						OVM Reading @ 1½ feet on rods = 3.3ppm
			24			
10			32			
			38			
			30			
			37			
			37			
15			40			
			40			
			38			
			46			
			57			
20			40			
			38			
			41			
			47			
			60			
25						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C85548

DATE 10-10-86

PW-6

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn

DRILLED BY GZA

WATER El. 7

SURFACE ELEVATION 2.1

ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25			58			
			40			
			54			
			42			
			65			
30						BOTTOM OF PROBE 30.0'
35						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

DATE 10-27-86

RIG Acker 82

WATER ENTERS Not Measured

Probe Hole/PL-1
Soccer Field

PROJECT LOCATION New Bedford, Mass.

LOGGED BY A. Brillinger DRILLED BY GZA

SURFACE ELEVATION 9.5 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0			17			Probe consists of AW rods with flat 1-3/8" tips pushed until resistance encountered and then driven with a 140 lb. hammer falling 30 inches.
			21			
			19			
			22			
			18			
5			25			
			25			
			18			
			19			
			23			
10			30			
			27			
			32			
			29			
			28			
15			37			
			31			
			34			
			35			
20						BOTTOM OF PROBE 19.0'

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B

PL-2

DATE 10-8-86

PROJECT LOCATION New Bedford, Mass.

RIG Acker

LOGGED BY C. Bohn DRILLED BY GZA

WATER ENTERS Not Measured

SURFACE ELEVATION El. 19.80 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0			7			Probe consists of AW rods with flat 1-3/8" tips pushed until resistance is encountered & then driven with a 140 lb. hammer falling 30 inches
			14			
			10			
			8			
			9			← Water Enters ATD
5			6			
			4			
			8			
			9			
			7			
10			12			
			36			
			79			
			126			Boring stopped when resistance reached 100 blows per foot
			100 / 6"			BOTTOM OF PROBE 14.5'
15						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-31-86

PD-1

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY A. Brillinger DRILLED BY GZA

WATER El. 3.0± ATD

SURFACE ELEVATION +1.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	3'/5'	P	Loose, dark brown, well-graded Silty SAND w/Gravel and Clay	SW SM	Push sample is with a 3-inch dia. tube pushed by 200 lbs. into the first 5 feet of material. Alluvium Split-Spoon Samples obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually
5	SS	20/24	2 3 5 6	Becoming Silty SAND	SM	
						BOTTOM OF BORING 7.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-31-86

PD - 2

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY A. Brillinger DRILLED BY GZA

WATER El. 3.

SURFACE ELEVATION +1.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	3'9" / 5'	P	Loose, black, organic, Sandy, Clayey SILT w/shell fragments	ML	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium Split Spoon Samples obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually
5	SS	24 / 24	P	Firm, dark gray, highly plastic ORGANICS with Sand and Clay	OH	
						BOTTOM OF BORING 7.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

PD - 3

PROJECT LOCATION New Bedford, Mass.

DATE 10-31-86

RIG Barge

LOGGED BY A. Brillinger DRILLED BY GZA

WATER El. 3.6 ± ATD

SURFACE ELEVATION 0.6 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'11" / 5'	P	Loose, black, organic, Silty SAND w/clay	SM	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-31-86

PD - 4

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY A. Brillinger DRILLED BY GZA

WATER El. 3.3

SURFACE ELEVATION +0.3 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'9" / 5'	P	Loose, black to light gray, poorly-graded Clayey, Silty SAND	SP-SM-SC	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium
5				Loose, light gray SILT with Sand	ML	BOTTOM OF BORING 5.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 11-1-86

PD - 5

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 2.5± ATD

SURFACE ELEVATION 1.4 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	1'8" / 5'	P	Loose, black, poorly-graded Silty SAND	SP-SM	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

1h

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-30-86

PD - 6

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn

DRILLED BY GZA

WATER El. 3.0

SURFACE ELEVATION 1.5

ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'0" / 5'0"	P	Loose, black, Sandy, Clayey SILT	ML	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material.
				Soft, light gray, highly plastic ORGANICS with Silt and Clay	OH	Alluvium Split Spoon Samples obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually.
5	SS	24/24	P			
	SS	18/24	P			
10						BOTTOM OF BORING 9.0'
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

lh

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 11-1-86

RIG Barge

WATER El. 4.0± ATD

PD - 7

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 0.9 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	2'10" / 5'0"	P	Loose, black, poorly-graded SAND w/ Silt	SP	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium
5	SS	24	P	Loose, light gray, Silty SAND	SM	Split Spoon Samples obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually. Alluvium
	SS	24	P 2 4	Becoming poorly graded	SM-SP	
10						BOTTOM OF BORING 9.0'
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-30-86

RIG Barge

WATER El. 4.8 D

PD - 8

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 1.8 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	2'10" / 5'0"	P	Loose, black, Sandy, Clayey SILT	ML	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material.
				Loose, light gray, Sandy SILT to Silty SAND	ML-SM	Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 11-1-86

RIG Barge

WATER El. 3.0 ± ATD

PD - 9

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 1.4 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'6" / 5'0"	P	Loose, black to dark gray, poorly-graded Silty SAND w/shells	SP-SM	Push Tube Sample is with 3-inch dia. tube pushed by 200 lbs. into the first five feet of material. Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 11-1-86

PD - 10

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 6

SURFACE ELEVATION 1.8 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'3" / 5'0"	P	Loose, black, poorly-graded SAND w/silt	SP	Push Tube Sample is with 3-inch dia tube pushed by 200 lbs. into the firs five feet of material. Alluvium
5	SS	13/24	P	Loose, light gray, Silty SAND	SM	Split Spoon Sample obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually.
	SS	18/24	P			
10						BOTTOM OF BORING 9.0'
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B 1

DATE 11-1-86

PD - 11

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 7.7± AT

SURFACE ELEVATION 2.7 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	3'3" / 5'0"	P	Loose, dark gray to black, Silty SAND	SM	Push Tube Sample is with 3-inch dia tube pushed by 200 lbs. into the first five feet of material. Alluvium
5	SS	24/24	P			Split Spoon Samples obtained by driving with 140-lb. hammer dropping 30 inches or pushed manually.
	SS	24/24	2 3 4 5			
10						BOTTOM OF BORING 9.0'
15						
20						NOTE: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

1h

BORING LOG

SHEET 1 OF 3

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-86

RIG Barge

WATER El. 6.

PD-12

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 2.4 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	OVM READING	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	G SS	7/24	P	Soft, dark gray and black, low plastic ORGANICS with Clay, Silt and Sand	On Sampler = 0.8ppm	OL	Boring Advanced by driving a 3-inch dia. casing in 5 foot sections, then wash boring & advancing 1-3/8 inch IDSS Sampler with AW rods with a 140 lb. hammer dropping 30 inches or pushed normally
	SS	11/24	P	With shell fragments	On Sampler = 2ppm		
5	G SS	12/24	2 1 3	Loose, dark gray, poorly graded SAND to Silty SAND	On Sampler <A	SP-SM	
	G SS	13/24	5 3 3 7	Loose to dense, brown, well graded SAND		SW	Alluvium
	SS	12/24	9 6 7 10		On Sampler <A		
10	G SS	12/24	9 12 20 13 15	Dense, brown, Silty SAND		SM	
15	G SS	24/24	18 22 20 31	Becoming poorly graded SAND to Silty SAND	On Sampler <A	SP-SM	
20	G SS	24/24	4 6 8 10		On Sampler <A		

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 2 OF 3

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-86

PD-12

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 6.4 ± A

SURFACE ELEVATION 2.4 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25	G SS	24/24	3 5 6 8	SAME: Dense, light brown to light gray, poorly graded SAND to Silty SAND	SP-SM	Alluvium
30	G SS	9/24	7 10 12 9	Becoming Silty SAND	SM	
35	G SS	4/24	21 10 11 12	Dense, tan, well graded SAND with Silt	SW	Alluvium
40	G SS	6/24	23 14 14 22			
45	G SS	5/24	24 12 6 9	Dense to very dense, light brown, poorly graded SAND to Silty SAND	SP-SM	Alluvium
50						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 3 OF 3

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-86

PD-12

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 6

SURFACE ELEVATION 2.4 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	OVM READING	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
50	SS	1/24	18 15 14 23	Very dense, poorly graded GRAVEL and SAND		GP-SP	Alluvium
							BOTTOM OF BORING 52.0'
55							
60							
65							
70							
75							

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-86

RIG Barge

WATER El. 8.5± AT

PD-13

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 3.0 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	OVM READINGS	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	10/24	P	Soft, black, low to highly plastic Clayey ORGANIC SILT	On Sampler <A	OL-OH	Boring Advanced by driving a 3" dia. casing in 5 foot sections and advancing 1-3/8" IDSS Sampler with a 140 lb. hammer dropping 30 inches or pushed manually
	SS	9/24	P	With shell contents	On Sampler <A		
5	SS	6/24	P	Becoming firm	On Sampler <A		Alluvium
	SS	18/24	P 5 18	Loose to dense, dark gray, poorly graded SAND to silty SAND	On Sampler = 0.5ppm	SP-SM	Alluvium
	SS	6/24	3 4 6 6				
	SS	0/24	P				
15	SS	4/24	19 26 54 50	Very dense, dark gray, well graded SAND	On Sampler <A	SW	Refusal Blow Count >100
							BOTTOM OF BORING 17.0'
20							
25							

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-28-86

PD-14

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 7.5±

SURFACE ELEVATION 3.0 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION		U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	9/24	P	Loose, dark olive-black, highly plastic ORGANIC Clay with Silt and Sand	On Sampler <A	OH	Boring Advanced by driving a 3" dia. casing in 5 foot sections, then wash boring and advancing 1-3/8" IDSS Sampler with AW rods with a 140 lb. hammer dropping 32" or pushed manually. Alluvium
				Soft to firm, dark olive-gray, highly plastic ORGANIC Clay with Sand		OH	
5	SS	24/24	P		On Sampler <A		
	SS	7/24	P		On Sampler <A		
	SS	8½/24	P	With Shell fragments	On Sampler <A		
10	SS	12/24	P		On Sampler <A		
				Loose, black, poorly graded, Silty SAND		SM SP	Alluvium
15	SS	24/24	P 3 6 5	Loose to dense, gray, poorly graded GRAVEL to Silty GRAVEL	On Sampler <A	GM-GP	Alluvium Started driving Casing
20	SS	9/24	9 7 7 9	Dense, gray and multicolored well graded GRAVEL with Sand		GW	Alluvium
25							

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-28-86

PD-14

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 7.5± ATD

SURFACE ELEVATION 3.0 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	OVA READINGS	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25	SS	24/24	5 6 6 9	Dense, gray, Silty SAND	On Sample <A	SM	Alluvium
							Refusal to Blow Count> 100
30	SS	0/4"	50/4"				BOTTOM OF BORING 30.0'
40							
45							
50							

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

PD-15

DATE 10-27-86

PROJECT LOCATION New Bedford, Mass.

RIG Acker 8

LOGGED BY A. Brillinger DRILLED BY GZA

WATER ENTERS El. 0.2± A

SURFACE ELEVATION 7.2' ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	4/24	2 7 6 4	Loose to dense, dark gray, Silty SAND and leather scraps, Silt, brick chips, wood fibers	SM	Fill Boring Advanced with 3-3/4" augers & driving 1-3/8" IDSS Sampler with 140 lb hammer dropping 30 inches Augers grinding @ 3.5' - 4.0'
5	SS	12/24	3 1 5 10	With organics		Alluvium ← Water Enters ATD Augers grinding @ 8' - 8.5'
10	SS	24/24	1 1 1 2	Loose, gray-green, poorly graded SAND with Silt	SP	Alluvium
15	SS	24/24	4 7 10 12	Loose to dense, brown and dark gray, well graded SAND with Gravel, Clay and Silt	SW	Alluvium
20	SS	19/24	9 11 7 6	Loose to dense, dark brown to brown, Silty SAND	SM	Alluvuim
25						

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-27 & 28-86

PD-15

PROJECT LOCATION New Bedford, Mass.

RIG Acker 82

LOGGED BY A. Brillinger DRILLED BY GZA

WATER ENTERS El. 0.2± ATD

SURFACE ELEVATION 7.2 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25	SS	24/24	3 5 7 8	Dense, green-gray, poorly graded SAND to Silty SAND	SM-SP	Alluvium
30	SS	5/24	8 9 10 11	Becoming Silty SAND	SM	
						BOTTOM OF BORING 32.0'

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

PD-16

PROJECT LOCATION New Bedford, Mass.

DATE 10-28-86

RIG Acker 8'

LOGGED BY A. Brillinger DRILLED BY GZA

WATER ENTERS Not Noted

SURFACE ELEVATION 8.2 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	18/24	2 9 14 18	Dense, black, Silty SAND with some Clay and brick fragments, coal, Slag and ash	SM	Fill Boring Advanced by 3-3/4" Augers & 1-3/8" SS Sampler with 140 lb. hammer dropping 30 inches
5	SS	2/24	1 2 1 1	Loose, black, poorly graded GRAVEL to Silty GRAVEL with Organics	GP-GM	Fill Augers grinding @ 9'-9.5'
10	SS	24/24	5 11 12 11	Loose to dense, brown, orange-brown and gray, poorly graded SAND to Silty SAND	SP SM	
15	SS	24/24	P 4 7	Becoming poorly graded	SP	
20	SS	15/24	8 7 11 11			
25						

BORING LOG

SHEET 2 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

PD - 16

DATE 10-28-86

PROJECT LOCATION New Bedford, Mass.

RIG Acker 82

LOGGED BY A. Brillinger DRILLED BY GZA

WATER ENTERS Not Noted

SURFACE ELEVATION 8.2 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
25	SS	20/24	5 6 11 13	Loose to dense, brown, SILT with Sand	ML	Alluvium
30	SS	20/24	3 3 6 7	Loose to dense, brown, Silty SAND	SM	Boring augered to 30', sampled to 32'
						BOTTOM OF BORING 32.0'

BORING LOG

SHEET 1 OF 2

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-8

PD - 17

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY C. Bohn DRILLED BY GZA

WATER El. 5.6± AT

SURFACE ELEVATION 2.1 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	SS	4/24	P	Loose, black, highly plastic ORGANIC Clay with Silt and Sand	OH	Boring Advanced by driving a dia. casing in 5 foot sections, then wash boring & advancing 1-3/8" IDSS Sampler with AW rods with a 140 lb. hammer dropping or pushed manually
	SS	12/24	P			
5	SS	9/24	P			Alluvium
	SS	4/24	P	Loose, gray, low plastic ORGANIC Clay with Silt	OL	
	SS	13/24	P			
10	SS	24/24	P			
				Very dense, gray, poorly graded SAND to Silty SAND	SP SM	Alluvium
15	SS	12/13	12 48 50/1"			Refusal Blow Count > 100
						BOTTOM OF BORING 16.1'
20						

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C8554B1

DATE 10-29-86

PD - 18

PROJECT LOCATION New Bedford, Mass.

RIG Barge

LOGGED BY A. Brillinger DRILLED BY GZA

WATER El. 3.3± ATD

SURFACE ELEVATION 1.3 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	4'11½ / 5	P	Loose, black, organic, Silty SAND with Clay	SM	Push Sample is with a 3-inch dia. tube pushed by 200 lbs. into the first 5 feet of material Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						Note: A Vanveen Sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

BORING LOG

SHEET 1 OF 1

PROJECT NAME NEW BEDFORD SUPERFUND SITE

PROJECT NO. 86C855481

DATE 10-30-86

RIG Barge

WATER El 3.0

PD - 19

PROJECT LOCATION New Bedford, Mass.

LOGGED BY C. Bohn DRILLED BY GZA

SURFACE ELEVATION 0.9 ELEVATION DATUM MLW

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Push Tube	3'6" / 5'0"	P	Soft, black, Sandy SILT	ML-SM	Push Sample is with a 3-inch dia. tube pushed by 200 lbs. into the first 5 feet of material
				Loose, light gray SILT	ML	Alluvium
5						BOTTOM OF BORING 5.0'
10						
15						
20						Note: A Vanveen sample was obtained 0-6"
25						

WOODWARD-CLYDE CONSULTANTS

Guild Drilling

September 1987

BORING LOCATION See Fig. 2 DATE START/FINISH 17 Sept 1987 / 18 Sept 1987

GROUND ELEVATION (MLW) 11.0 ft. DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 3.0 ft. DATE 17 Sept87 LOGGED BY T. May, GEI TOTAL DEPTH (FT) 26.0

PD-20

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
10		S1	1-3-7-15	24	18		FILL	S1: Silty Sand with gravel. Fine to Coarse sand fine to coarse gravel, nonplastic fines, cinders, dark brown to black, dry. (FILL).
		S2	18-16-18-26	24	24	HW Casing		S2: Silty Sand with gravel. Fine to coarse sand, fine to coarse gravel, silt, blue gray, dry, and brick fragments. (FILL).
	5	S3	27-15-8-11	24	18	NW Casing Wash Boring		S3: Silty Sand. Widely graded fine to coarse sand with about 30% fines; cinders, and coal, black, dry. (FILL).
5		S4	6-8-8-9	24	8			S4: Similar to S3 but with fine gravel and metal. (FILL).
	10	S5	1-1-2-1	24	12		ORGANIC CLAY	S5: Organic Clay. Organic clay with fine sand, occ. coarse sand to fine gravel, saturated, organic odor, dark gray. (OH).
0								
	15	S6	4-2-2-3	24	24			S6: Organic Clay. Organic clay with trace of sand, organic odor, dark gray. (OH).
-5								
	20	S7	6-4-3-8	24	8			S7: Organic clay. Organic clay with shells, organic odor, dark gray. (OH).
-10						Change in wash returns. Bottom of Casing		
	25	S8	50/4"-4*/2"-7*-6*-5*	24	20	*300# hammer	SILTS TAYND	S8: Silty Sand. Fine to medium sand with 20% fines, golden orange brown. (SM).
								BOTTOM OF BORING 26.0 FEET.

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 15 Sept 1987/ 15 Sept 1987

PD-21

GROUND ELEVATION (MLW) 11.9 ft. DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Not Observed DATE 15 Sept87 LOGGED BY T. May, GEI TOTAL DEPTH (FT) 4.0

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS	SOIL AND ROCK DESCRIPTIONS
10		S1	3-8-7-9	24	10	10 ppm VOC in borehole(1)	S1: Silty Sand. Fine to medium sand with fine gravel, organic silt, glass, dark brown, dry. (FILL).
		S2	3-5-7-11	24	8	15 ppm VOC in borehole(1)	S2: Silty Sand. Widely graded fine to coarse sand with gravel and silt, chips of coal, oily odor. (FILL).
	5						BOTTOM OF BORING 4.0 FEET.
5							
	10						
0							
	15						
-5							
	20						
-10							
	25						
-15							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1)Volatile organic compounds meas. using HNU photoionization detector.
2) Boring terminated due to elevated VOC in borehole.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 18 Sept 1987 / 18 Sept 1987	PD-21A
GROUND ELEVATION (MLW) 11.9 ft.	DRILLED BY P. Didden, Guild Drilling	
GROUNDWATER EL. Depth 7 ft DATE 20 min(1)	LOGGED BY T. May, GEI TOTAL DEPTH (FT) 26.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S1	3-6-4-2	24	12	Ambient HNU readings	FILL	S1: Silty Sand. Widely graded fine to coarse sand and gravel with silt, glass, slag, cinders, and coal. (FILL).
10		S2	3-16-11-10	24	2	Wash Boring Using NW Casing		S2: Silty Sand. Widely graded sand with nonplastic fines, slag, cinders, and glass. (FILL).
	5	S3	26-24-17-17	24	6			S3: Sand. Fine sand with brick fragments, light brown (FILL).
5		S4	13-11-14-16	24	24		SANDS	S4: Narrowly Graded Sand. Fine sand with <5% fines, light brown, dry. (SP).
		S5	10-13-17-16	24	20			S5: Narrowly Graded Sand with silt. Fine sand with about 10% fines, light brown. (SP-SM).
	10							
0								
		S6	4-6-9-7	24	12			S6: Similar to S5.
	15							
-5								
		S7	7-7-13-14	24	18			S7: Silty Sand. Narrowly graded fine sand with 10-20% nonplastic fines, stratified, light brown. (SP-SM).
	20							
-10						Bottom of Casing		
		S8	10-12-9-12	24	12		SW	S8: Sand. 0-6" Narrowly graded fine sand. (SP). 6-12" Widely graded fine to coarse sand with gravel. (SW).
	25							
-15								BOTTOM OF BORING 26.0 FEET.

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1) Measured about 20 min. after completion of boring.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 14 Sept 1987 / 15 Sept 1987

GROUND ELEVATION (MLW) 12.0 ft. DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 6 ft. DATE 15 Sept87 LOGGED BY M.Mahoney/T.MayGEI TOTAL DEPTH (FT) 41.0

PD-22

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S1	2-8-10-12	24	12	Hollow Stem Augers		S1: Silty Sand. Widely graded sand, low plasticity fines, leather scraps, <5% gravel, brown. (FILL).
10		S2	10-100/5"	10	8	Augers bounced while advancing 2.8'-4.0'. Auger cuttings include leather scraps.	FILL	S2: Leather scraps, ashes, glass, debris, etc., <5% soil. (FILL)
	5	S3	14-9-24-16	24	20			S3: Narrowly Graded Sand, fine sand, 30-40% brick fragments, gold-brown. (FILL).
5		S4	3-4-6-6	24	16	Approximate Stratum change		S4: Narrowly Graded Sand, fine sand, 5% ash, gold-brown. (FILL).
		S5	4-10-18-26	24	12			S5: Narrowly Graded Sand. Stratified by color into <1 inch layers, gold-brown. (SP).
	10							
0						Auger cuttings 10-15' narrowly graded sand, saturated.		
	15	S6	4-10-7-10	24	13			S6: Widely Graded Sand. Fine to medium sand, stratified by color and particle size into <1 inch layers, <5% fines, occasional fine gravel, light brown to gray. (SW).
-5						Auger cuttings 17'-20' Widely graded sand, saturated.	SANDS	
	20	S7	3-6-9-10	24	20			S7: Similar to S6.
-10						Advanced augers to 24' NW casing from 24'-39'.		
	25	S8	13-8-8-10	24	13	Wash Boring Using NW Casing		S8: Widely Graded Sand. Fine to coarse sand, <5% fines, light brown. (SW).
-15						Wash returns fine to medium sand.		
		S9	4-5-5-9	24	10			S9: Similar to S8.

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATE

NOTES:

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 14 Sept 1987 / 15 Sept 1987 PD-22

GROUND ELEVATION (MLW) 12.0 ft DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 6.0 ft. DATE 15 Sept87 LOGGED BY M.Mahoney/T.MayGEI TOTAL DEPTH (FT) 41.0 PG. 2 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S9	4-5-5-9	24	0	Sand running into casing sample taken for soil classification.		
-20						Wash returns Med. to coarse sand, gravel in casing.		
	35	S10	10-10-4-12	24	22		SANDS	S10A: 0-12" Sand. Predominantly fine to medium sand, <5% fines, light brown. (SP). S10: 12-22" Sand. Medium to coarse sand, <5% fines, <5% fine gravel, light brown. (SP).
-25						Wash Boring Using NW Casing Bottom of casing		
	40	S11	21-16-47-33	24	14			S11: Silty Sand. Fine sand with fine to medium gravel 20-30% fines, light brown. (SM).
	45							BOTTOM OF BORING 41.0 FEET.

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:

NEW BEDFORB SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 16 Sept 1987 / 16 Sept 1987

GROUND ELEVATION (MLW) 9.3 ft. DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 3.0 ft DATE 20 min(1) LOGGED BY T. May, GEI TOTAL DEPTH (FT) 39.3

PD-23

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S1	3-39-20-3	24	18	Driving on solid object.	FILL	S1: 0-4" Sandy Organic. TOPSOIL 4-18" Brick fragments and Sand. Fine to medium sand light brown, dry. (FILL).
		S2	5-12-11-10/5"-20/0"	23	6	Wash Boring Using NW Casing Wash returns:		S2: Brick Fragments and Mortar. (FILL).
5	5					Brick & mortar Roller bit ahead Fine sand		
		S3	7-13-20-21	24	24	NW Casing Samples wet	SILTY SANDS	S3: Silty Sand. Narrowly graded fine sand with 10-15% fines, light tan saturated. (SP-SM).
0	10	S4	10-13-14-16	24	20			S4: Silty Sand. Narrowly graded fine sand with 30% fines, light tan. (SM).
-5	15	S5	8-10-10-10	24	24			S5: Silty Sand to Sandy Silt. Very fine sand, ≥50% nonplastic fines, light gray to tan. (SM-ML).
-10	20	S6	4-7-12-13	24	24		STRATIFIED SANDS	S6: Narrowly Graded Sand. Fine to medium sand, <5% fines, light brown. (SP).
-15	25	S7	2-6-9-10	24	10			S7: Similar to S6: with occasional coarse grains ar gravel.
-20		S8	10-13-21	24	10			S8: Silty Sand. Widely graded fine to coarse sand with ≥20% fines, 10-15% gravel, golden brown, till structure. (SM).

13

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1) Measured about 20 min. after completion of boring.

NEW BEDFORD SUPERFUND SI

NEW BEDFORD, MA

DATE 13 Nov87 PROJECT 87

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 16 Sept 1987 / 16 Sept 1987

GROUND ELEVATION (MLW) 9.3 ft. DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 3.0 ft DATE 20 min(1) LOGGED BY T. May, GEI TOTAL DEPTH (FT) 39.3

PD-23

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S8	10-13-21 13	24	8	Wash Boring Using NW Casing	SANDS	Silty Sand continued.
-25		S9	40*/3"	3	3	* 300# hammer		S9: Silty Sand. Widely graded fine to coarse sand with ≲20% fines, golden brown. (SM).
	35	RUN 1	min/ft 5 4 5 5 5	60 RQD 83%	56	NW Rock Core	GRANITE	RUN 1: Mica Gneiss. Pinkish gray with mineralized discontinuities dipping at approx. 80 degrees.
-30								
	40							BOTTOM DEPTH 39.3 FEET.
-35								
	45							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1) Measured about 20 min. after completion of boring.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 17 Sept 1987 / 17 Sept 1987 PD-24

GROUND ELEVATION (MLW) 8.2 feet DRILLED BY P. Didden, Guild Drilling

GROUNDWATER EL. Depth 4.0 ft DATE 20 min(2) LOGGED BY T. May, GEI TOTAL DEPTH (FT) 40.0 PG. 1 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S1	6-7-6-11	24	18	3ppm VOC in borehole(1)		S1: 0-3" Brick Fragments. 3-18" Silty Sand. Widely graded fine to coarse sand contains cinders and coal, black. (FILL).
5		S2	8-6-11-12	24	16	Wash boring using HW casing	FILL	S2: Cinders and Slag. (FILL).
	5	S3	3-2-2-3	24	18	NW casing		S3: Similar to S2, saturated. (FILL).
		S4	5-4-3-4	24	10			S4: 0-5" Cinders in Silty Sand. (FILL). S4A: 5-10" Silty Sand. Narrowly graded fine sand with about 35% fines, dark gray, saturated. (SM).
0		S5	4-4-3-3	24	12		ORGANIC SM ??	S5: Silty Sand. Narrowly graded fine sand with about 30 to 40% organic silt, gray to orange brown. (SM with OL)
	10							
-5						Approximate boundary between Org. SM and SM		
	15	S6	16-11-8-13	24	18		SILTY SAND	S6: Silty Sand. Narrowly graded fine sand with about 10 to 20% non-plastic fines. Occ. coarse sand and fine gravel. (SM)
-10								
	20	S7	11-17-23-24	24	24			S7: 0-20" Silty Sand to Silt. Narrowly graded fine sand with about 30% fines (nonplastic silt), light gray. (SM-ML).
							STRATIFIED SANDS	20-24" Narrowly Graded Sand. Medium sand with about 5% fines, brown. (SP)
-15								
	25	S8	7-11-13-13	24	24			S8A: 0-18" Narrowly Graded Sand. Medium to coarse sand with <5% fines, brown. (SP) S8: 18-24" Silty Sand. Narrowly graded fine sand with about 10-20% fines, brown. (SP-SM)
-20								
		S9	3-6-8-13	24	24			S9: Narrowly Graded Sand. Fine to medium sand with < 5% fines, light brown. (SP-SW)

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1)Volatile organic compounds meas. using HNu photoionization detector.
2)Measured about 20 min. after completion of boring.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 17 Sept 1987 / 17 Sept 1987	PD-24
GROUND ELEVATION (MLW) 8.2 ft.	DRILLED BY P. Didden, Guild Drilling	
GROUNDWATER EL. Depth 4 ft. DATE 20 min(2)	LOGGED BY T. May, GEI TOTAL DEPTH (FT) 40.0	PG. 2 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S9	3-6-8-13	24	24	Wash Boring Using NW Casing	WIDELY GRADED SAND	S9: Narrowly Graded Sand. Fine sand with <5% fines, brown. (SP). Widely Graded Sand. Fine to coarse sand with <5% fines, brown, in shoe of sampler. (SW).
-25								
	35	S10	5-5-5-8	24	4			S10: Widely Graded Sand. Fine to coarse sand with <5% fines, brown. (SW).
-30								
		S11	100-50*	12	0	*300# hammer		S11: Widely Graded Sand. Medium to coarse with <5% fines, ≲5% gravel, gray brown. (SW). See note 1
	40					Driller says pushing a cobble.		BOTTOM OF BORING 40 FEET.
	45							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1) Split spoon sample S11 maybe wash material.
2) Measured about 20 min. after completion of boring.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 25 Sept 1987 / 28 Sept 1987

GROUND ELEVATION (MLW) -2.2 ft DRILLED BY D. Serowik, Guild Drilling

GROUNDWATER EL. N/A DATE _____ LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 22.0

PD-25

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL
								1.0-1.8′ 140 20
-5								2.8-3.6′ 210 30
	5							4.6-5.4′ 190 25
								6.4-7.2′ 280 40
-10							DRAINGICS	8.2-9.0′ 260 20
	10							10.0-10.8′ 280 15
								11.8-12.6′ 300 30
-15								13.6-14.4′ >600 —
	15	S1	1/12"-15-10	24	22			S1: 0-15" Peat with about 40-50% organic silt, trace fine sand, brown. (PT)
-20							SAND	15-22" Silty Sand. Widely graded sand with silt and gravel, fine to coarse sand, angular gravel to 3/4" max., 20-30% low plasticity fines, non-stratified, gray. (SM).
	20	S2	6-9-11-11	24	8			S2: Silty Sand. Widely graded fine to coarse sand with 10-20% low plasticity fines and 5% fine gravel, nonstratified, gray. (SM).
-25								BOTTOM OF BORING 22.0 FEET.
	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 25 Sept 1987 / 25 Sept 1987	PD-26
GROUND ELEVATION (MLW) -1.2 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 22.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing for vane tests.		FIELD SHEAR VANE — DEPTH TESTED / TORQUE (INCH-LBS) PEAK / RESIDUAL
						Wash boring using NW casing after vane tests.		1.0-1.8′ — 80 — 5
-5								2.8-3.6′ — 160 — 25
	5							4.6-5.4′ — 225 — 35
							ORGANICS	6.4-7.2′ — 160 — 25
-10								8.2-9.0′ — 300 — 15
	10							10.0-10.8′ — 510 — 35
								11.8-12.6′ — 600 — 25
-15						Could not push vane past 14.5 feet.		13.6-14.4′ — >600 — —
	15	S1	3-3-2-1	24	16		SAND	S1: 0-2" Organic Clay with narrowly graded fine sand occasional shells and fiberous brown organic matter, high plasticity fines, olive. (OH). 2-16" Widely Graded fine to coarse sand nonstratified, <5% fines, <5% fine gravel, light gray. (SW).
-20								
	20	S2	13-24-22-22	24	6			S2: Widely Graded Sand with gravel. Fine to coarse sand, ≈15-20% fine gravel, <5% fines, nonstratified, light gray. (SW).
-25								BOTTOM OF BORING 22.0 FEET.
	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 21 Sept 1987 / 22 Sept 1987	PD-27
GROUND ELEVATION (MLW) -0.9 ft	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 32.0	PG. 1 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8′ 155 15 2.8-3.6′ 140 30 4.6-5.4′ 210 40
-5	5							
		U01	PUSH	24	24		DRGANIC CLAY	U01: (tube trimmings) Organic Clay with narrowly graded sand, 5-15 % fine sand, high plasticity <5% shells, moderate organic odor, dark olive. (OH).
-10	10	U02	PUSH	24	24			U02: (tube trimmings) Similar to U01.
		U03	PUSH	24	24			U03: (tube trimmings) Similar to U01 with 15-20% fine sand.
-15	15	U04	PUSH	24	19			U04: Top of tube similar to U03. (tube trimmings) Peat. Fibrous brown peat, 30-40% high plasticity organic clay, <5% fine sand, moderate organic odor. (PT).
		S1	WOR-9-9	24	24		PEAT	S1: 0-18" Similar to U04 tube trimmings. 18-24" Silty Sand. Narrowly graded fine sand, <5% medium sand, 25-30% fines, gray. (SM).
-20	20	S2	1-2-13	18	18		SILTY FINE SAND	S2: 0-6" Similar to S1. 6-12" Similar to S1 with 40-50% low plasticity fines. (SM). 12-18" Silty Sand. Narrowly graded fine sand, 10-20% low plasticity fines, stratified by color into <1/2" layers, oxidation staining, gold brown. (SM).
-25	25	S3	6-6-8-9	24	19			S3: Silty Sand. Narrowly graded fine sand stratified by color into <1/2" layers, one 1" lens of widely graded sand, 10-20% low plasticity fines tan. (SM).
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 21 Sept 1987 / 22 Sept 1987

PD-27

GROUND ELEVATION (MLW) -0.9 ft. DRILLED BY D. Serowik, Guild Drilling

GROUNDWATER EL. N/A DATE _____ LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 32.0

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S4	11-15-21-24	24	13		SAND	S4: Widely Graded Sand. Fine to medium sand with 5-15% low plasticity fines, tan. (SW-SM).
								BOTTOM OF BORING 32.0 FEET.
-35	35							
-40	40							
-45	45							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 28 Sept 1987 / 28 Sept 1987	PD-28
GROUND ELEVATION (MLW) -0.5 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 17.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using HW casing after vane tests.	ORGANICS	FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED — PEAK — RESIDUAL 1.0-1.8′ — 180 — 30 2.8-3.6′ — 180 — 35 4.6-5.4′ — 145 — 30 6.4-7.2′ — 325 — 30 8.2-9.0′ — 310 — 40 10.0-10.8′ — 470 — 35 11.8-12.6′ — 410 — 120
-5	5							
-10	10							
-15	15	S1	6-3-6-12	24	15	Could not push vane below 13.0 feet.	SILTY SAND	S1: Silty Sand. Widely graded fine to medium sand, ≲15% low plasticity fines, ≲5% coarse gravel, tan-gray. (SW-SM).
-20	20							BOTTOM OF BORING 17.0 FEET.
-25	25							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 23 Sept 1987 / 23 Sept 1987	PD-29
GROUND ELEVATION (MLW) -1.2 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 32.0	PG. 1 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8′ 170 40 2.8-3.6′ 220 40
-5							ORGANICS	
	5	U01	PUSH	23	23			U01: (tube trimmings) Organic Clay with narrowly graded sand, 5-15% fine sand, occasional shells high plasticity, olive gray. (OH).
		U02	PUSH	24	24			U02: (tube trimmings) Similar to U01 with 15-25 % fine sand.
-10								
	10	U03	PUSH	24	24			U03: Top of tube similar to U01. (tube trimmings) Silty Sand. Narrowly graded fine sandwith 10-20% low plasticity fines, trace organics, olive gray. (SM).
		U04	PUSH	24	24			U04: Similar to bottom of U03.
-15								
	15						SILTY SAND	
-20								
	20	S1	2-3-5-7	24	4	Soil was rising up into casing.		S1: Widely Graded Sand with Silt. Fine to coarse sand with 5-15% fines, nonstratified, gray. (SM).
-25								
	25	S2	18-12-11 -11	24	4	Blow count may be inflated due to sampler becoming full before 24" penetration.		S2: Sample appears to be wash material.
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 23 Sept 1987 / 23 Sept 1987	PD-29
GROUND ELEVATION (MLW) -1.2 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 32.0	PG. 2 OF 2

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
		S3	5-8-10-11	24	0	SILTY	SAND	S3: No recovery.
								BOTTOM OF BORING 32.0 FEET.
-35								
	35							
	40							
	45							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 24 Sept 1987 / 24 Sept 1987	PD-30
GROUND ELEVATION (MLW) -1.7 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 17.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.	DRGANICS	FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8' 150 25 2.8-3.6' 300 45
-5	5	U01	PUSH	24	24			U01: Top of tube - Organic Clay with narrowly graded sand. Fine sand, occasional shells and fibrous brown organic matter, high plasticity fines, olive gray. (OH). Bottom of tube - Silty Sand. Narrowly graded fine sand, 10-20% low plasticity fines, occasional organics, gray. (SM).
-10		S1	4-1-4-3	24	12		SILTY SAND	S1: Silty Sand. Narrowly graded fine sand with <5% medium sand, 15-25% low plasticity fines, non-stratified gray. (SM).
	10	S2	3-3-5-7	24	12			S2: Widely Graded Sand fine to medium with <5% coarse sand, <5% fines, well stratified by color into <2" layers, gray black. (SW).
-15	15	S3	3-4-4-4	24	3			S3: Silty Sand. Narrowly graded very fine to fine sand, with 35-45% low plasticity fines, light gray. (SM).
-20	20							BOTTOM OF BORING 17.0 FEET.
-25	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 22 Sept 1987 / 23 Sept 1987	PD-31
GROUND ELEVATION (MLW) -2.1 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 17.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8′ 110 20 2.8-3.6′ 160 30 4.6-5.4′ 320 50 6.4-7.2′ 295 30 8.2-9.0′ 215 20 10.0-10.8′ 365 40 11.8-12.6′ >600 — 13.6-14.4′ >600 —
-5								
	5						ORGANICS	
-10								
	10							
-15								
	15	S1	6-6-3-12	24	14		SILTY SAND	S1: Silty Sand. Widely graded fine to medium sand, with 20-30% low plasticity fines, trace of organics, well stratified by color and texture, gray brown. (SM). BOTTOM OF BORING 17.0 FEET.
-20								
	20							
-25								
	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 24 Sept 1987 / 25 Sept 1987	PD-32
GROUND ELEVATION (MLW) -2.1 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 22.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8′ 100 10
-5								2.8-3.6′ 160 25
	5							4.6-5.2′ 150 35
								6.2-7.0′ 430 50
-10							ORGANICS	8.0-8.8′ 285 60
	10							9.8-10.6′ 260 50
								11.6-12.2′ >600 —
-15						Could not push vane below 12.7 feet.		
	15	S1	1-2-9-11	24	12			S1: 0-6" Sandy Organic Clay. Organic clay with 15-25% narrowly graded fine sand, occasional shells and fibrous brown matter, high plasticity fines olive gray. (OH). 6-12" Widely Graded Sand. Fine to medium sand with <5% fines, nonstratified, light gray. (SW)
-20							SAND	
	20	S2	5-6-6-5	24	8			S2: Similar to 6-12" portion of S1.
-25								BOTTOM OF BORING 22.0 FEET.
	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 DATE START/FINISH 17 Sept 1987 / 17 Sept 1987 PD-33

GROUND ELEVATION (MLW) -1.4 ft. DRILLED BY D. Serowik, Guild Drilling

GROUNDWATER EL. N/A DATE _____ LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 22.0 PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						After performing field shear vane tests, barge was moved 5 ft east for split spoon sampling.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 0.6-1.4' 130 30 2.4-3.2' 420 18 3.2-4.2' 278 80 4.2-5.0' 320 40 6.0-6.8' 410 60 6.8-7.6' 540 80
-5	5	S1	WOR	24	8	No casing used for vane tests.		
						Wash boring using NW casing after vane tests.		
-10							GANIC CLAY	S1: Organic Clay. <10% fibrous brown organic matter occasional shells, high plasticity, olive gray top 3" of sample was black. (OH).
	10	S2	WOR	24	24			S2: Sandy Organic Clay. 10-20% fine sand, occasional shells, high plasticity, olive gray. (OH).
-15								
	15	S3	WOR	24	12			S3: Similar to S2. Shoe of spoon contained 1" of gray fine sand with clay. (OH).
-20							SAND	
	20	S4	5-8-9-11	24	20		SW SP	S4: 0-15" Widely Graded Sand with Gravel. Fine to coarse sand with 20-30% gravel to 1", <5% fines, brown. (SW). 15-20" Silty Sand. Narrowly graded fine sand, 25-30% low plasticity fines, stratified by color into <1/2" layers, red-brown. (SP). BOTTOM OF BORING 22.0 FEET.
-25								
	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2	DATE START/FINISH 17 Sept 1987 / 18 Sept 1987	PD-34
GROUND ELEVATION (MLW) -0.6 ft.	DRILLED BY D. Serowik, Guild Drilling	
GROUNDWATER EL. N/A DATE	LOGGED BY M. Mahoney, GEI TOTAL DEPTH (FT) 17.0	PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.		FIELD SHEAR VANE TORQUE (INCH-LBS) DEPTH TESTED PEAK RESIDUAL 1.0-1.8′ 100 30
								2.8-3.6′ 397 30
-5	5	U1	PUSH	24	0		ORGANIC CLAY	U1: No recovery. Olive gray organic clay adhered to outside of tube with occasional shells.
		U2	PUSH	24	8			U2: Sandy Organic Clay. 10-20% fine sand, occasional shells, one piece of glass, one 3"shell,high plasticity, olive gray with zones of black (OH)
-10	10	U3	PUSH	24	23			U3: Sandy Organic Clay. (tube trimmings) 10-20% narrowly graded fine sand, trace shell fragments, trace fibrous brown organics, strong organic odor, olive gray. (OH).
		U4	PUSH	24	10			UF4: (Piston Slipped 10") soil similar to U3.
-15	15	U5	PUSH	24	23			UF5: Similar to U3.
-20	20							BOTTOM OF BORING 17.0 FEET.
-25	25							
-30								

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

BORING LOCATION See Fig. 2 | DATE START/FINISH 21 Sept 1987 / 21 Sept 1987 | PD-34A

GROUND ELEVATION (MLW) -0.4 ft. | DRILLED BY D. Serowik, Guild Drilling

GROUNDWATER EL. N/A | DATE | LOGGED BY M. Mahoney, GEI | TOTAL DEPTH (FT) 8.5 | PG. 1 OF 1

EL. FT	DEPTH FT	SAMPLE TYPE & No.	BLOWS/ 6 IN.	PEN IN.	REC. IN.	REMARKS		SOIL AND ROCK DESCRIPTIONS
						No casing used for vane tests. Wash boring using NW casing after vane tests.	SANDY ORGANIC CLAY	
-5	5	U01	PUSH	24	24			U01: (Tube trimmings) Sandy Organic Clay. 10-20% narrowly graded fine sand, low plasticity, 10-20% shells, strong organic odor, olive gray. (OL).
		U02	PUSH	24	24			U02: Similar to U01.
-10	10							BOTTOM OF BORING 8.5 FEET.
-15	15							

BLOWS PER 6"-140LB. HAMMER FALLING 30" TO DRIVE A 2.0 IN. OD SPLIT SPOON SAMPLER
PEN-PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC-RECOVERY LENGTH OF SAMPLE
RQD-LENGTH OF SOUND CORES>4 IN./LENGTH CORED, %
S-SPLIT SPOON SAMPLE
U-UNDISTURBED SAMPLE UF-FIXED PISTON
UO-OSTERBERG
▼ GROUNDWATER

NOTES:
1). All depths are referenced to river bottom.

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MA
DATE 13 Nov 87 PROJECT 87311

G E I

TEST PIT LOG

TP-1

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 6.0 ft
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
1 2 3 ▽	Silty Sand. Widely graded, predominantly fine to coarse sand, 10-15% fines, 10% gravel to 3", 40% by volume angular cobbles and boulders to 3'max. dimension, tan. (SM). 3.2 feet
4 5 6	BOTTOM OF HOLE 4 FEET.

REMARKS:
1) Samples collected by Corps personnel: 1 composite sample

PIT DIMENSIONS (FT)
LENGTH 11
WIDTH 6
DEPTH 4

GEI

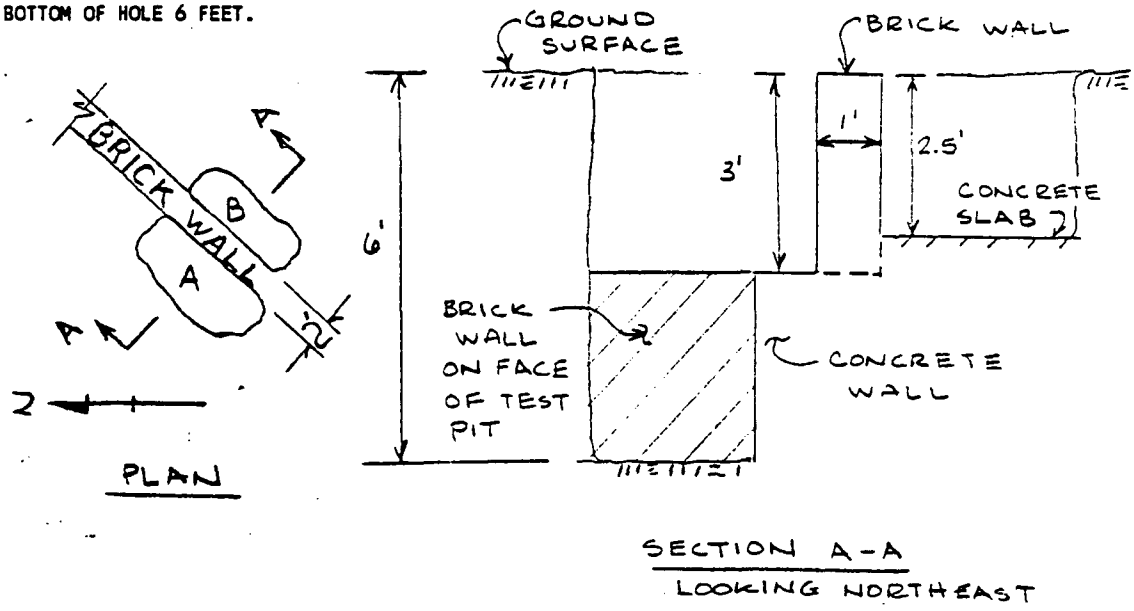
TEST PIT LOG

TP-2

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 10.8 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION (PIT A)
	0-0.1' TOPSOIL 0.1-0.6' Narrowly Graded Sand. Fine to very fine sand, <5% fines, dark gray-green. (SP). 0.6-1.0' Leather Scraps, Glass, and Wood.(FILL)
1	
	1.0-5.0' Brick Rubble. Bricks and mortar, some metal pipes. Matrix of silty sand, widely graded fine to medium sand, 10-15% fines, black.(FILL)
2	
3	
4	
5	5.0-6.0' Silty Sand. Widely graded fine to medium sand, 10-15% fines, 5-10% gravel to 2" max. size, light orange-brown. (SW-SM).
6	BOTTOM OF HOLE 6 FEET.
7	
8	



REMARKS:
1) Samples collected by Corps personnel: 1 from 0.1-0.6'
1 composite

2) No groundwater observed.

PIT DIMENSIONS (FT)

	A	B
LENGTH	10	8
WIDTH	3.5	3
DEPTH	6	2.5

GEI

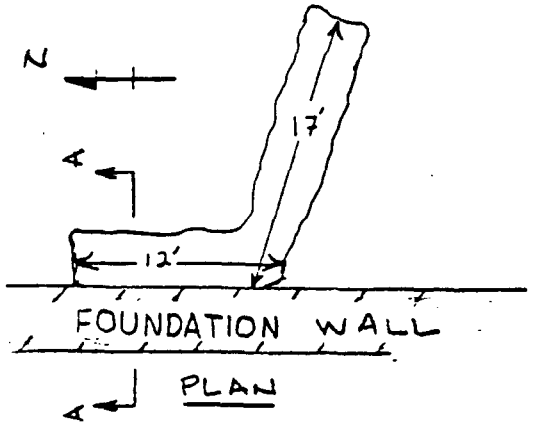
TEST PIT LOG

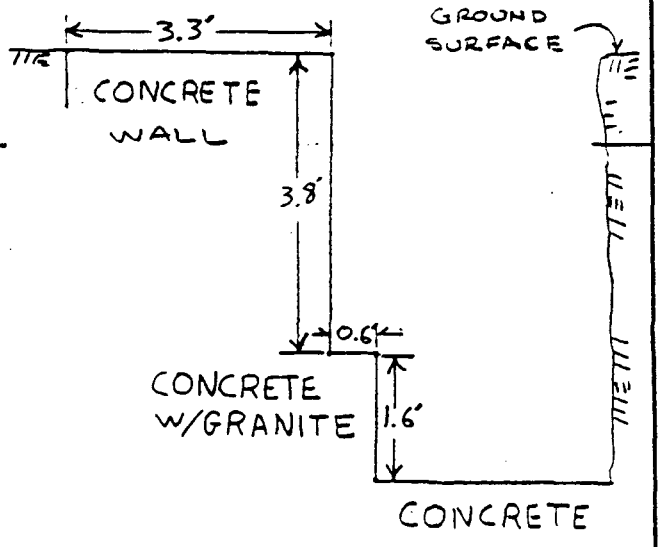
TP-3

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 8.7 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
1, 2	Silty Sand. Widely graded fine to medium sand, 10-15% fines, many cinders and slag black, (layer get thicker to east: extends to 6' deep 17' away).(FILL)
3, 4, 5, 6 ▽	Widely Graded Sand. Medium to coarse sand, 5-10% rounded gravel to 2" max. size, 5-10% fines, tan. (SW-SM). 6.0 feet
7, 8	BOTTOM OF HOLE 6.5 FEET.





SECTION A-A
LOOKING NORTH

REMARKS:
1) Samples collected by Corps personnel: 1 from 0-1.0'
1 from 1-2.5'
1 composite
2) Sample taken at 4' by GEI for gradation test.

PIT DIMENSIONS (FT)
LENGTH 12, 17
WIDTH 3.5
DEPTH 6.5

GEI

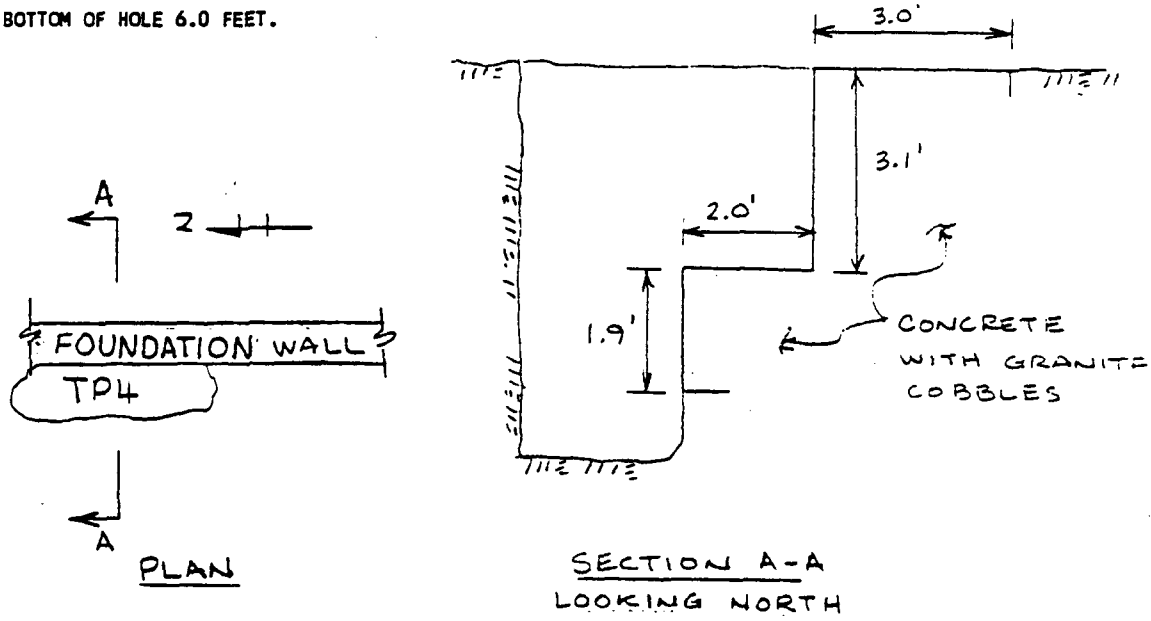
TEST PIT LOG

TP-4

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 8.4 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Silty Sand. Widely graded fine to medium sand, 10-15% fines, many cinders and slag, sheet metal, some bricks, black.(FILL)
1	1.0-1.6' Narrowly Graded Sand. Fine to medium sand, <5% fines, light yellow-tan. SP.
2	1.6-2.0' Narrowly Graded Sand. Fine to medium sand, 5-10% fines, light brown-beige. (SP-SM).
	2.0-3.0' Widely Graded Sand with gravel. Fine to coarse sand, 10-15% gravel to 3" max. size, 5-10% fines, occasional cobbles, light orange brown. (SW-SM).
3	grading to 3.0-5.5' Narrowly Graded Sand. Fine to medium sand, 5-10% fines, light orange brown. (SP-SM).
4	
5	
▽ 5.9 ft. 6	5.5-6.0' Narrowly Graded Sand. Fine to very fine sand, 5-10% silt, light orange-brown. (SP-SM).
7	BOTTOM OF HOLE 6.0 FEET.
8	



REMARKS:
1) Samples collected by Corps personnel: 1 from 0-1.0'
1 from 1.6-2.0'

2) Sample collected from 3.0-4.0' by GEI for gradation tests.

PIT DIMENSIONS (FT)
LENGTH 10
WIDTH 4.5
DEPTH 6.0

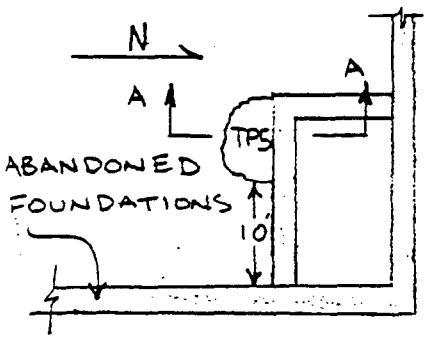
GEI

TEST PIT LOG

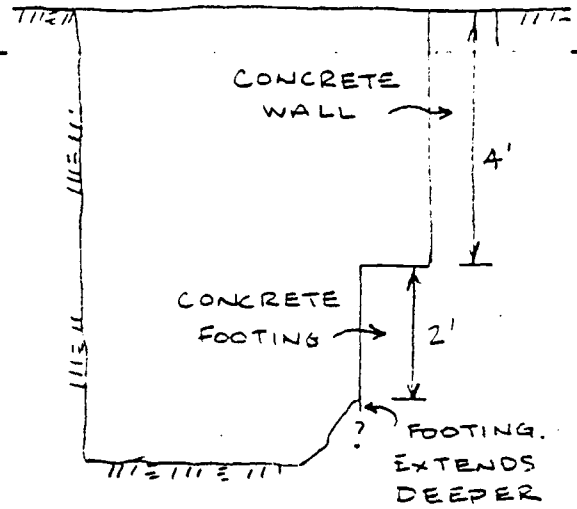
TP-5

PROJECT NEW BEDFORD SUPERFUND SITE	PROJECT NO. 87311
LOCATION NEW BEDFORD, MA	LOCATION See Fig. 2
CLIENT U.S. ARMY CORPS OF ENGINEERS	
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750	GROUND EL. 8.1 ft.
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987	DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Brick Rubble. Bricks and mortar, matrix of widely graded silty sand, predominantly medium to fine sand, 10-15% fines, black.(FILL)
1	
2	
3	
3.5	Silty Sand with Gravel. Widely graded fine to coarse sand, 10-15% gravel to 3" max. size, 10-15% fines, occasional cobbles, tan. (SW-SM).
4	
5	
6 ▽	6.0 feet
7	BOTTOM OF HOLE 7 FEET.
8	
9	



PLAN



SECTION A-A

REMARKS:
1) Samples collected by Corps personnel: 1 composite

PIT DIMENSIONS (FT)
LENGTH 10
WIDTH 5.5
DEPTH 7

GEI

TEST PIT LOG

TP-6

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 8.4 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
1	0-1.0' Brick Rubble. Brick and mortar, matrix of silty sand, widely graded fine to medium sand, 10-15% fines, black.(FILL) 1.0-1.6' Ash. Ash with narrowly graded sand, mostly medium sand, occasional gravel to 2" max. size, light gray to brown.(FILL)
2	1.6-3.0' Narrowly Graded Sand. Fine to medium sand, 5-10% fines, tan. (SP-SM)
3	3.0-4.0' Widely Graded Sand with Gravel. Fine to coarse sand, 10-15% gravel to 2" max. size, 5-10% fines, light orange-brown. (SW-SM).
4	4.0-7.0' Silty Sand. Narrowly graded fine to medium sand, 10-15% fines, tan. (SP-SM).
5	
6 ▽	6.0 feet
7	7.0-7.5' Silty Sand. Narrowly graded organic very fine to fine sand, 15-20% fines, contains significant organic matter. (SP-SM)
8	BOTTOM OF HOLE 7.5 FEET.
9	

REMARKS:
1) Samples collected by Corps Personnel: 1 composite
2) Bottom of foundation not encountered.

PIT DIMENSIONS (FT)
LENGTH 10
WIDTH 5
DEPTH 7.5

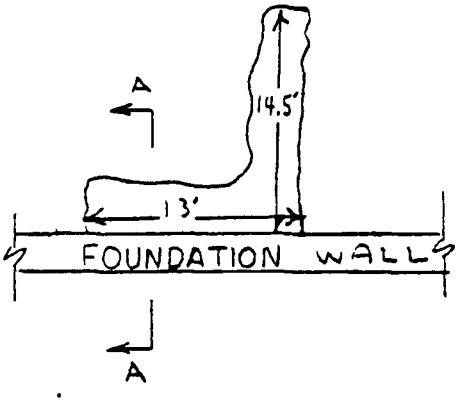
GEI

TEST PIT LOG

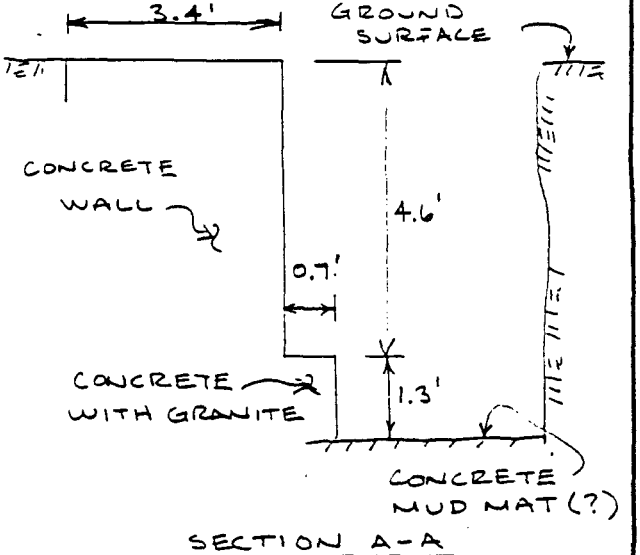
TP-7

PROJECT NEW BEDFORD SUPERFUND SITE	PROJECT NO. 87311
LOCATION NEW BEDFORD, MA	LOCATION See Fig. 2
CLIENT U.S. ARMY CORPS OF ENGINEERS	
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750	GROUND EL. 8.9 ft.
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987	DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
0.6	Widely Graded Sand. Medium to coarse sand 15-20% gravel to 2" max. size, <5% fines, many cinders, slag, some bricks and cobbles, black.(FILL)
1	0.6-1.1' Widely Graded Sand with Gravel. Medium to coarse sand, about 15% gravel to 3" max. size, occasional cobbles, <5% fines, tan. (SW).
	1.1-2.0' Similar to surface layer. (FILL)
2	Widely Graded Sand. Medium to coarse sand, 5-10% rounded gravel to 2" max. size, occasional cobbles, 5-10% fines, tan. (SW).
3	
4	
5	
6 ▽	6.0 feet
7	BOTTOM OF HOLE 6.5 FEET.



PLAN



SECTION A-A

REMARKS:

PIT DIMENSIONS (FT)

LENGTH	13 14.5
WIDTH	4
DEPTH	6.5

GEI

TEST PIT LOG

TP-8

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 8.7 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Brick Rubble. Bricks and mortar, metal pipes, timbers, scrap metal. Matrix of silty sand, widely graded, fine to medium sand, 10-15% fines, brown-black. (FILL)
1	
2	
3	
4	Refusal, concrete slab
	BOTTOM OF HOLE 4.2 FEET.
5	
6	

REMARKS:
1) Samples collected by Corps personnel: 1 composite

2) No groundwater encountered.

PIT DIMENSIONS (FT)
LENGTH 18
WIDTH 10
DEPTH 4.2

GEI

TEST PIT LOG

TP-9

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 11.0 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Asphalt. Asphalt slabs, some bricks, matrix of silty sand, widely graded fine to medium sand, 10-15% fines, 5-10% gravel to 2" max. size, light brown.(FILL)
1	
1.8	
2	Widely Graded Sand with Silt. Fine to medium sand with about 10-15% fines, many cinders, glass, bricks, steel pipe, black.(FILL)
3	
3.5	
4	Silty Sand with Gravel. Widely graded fine to coarse sand, 15-20% gravel to 2" max. size, 10-15% fines, many cobbles, light yellow-brown. (SW-SM).
5	
6	
▽	6.5 feet
7	BOTTOM OF HOLE 7 FEET.
8	
9	

REMARKS:
1) Samples collected by Corps personnel: 1 composite
1 from 1.8-3.5'

PIT DIMENSIONS (FT)
LENGTH 10
WIDTH 5
DEPTH 7

GEI

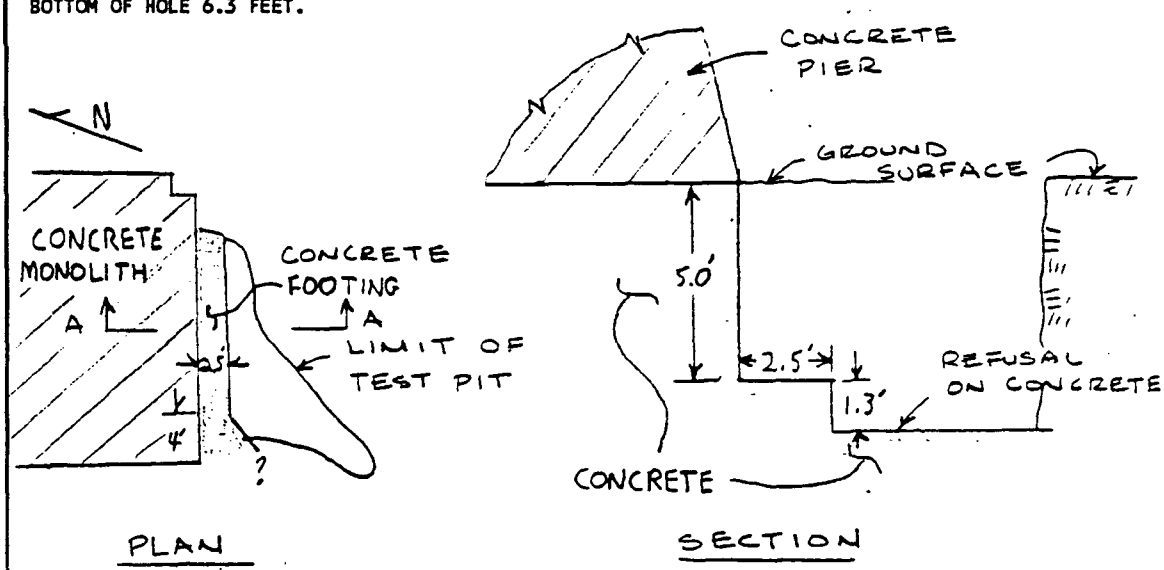
TEST PIT LOG

TP-10

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 12.0 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
1	Brick Rubble. Bricks, mortar and concrete, many bottles, broken glass, scrap metal, wire, wood, matrix of silty sand, widely graded medium to fine sand, 10-15% fines, dark brown.(FILL)
2	
3	
4	
5	
6	
7	Concrete pad or mud mat. BOTTOM OF HOLE 6.3 FEET.
8	



REMARKS:

1) No groundwater encountered.

PIT DIMENSIONS (FT)
LENGTH Irregular
WIDTH Irregular
DEPTH 6.3

GEI

TEST PIT LOG

TP-11

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 21 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 10.0 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Brick Rubble. Bricks and mortar, some cinders: matrix of silty sand, fine to medium sand, 10-15% fines, black.(FILL)
1	
2	
3	
3.5	Ash with Sand. Ashes with narrowly graded sand, mostly medium sand, occasional gravel to 2" max. size, some bricks, light gray, occasional rust-orange stained layers.(FILL)
4	
5	Silty Sand. Widely graded fine to medium sand, some coarse sand, about 10% gravel to 3" max. size, 10-15% fines, some bricks, tan. (SW-SM/FILL).
6	
▽	6.4 feet
7	BOTTOM OF HOLE 7 FEET.
8	

REMARKS:
1) Samples collected by Corps personnel: 1 composite
1 from 3.5-5.0'

PIT DIMENSIONS (FT)
LENGTH 9
WIDTH 4
DEPTH 7

GEI

TEST PIT LOG

TP-12

PROJECT NEW BEDFORD SUPERFUND SITE
LOCATION NEW BEDFORD, MA
CLIENT U.S. ARMY CORPS OF ENGINEERS
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987

PROJECT NO. 87311
LOCATION See Fig. 2
GROUND EL. 9.8 ft.
DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Brick Rubble. Bricks and mortar, some ash and cinders. Matrix of silty sand, widely graded fine to medium sand, 10-15% fines, black.(FILL)
1	
2	
3	
4	Concrete slab
	BOTTOM OF HOLE 4 FEET.
5	
6	
7	

REMARKS:
1) Samples collected by Corps personnel: 1 composite
1 surface sample
2) Leather cuttings and scraps on surface.
3) No groundwater encountered.

PIT DIMENSIONS (FT)
LENGTH 11
WIDTH 3.5
DEPTH 4

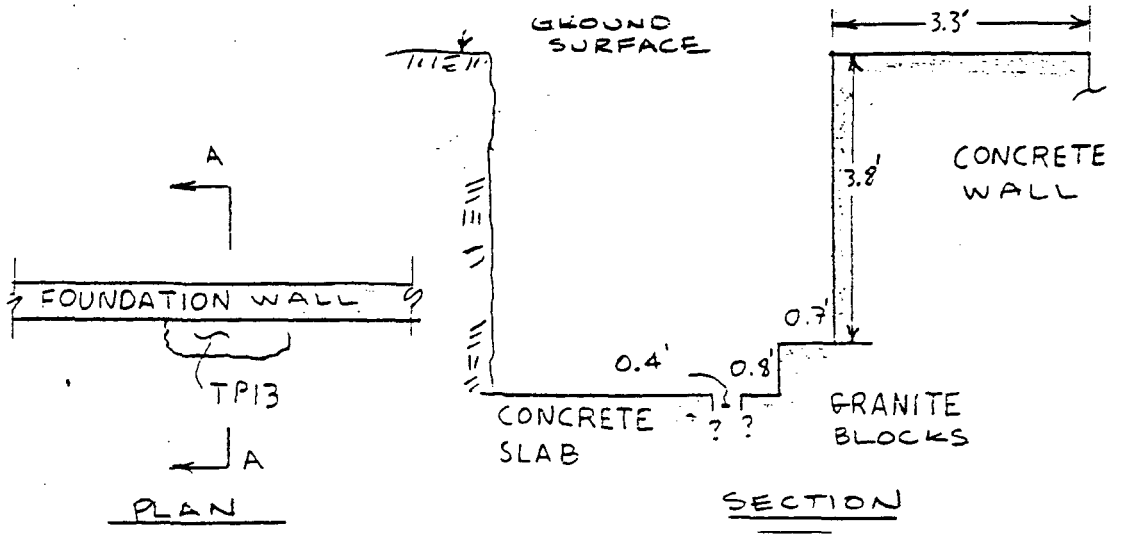
GEI

TEST PIT LOG

TP-13

PROJECT NEW BEDFORD SUPERFUND SITE	PROJECT NO. 87311
LOCATION NEW BEDFORD, MA	LOCATION See Fig. 2
CLIENT U.S. ARMY CORPS OF ENGINEERS	
CONTRACTOR/EQUIPMENT J.S. LUIZ, INC. / FORD 750	GROUND EL. 8.7 ft.
OBSERVED BY B. KILCOYNE, GEI DATE 22 SEPT 1987	DATUM MLW

DEPTH BELOW GROUND SURFACE (FT)	SOIL DESCRIPTION
	Brick Rubble. Brick and mortar, some scrap metal, matrix of silty sand, widely graded, mostly fine to medium sand, 10-15% fines, brown-black.(FILL)
1	
2	
3	
4	
4.6	Concrete slab.
	BOTTOM OF HOLE 4.6 FEET.
5	
6	



REMARKS:

1) No groundwater encountered.

PIT DIMENSIONS (FT)
LENGTH 12
WIDTH 4.5
DEPTH 4.6

GEI

Environmental Drilling, Inc.

September 1988

Site New Bedford Superfund Pilot Study	Boring No. PD-35 Sta. 11+00 75' Lt.	Page 1 of 2

ELEV.	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
						* Geotextile
2	1	4"	X	70	Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic Clay (Mud Wave)
0	2	4"	X	155		
-2	3	4"	X	180		
-4	4	4"	X	245		
-6	5	4"	X	245		
-8	6	4"	X	415		
-10	7	4"	X	480		
-12	9	4"	X	600		

Site New Bedford Super fund Pilot study	Boring No. PD-35 Sta. 11+00 75' Lt.	Page 2 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
		9	4"	X	600		Organic Clay Bottom of boring at -14.5'
16							

Form 58A(Test)

Boring No. PD-35

Site New Bedford Superfund Pilot Study	Boring No. PD-36 Sta. 11+57 24' Rt.	Page 1 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
							✓ Top of dike
3						Hand excavated to geotextile	Granular Fill
							✓ Geotextile
		1	4"	X	320	Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic Clay
1							
		2	4"	X	215		
-1							
		3	4"	X	170		
-3							
		4	4"	X	195		
-5							
		5	4"	X	195		
-7							
		6	4"	X	210		
-9							
		7	4"	X	270		
-11							
		8	4"	X	390		

Site New Bedford Superfund Pilot Study	Boring No. PD-36 Sta. 11+57 24' Rt.	Page 2 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
							Organic Clay
		9	4"	X	600		
15							
		10	4"	X	7600		Bottom of boring at -16.0'
17							

Form 58A (Test)

Boring No. PD-36

Site New Bedford Superfund Pilot Study	Boring No. PD-37 Sta. 11+00 18' Lt.	Page 1 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
							↓ Top of dike
4						Drilled and washed through granular fill. Four-inch diameter casing advanced to elev. -2.0.	Granular Fill
2							
0							↓ Geotextile
-2						Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic Clay
		1	3"	X	165		
-4							
		2	3"	X	80		
-6							
		3	3"	X	95		
-8							
		4	3"	X	140		
-10							
		5	3"	X	185		

Site New Bedford Superfund Pilot Study	Boring No. PD-37 Sta. 11+00 18' Lt.	Page 2 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
							Organic Clay
		6	3"	X	203		
-14							
		7	3"	X	320		
-16							Bottom of boring at -16 ±
-18							

Site New Bedford Superfund Pilot Study	Boring No. PD-38 Sta. 10 + 96 10' Rt.	Page 1 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
						Drilled and washed through granular fill. Four-inch diameter casing advanced to elev. -6.5	Granular Fill
2							
0							
-2							
-4							
-6							Geotextile
						Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic Clay
-8		1	3"	X	140		
-10		2	3"	X	177		
-12		3	3"	X	174		

Site New Bedford Superfund Pilot Study	Boring No. PD-38 Sta. 10+96 18' Lt.	Page 2 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
							Organic Clay
-14		4	3"	X	190	Refusal	Bottom of boring at -14.9'
-16							

Site New Bedford Superfund Pilot Study	Boring No. PD-38 Sta. 11+00 75' Rt.	Page 1 of 1

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
						Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic Clay (mud wave)
2		1	4"	X	145		
0		2	4"	X	115		
-2		3	4"	X	160		
-4		4	4"	X	155		
-6		5	4"	X	240		
-8		6	4"	X	315		
-10		7	4"	X	520		Bottom of boring at -10.2'
-12							

FORM 58A(Test)

Boring No. PD-38

Site New Bedford Superfund Pilot Study	Boring No. PD-40 Sta. 10+00 10' Lt.	Page 1 of 2

ELEV.	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
						Top of dike
2					Drilled and washed through granular fill. Four-inch diameter casing advanced to elev. - 11.5.	Granular Fill
0						
-2						
-4						
-6						
-8						
-10						Geotextile
-12	1	3"	X	340	Performed hand cranked vane shear tests at 2 foot intervals. Shear vane was pushed to each new location.	Organic clay

Site New Bedford Superfund Pilot Study	Boring No. PD-40 Sta. 10+00 10' Lt.	Page 2 of 2

ELEV.	1" = 2'	VANE TEST NO.	SIZE	DEPTH RANGE	T (IN-LB)	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
		2	3"	X	275		Organic Clay
-16		3	3"	X	480		Bottom of boring at -16.0'

Form 58A(Test)

Boring No. PD-40

Goldberg - Zoino Drilling

August 1988 and November 1988

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MI-1
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 8/24/88 DATE END 8/25/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/25				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST
									FILL
5									
10									Geotextile Matting 11'
									ORGANICS
20									23'
25									SAND, Gravel
30									28' BOTTOM OF BOREHOLE

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
>50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Slope Indicator Casing to depth of 23'7 using following listed materials:
a.) 30' of slope indicator casing with couplings.
b.) 50 pounds of flint shot sand.
c.) Cement groute from 28' to 23' depth.
d.) Sand backfill from 23' to 3' depth.

2. This installation was not accepted due to misalignment of casing and was redone and numbered MI-1A

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MI-1

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MI-1A
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 8/25/88 DATE END 8/26/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/26				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST
5									FILL
10									Geotextile Matting 11'
15									ORGANICS
20									23'6
25									SAND, Gravel
30									28'6 BOTTOM OF BOREHOLE

This is to certify the information reported herewith is accurate to the best of my knowledge and belief:

John B. Forde

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Slope Indicator Casing to depth of 28'6 using following listed materials:
a.) 30' of slope indicator casing with couplings.
b.) 50 pounds of flint shot sand.
c.) Cement groute from 28'6 to 23' depth.
d.) Sand backfill from 23' to 3' depth.
e.) 4" dia x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MI-2
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 8/23/88 DATE END 8/23/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS				
DATE	TIME	WATER	CASING	STABILIZATION TIME
8/23				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST
5									FILL
10									Geotextile Matting 12'
20									ORGANICS 23'6
25									SAND, Gravel 28'6
30									BOTTOM OF BOREHOLE

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Slope Indicator Casing to depth of 28'6 using following listed materials:
a.) 30' of slope indicator casing with couplings.
b.) 50 pounds of Ottowa filter sand.
c.) Cement groute from 28'6 to 23' depth.
d.) Sand backfill from 23' to 3' depth.
e.) 4" dia x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-A
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 11/8/88 DATE END 11/8/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION
11/8		10'		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMARKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									10' ORGANICS
15									16' BOTTOM OF BOREHOLE
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 16'using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 12' Riser Pipe
b.) 100 pounds of ottowa filter sand from 16' to 11'
c.) 25 pounds of bentonite pellets from 11' to 8'
d.) Sand backfill from 8' to ground surface
e.) 4" dia x 7'6 Protective casing with lock

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MW-A

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-B
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 11/9/88 DATE END 11/9/88

PLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/9		3'		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
									3' ORGANICS
5									7' BOTTOM OF BOREHOLE
10									
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 7'0 using following listed materials:
a.) 1'of 2" Teflon Silt Trap, 5' Screen, 5' Riser Pipe
b.) 100 pounds of ottowa filter sand from 7'0 to 1'0
c.) 25 pounds of bentonite pellets from 1'0 to ground surface

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MW-B

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-C
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 11/9/88 DATE END 11/9/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/9		3'		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMARKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
									3'
5									ORGANICS
									7'
									SAND & GRAVEL
10									12' BOTTOM OF BOREHOLE
15									
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 12'using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 10' Riser Pipe
b.) 100 pounds of ottowa filter sand from 12' to 5'
c.) 25 pounds of bentonite pellets from 5' to 3'
d.) Sand backfill from 3' to ground surface

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-D
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 11/9/88 DATE END 11/9/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/9		12'8		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									
									17'
20									ORGANICS
25									27' BOTTOM OF BOREHOLE
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 27'using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 25' Riser Pipe
b.) 100 pounds of ottawa filter sand from 27' to 20'
c.) 25 pounds of bentonite pellets from 20'to 18'
d.) Sand backfill from 18'to ground surface
e.) 4" dia x 7'6 Protective casing with lock

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MW-D

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-E
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 11/9/88 DATE END 11/9/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/9		12'8		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMARKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									
15									17' ORGANICS
									18' BOTTOM OF BOREHOLE
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 18'using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 14' Riser Pipe
b.) 100 pounds of ottowa filter sand from 18' to 9'
c.) 25 pounds of bentonite pellets from 9' to 7'
d.) Sand backfill from 7' to ground surface
E.) 4" X 7'6 Protective casing with lock

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-F
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 11/8/88 DATE END 11/8/88

PLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/8		8'		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									12' ORGANICS
									14' BOTTOM OF BOREHOLE
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
0-50	DENSE	8-15	STIFF
50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 14'using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 10' Riser Pipe
b.) 100 pounds of ottowa filter sand from 14' to 7'
c.) 25 pounds of bentonite pellets from 7' to 5'
d.) Sand backfill from 5' to ground surface
E.) 4" X 7'6 Protective casing with lock

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MW-F

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. MW-G
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. MOORE
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 11/10/88 DATE END 11/10/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
11/10		8'		TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									13' ORGANICS
15									14'6 BOTTOM OF BOREHOLE
20									
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde,

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Observation Well to a depth of 14'6 using following listed materials:
a.) 2'of 2" Teflon Silt Trap, 5' Screen, 10' Riser Pipe
b.) 100 pounds of ottowa filter sand from 14'6 to 7'
c.) 25 pounds of bentonite pellets from 7' to 5'
d.) Sand backfill from 5' to ground surface
E.) 4" X 7'6 Protective casing with lock

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. MW-F

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. PIEZ-1
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 8/19/88 DATE END 8/22/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/19				TIDAL AREA

DEPTH	CASING BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0								0' STONE DUST FILL Geotextile Matting 1'6
								STONE DUST
5								FILL
10								
								Geotextile Matting 15'
								ORGANICS
20								21'
								BOTTOM OF BOREHOLE
25								
30								

This is to certify the information reported herewith is acccurate to the best of my knowledge and belief.

John B. Forde

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Piezometer to depth of 19' using following listed materials:
a.) One 1-1/2" x 30" porous tube piezometer tip.
b.) 20' of 3/4" Schedule 80 PVC riser.
c.) Sand backfill from 21' to 16' depth.
d.) 25 pounds of non stick bentonite pellets used to place seal from 16' to 12' depth.
e.) 4" dia. x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. PIEZ-1

GZA DRILLING, INC.
1215 W. CHESTNUT ST., BROCKTON, MA 02401
(A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)

PROJECT
COMBINED DISPOSAL FACILITY
NEW BEDFORD, MA

REPORT OF BORING No. PIEZ-2
SHEET 1 OF 1
FILE No. 13274
CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 8/18/88 DATE END 8/19/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/18				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION / BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									5' Geotextile Matting ?
10									STONE DUST FILL
13'6									Geotextile Matting ?
15									ORGANICS
20									20' BOTTOM OF BOREHOLE
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Piezometer to depth of 18' using following listed materials:
a.) One 1-1/2" x 30" porous tube piezometer tip.
b.) 20' of 3/4" Schedule 80 PVC riser.
c.) Sand backfill from 20' to 15' depth.
d.) 25 pounds of non stick bentonite pellets used to place seal from 15' to 11' depth.
e.) 4" dia. x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. PIEZ-2

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. PIEZ-3
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 8/18/88 DATE END 8/19/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/18				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									Geotextile Matting 10'
									ORGANICS
20									21' BOTTOM OF BOREHOLE
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Piezometer to depth of 20'6 using following listed materials:
a.) One 1-1/2" x 30" porous tube piezometer tip.
b.) 20' of 3/4" Schedule 80 PVC riser.
c.) Sand backfill from 21' to 16' depth.
d.) 25 pounds of non stick bentonite pellets used to place seal from 16' to 9' depth.
e.) 4" dia. x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. PIEZ-3

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. PIEZ-4
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION DATUM
DATE START 8/22/88 DATE END 8/22/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/22				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' STONE DUST FILL
5									
10									9'6 Geotextile Matting STONE DUST -FILL 12'6 Geotextile Matting
15									ORGANICS
20									19' BOTTOM OF BOREHOLE
25									
30									

This is to certify the information reported herewith is accurate to the best of my knowledge and belief.

John B. Forde

John B. Forde

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
10-30	M. DENSE	4- 8	M. STIFF
30-50	DENSE	8-15	STIFF
> 50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Piezometer to depth of 17' using following listed materials:
a.) One 1-1/2" x 30" porous tube piezometer tip.
b.) 16' of 3/4" Schedule 80 PVC riser.
c.) Sand backfill from 19' to 14' depth.
d.) 30 pounds of nonstick bentonite pellets used to place seal from 14' to 10' depth.
e.) 4" dia. x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. PIEZ-4

GZA DRILLING, INC.	PROJECT	REPORT OF BORING No. PIEZ-5
1215 W. CHESTNUT ST., BROCKTON, MA 02401 (A DIVISION OF GOLDBERG-ZOINO & ASSOCIATES, INC)	COMBINED DISPOSAL FACILITY NEW BEDFORD, MA	SHEET 1 OF 1 FILE No. 13274 CHKD. BY JEH

FOREMAN: R. JONES
CLASSIFIED BY: J. FORDE
INSPECTOR:

BORING LOCATION AS LOCATED BY R. ZOPPO COMPANY
GROUND SURFACE ELEVATION _____ DATUM _____
DATE START 8/22/88 DATE END 8/23/88

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 In.

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb. HAMMER FALLING 24 In.

CASING SIZE: 4" (HW) OTHER:

GROUNDWATER READINGS

DATE	TIME	WATER	CASING	STABILIZATION TIME
8/23				TIDAL AREA

DEPTH	CASING	BLOWS	SAMPLE No.	PEN./REC	DEPTH (Ft.)	BLOWS/6"	SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	REMKS	STRATUM DESCRIPTION
0									0' FILL 0'9 Geotextile Matting STONE DUST FILL Geotextile Matting 8' ORGANICS 18' BOTTOM OF BOREHOLE
5									
10									
20							This is to certify the information reported herewith is accurate to the best of my knowledge and belief. John B. Forde		
25									
30									

GRANULAR SOILS Blows/Ft	Density	COHESIVE SOILS Blows/Ft	Density
0- 4	V. LOOSE	< 2	V. SOFT
4-10	LOOSE	2- 4	SOFT
0-30	M. DENSE	4- 8	M. STIFF
0-50	DENSE	8-15	STIFF
50	V. DENSE	15-30	V. STIFF
		> 30	HARD

REMARKS: 1. Installed Piezometer to depth of 16' using following listed materials:
a.) One 1-1/2" x 30" porous tube piezometer tip.
b.) 16' of 3/4" Schedule 80 PVC riser.
c.) Sand backfill from 18' to 13' depth.lets.
d.) 25 pounds of non stick bentonite pellets used to place seal from 13' to 9' depth.
e.) 4" dia. x 7'6 Protective casing with lock.

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA

BORING No. PIEZ-5

APPENDIX 6-B

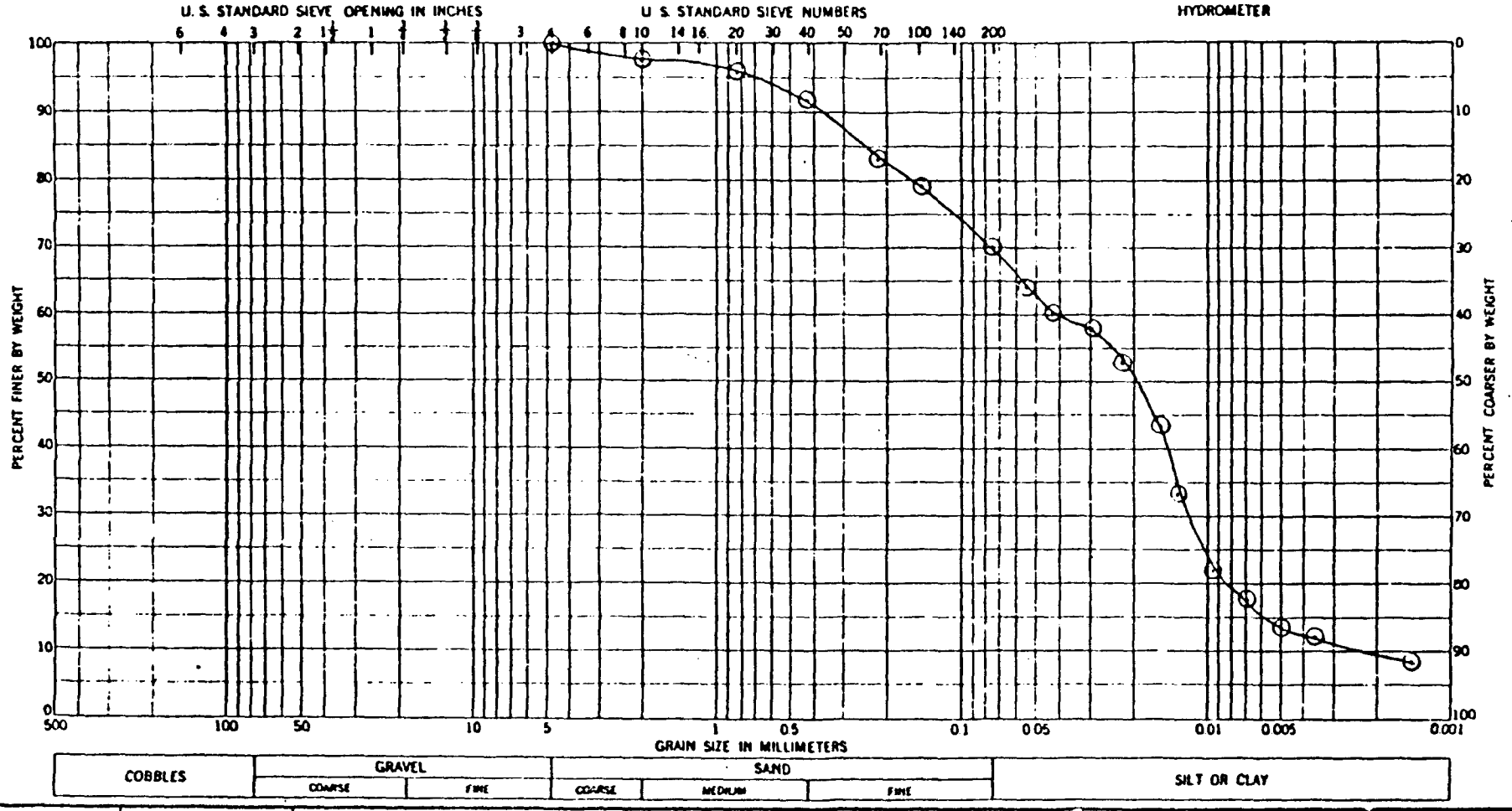
Soil Laboratory Test Data

NED Materials and Water Quality Lab

October 1985 to December 1985

Table VII
New Bedford Superfund
Physical Analyses
Moisture and Volatiles

Grid No.	Stratum (inches)	Lab ID No.	% Moisture	% Volatiles
E-25-1	0-24	9910 E/E	54.1	14.4
E-27-1	0-18	9912 C	53.4	7.64
G-13-1	0-10	9914 E	52.7	13.6
G-17-2	0-38	9918 C	68.6	21.3
G-20-2	0-9	9921 D	55.6	12.2
G-29-1	0-27	9922 D	54.0	7.05
H-21	0-37	9869 D	62.6	13.7
H-25	0-12	9907 D	60.6	13.4
H-33	0-36	9859 D	48.0	5.64
I-3-1	18-28	9925 D	31.8	5.62
I-9-1	0-8	9927 D	64.5	17.0
I-11-1	0-13	9930 E	67.4	22.8
I-15	6-46	9902 F	55.9	7.54
I-19	0-13	9786 D	67.3	14.2
I-23	24-45	9840 E	58.7	11.3
I-28	0-38	9849 D	58.8	11.2
I-31	0-8	9778 C	30.5	5.33
J-5-1	0-12	9934 C	50.4	9.31
J-8-2	0-15	9938 C	68.1	22.9
J-13-2	0-20	9941 C/D	29.2	4.55
J-15-1	0-16	9942 B	40.5	7.09
J-17-2	0-6	9945 C	51.9	10.8
J-20-2	0-16	9947 B	24.1	3.04
K-5-2	0-7	9949 D	66.2	21.7
K-26-1	0-22	9950 C/D	23.2	2.99
K-28-2	8-20	9953 D	24.1	2.64
K-32-1	0-23	9954 C	30.2	3.47
L-10-1	11-34	9956 E	54.2	7.31
L-29-2	6-34	9962 E	56.9	6.87
M-6-2	24-31	9965 D	42.2	7.32
M-27-1	16-26	9967D	27.2	3.24



Sample No	~~Elev or~~ Depth	Classification	Nat w %	LL	PL	PI
9907D	0"-12"	Black-org. sandy, silty CLAY (OH) w/ mar. odor Sp. Gr. = 2.44		135	48	87

Project NEW BEDFORD, MA

Hole 9907 D

LAB DEA

Boring No 100-422-8

Date 10/31/85

GRADATION CURVES

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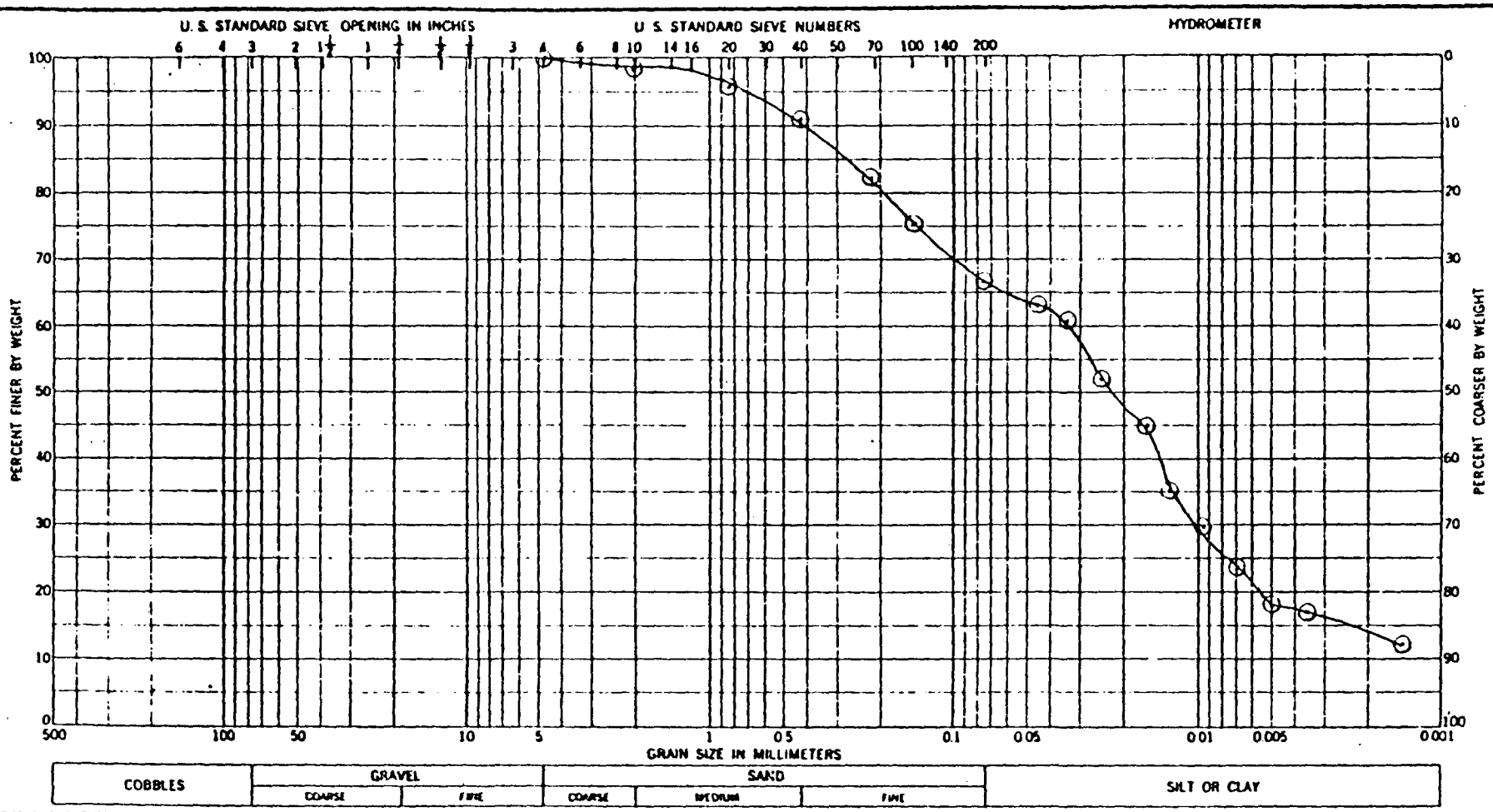


Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI
9910 E+F	0"-24"	Olive green - org. sandy, silty CLAY (OH) w/ mat. odor Sp. Gr = 2.50		123	46	76

Project: NEW BEDFORD, MA

Area: 9910 E+F

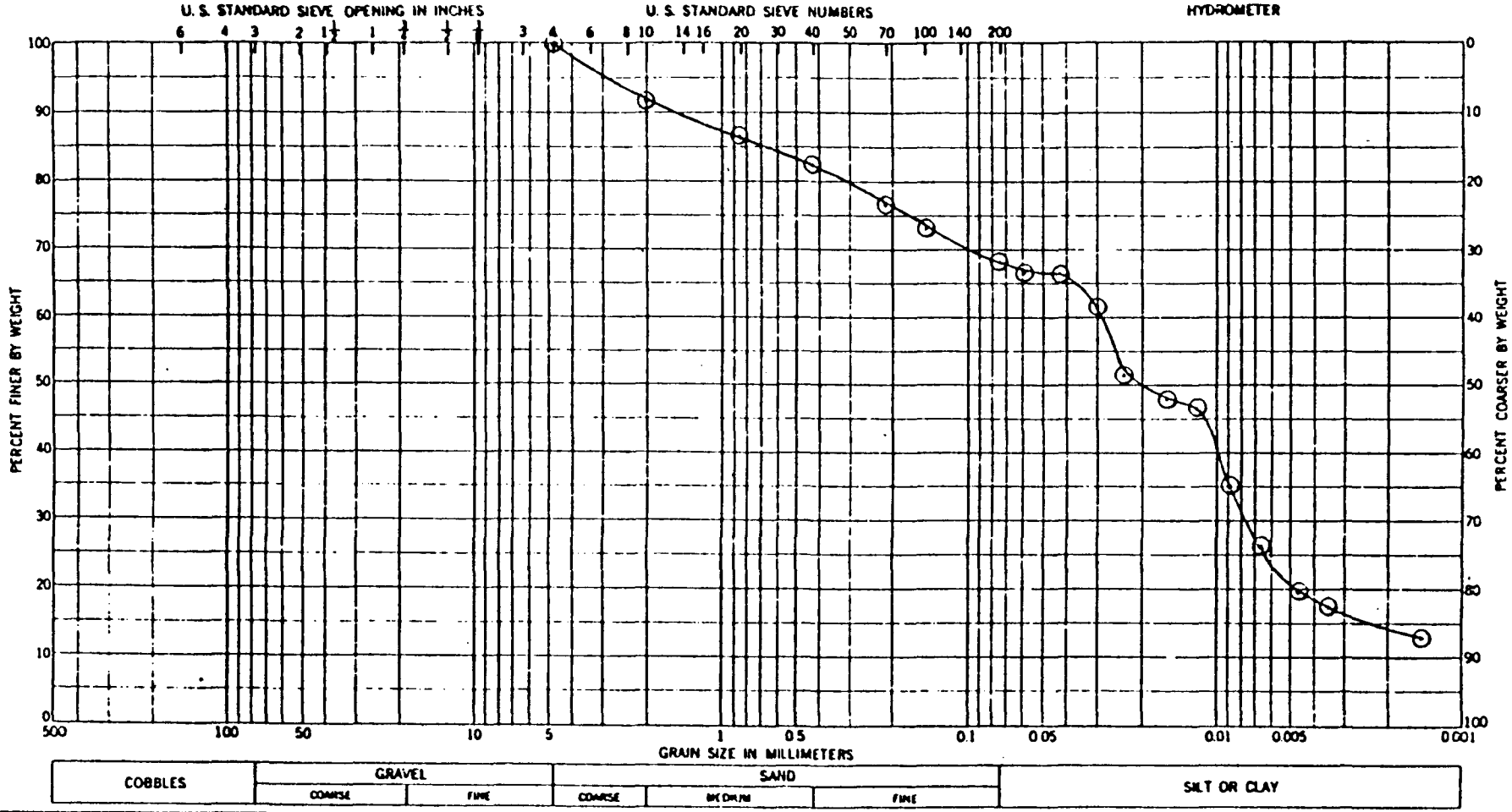
AB SER: 100-422-9

Boring No.

Date: 10/31/85

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No	Elev—or Depth	Classification	Nat w %	LL	PL	PI
9912 C	0"-18"	Black-org. sandy silty CLAY (OH) w/ mdr. odor Sp. Gr. = 2.53		136	43	93

Project NEW BEDFORD, MA

Area 9912 C

LAB SEIC Boring No. 100-422-10

Date 10/31/85

GRADATION CURVES

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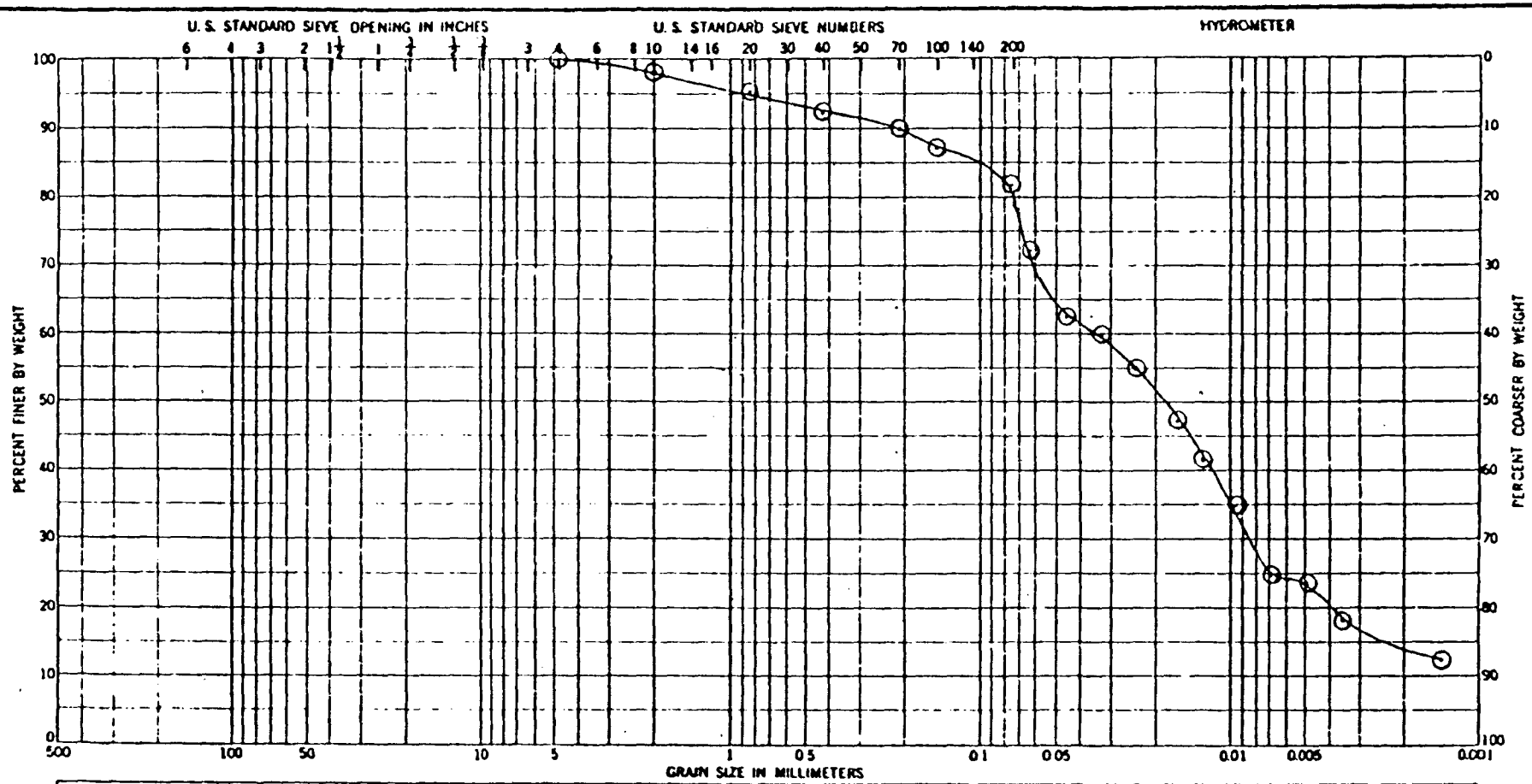

Sample No	Elev—or Depth	Classification	Nat w %	LL	PL	PI
9922D	0"-27"	Black-olive green-org. sandy silty CLAY (OH) w/ mar odor Sp. Gr. = 2.57		124	36	88

GRADATION CURVES

Project: NEW BEDFORD, MA

Area: 9922 D

LAB SER Boring No: 100-422-14

Date: 10/31/85

ENG FORM 1 MAY 63 2087

Woodward - Clyde Consultants

November 1986 to December 1986

86C8554B

SUMMARY OF LABORATORY TEST DATA

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOLIDATION STRESS, ksf	VOLUME CHANGE, INUNDATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
BW-6	0-2	OH	91		77	37	2.49	F-8											
	5-7	OH	112		61	33	2.47	F-8											
	10-12	SW					2.70	F-9											
	15-17	SW-SP	22				2.68	F-9											
	23-25	SP	17					F-9											
BW-7	0-2	SW	27				2.73	F-10											
	5-7	SM	21					F-10											
	10-12	SM	20					F-10											
	15-17	SP	18					F-11											
	20-22	ML	24					F-11											
	25-27	SP-SM	22					F-11											
BW-8	0-2	OH	161				2.26	F-12											
	5-7	OH			NP	NP	2.34	F-12											
	10-12	SM	28		NP	NP		F-12											
	15-17	SP-SM						F-12											
BW-9	0-2	SM						F-13											
	5-7	SP-SM	21					F-13											
	15-17	SP-SM	16					F-13											

TABLE

SUMMARY OF LABORATORY TEST DATA

86C8554B

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOLIDATION STRESS, ksf	VOLUME CHANGE, INUNDATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
BW-10	0-2	OL-OH	133		49	35		F-14											
	5-7	OH			79	38		F-14											
	10-12	SP	17					F-14											
	15-17	SW	16					F-15											
BW-11	0-2	OL	89		43	26		F-16											
	5-7	SM	23		NP	NP		F-16											
	10-12	SM			NP	NP		F-16											
	15-17	ML	26				2.70	F-15											
BW-12	0-2	OL	86				2.48	F-17											
	7-9	OH	100		71	32	2.51	F-17											
	12-14	ML	16				2.70	F-18											
	15-17	SM	20					F-18											
	20-22	SP	16					F-18											
	30-32	SM	23					F-18											
BW-13	0-2	OL			NP	NP	2.54	F-19											
	10-12	SM	32				2.70	F-20											
	15-17	SP	22					F-20											

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SUMMARY OF LABORATORY TEST DATA

86C8554B

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOLIDATION STRESS, ksf	VOLUME CHANGE, INUNDATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
BL-1	0-2	SW	11				2.65	F-22											
	5-7	SW	10		NP	NP		F-22											
	10-12	SW	12				2.69	F-23											
	15-17	SM	10					F-23											
BL-2	0-2	SM	8				2.66	F-24											
	5-7	ML	24				2.67	F-24											
	10-12	SW	9		NP	NP		F-24											
	15-17	GW	10					F-25											
	20-22	SM-SP	10					F-25											
BL-3	0-2	SM	13					F-26											
	5-7	SP-SM	5					F-26											
	10-12	SM	22					F-27											
	20-22	SM	24					F-27											
BL-5	0-2	SM	9					F-28											
	5-7	SM						F-28											
	15-17	ML	25					F-28											
	20-22	SM						F-28											
OW-1	0-2	SP-SM	4					F-29											
	5-7	SM	7		NP	NP		F-29											

DATA FROM GUAY/GERMUUM

TABLE

SUMMARY OF LABORATORY TEST DATA

86C8554B1

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOLIDATION STRESS, ksf	VOLUME CHANGE, INUNDATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
PD-1	5-7	SM			NP	NP	2.57	G-1											
PD-2	5-7	OH			59	34	2.44	G-2											
PD-6	5-7	OH			74	40	2.31	G-3											
	7-9	OH					2.43	G-3											
PD-7	5-7	SM			NP	NP	2.57	G-4											
	7-9						2.64	G-4											
PD-10	5-7	SM			NP	NP	2.61	G-5											
	7-9	SM					2.67	G-5											
PD-11	5-7	SM			NP	NP	2.61	G-6											
PD-12	0-2	OL	101				2.50	G-7											
	2-4	OL			NP	NP	2.62												
	4-6	SP-SM	21				2.69	G-8											
	6-8	SW	15					G-8											
	10-12	SM	20		NP	NP		G-8											
	15-17	SP-SM	22				2.75	G-8											
	20-22	SP-SM	25					G-9											
	25-27	SP-SM	25				2.75	G-9											
	30-32	SM	11					G-9											
	[illegible]	SW	11					G-10											

WOODWARD-CLYDE CONSULTANTS

SUMMARY OF LABORATORY TEST DATA

86C8554B1

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOL - IDATION STRESS, ksf	VOLUME CHANGE, INUN - DATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
PD-12	40-42	SW	10																
	45-47	SP-SM	17																
PD-13	0-2	OL-OH	131				2.45	G-11											
	2-4	OL					2.49	G-11											
	4-6	SM	47		NP	NP	2.71	G-12											
	6-8	SP-SM	19				2.71	G-12											
	8-10	SM	25				2.71	G-12											
	15-17	SW	33					G-12											
PD-14	0-2	OH					2.30	G-13											
	5-7	OH	109		69	41	2.36	G-13											
	7-9	OH						G-13											
	9-11	OH	78				2.49	G-14											
	11-13	OH			59	31		G-14											
	15-17	GM-GP	28					G-15											
	20-22	GW	8					G-16											
	25-27	SM	18					G-16											
PD-15	5-7	SM						G-17											
	10-12	SM						G-17											
	15-17	SW	17					G-18											
	20-22	SM	24				2.64	G-18											
	25-27	SM-SP	22				2.65	G-18											

TABLE

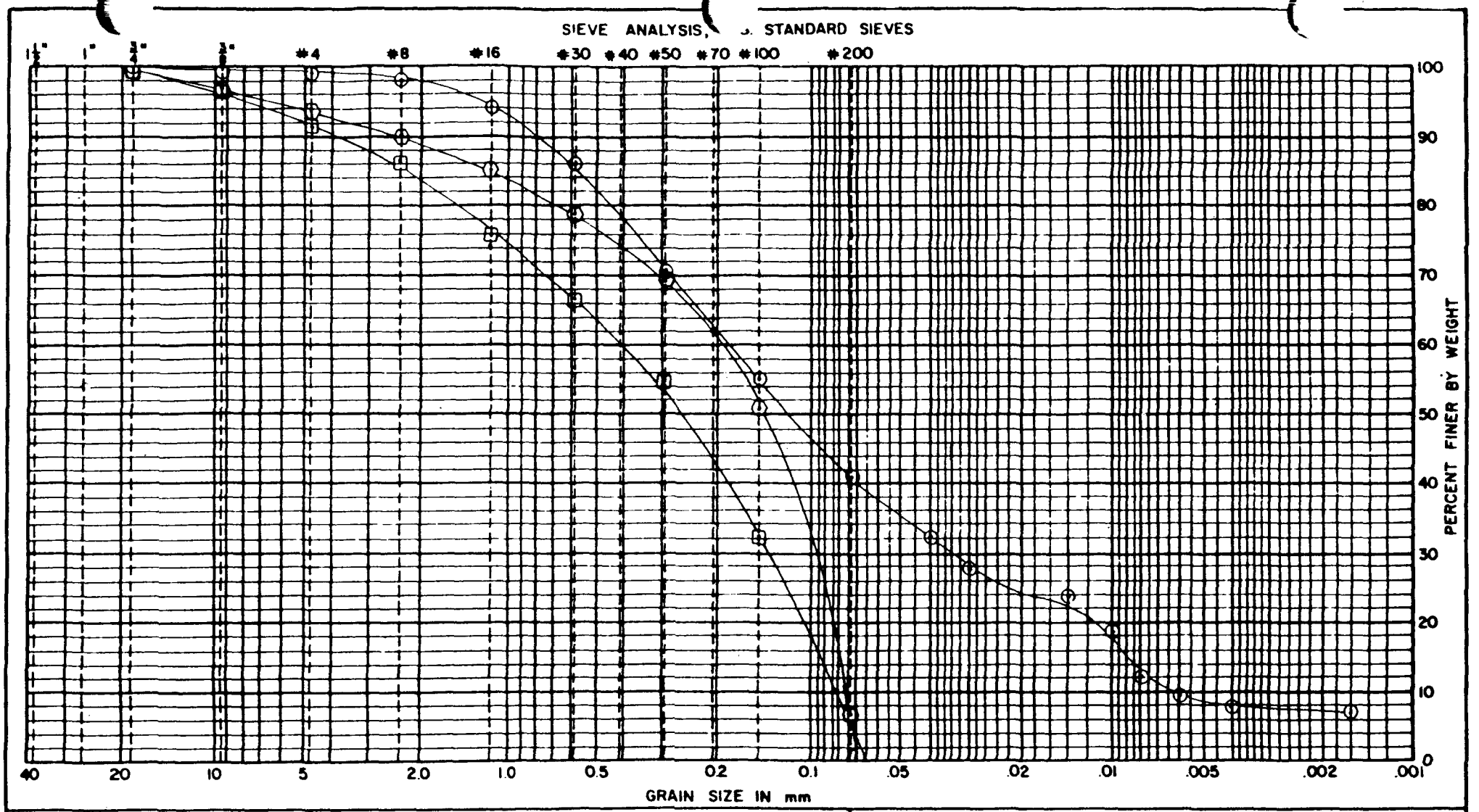
SUMMARY OF LABORATORY TEST DATA

86C8554B1

NEW BEDFORD SUPERFUND SITE
NEW BEDFORD, MASSACHUSETTS

BORING OR TEST PIT NUMBER	SAMPLE DEPTH, ft.	UNIFIED SOIL CLASSIFICATION SYMBOL	CLASSIFICATION PROPERTIES						PHYSICAL PROPERTIES										
									COMPRESSIVE STRENGTH						VOLUME CHANGE				
									UNCONFINED			TRIAXIAL							
			AVERAGE NATURAL WATER CONTENT, %	DRY UNIT WEIGHT, pcf	LIQUID LIMIT, %	PLASTIC LIMIT, %	SPECIFIC GRAVITY	GRAIN SIZE DATA - FIGURE	COMPRESSIVE STRENGTH, ksf	WATER CONTENT AT END OF TEST, %	STRAIN AT FAILURE, %	TRIAXIAL DATA - FIGURE	TYPE OF TEST	WATER CONTENT START - END, %	VOLUME CHANGE DATA - FIGURES	EXISTING OVERBURDEN STRESS, ksf	ESTIMATED PRECONSOL - IDATION STRESS, ksf	VOLUME CHANGE, INUN - DATED @ 1 psi, %	SWELL PRESSURE MAXIMUM - CONFINED INNUNDATED, psi
PD-15	30-32	SM	16					G-18											
PD-16	0-2	SM	18					G-19											
	5-7	GP-GM	48					G-19											
	10-12	SP-SM	23					G-19											
	15-17	SP	27					G-19											
	25-27	ML	26				2.70	G-20											
	30-32	SM	24					G-20											
PD-17	0-2	OH						G-21											
	2-4	OH					2.45	G-21											
	4-6	OH	85		62	34		G-22											
	6-8	OL	106				2.69	G-22											
	15-17	SP-SM	17					G-22											

WOODWARD-CLYDE CONSULTANTS



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
○	BW-9	0'-2'	SILTY SAND (SM)
○	"	5'-7'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
□	"	15'-17'	POORLY GRADED SAND TO SILTY SAND (SP-SM)

NEW BEDFORD SUPERFUND SITE

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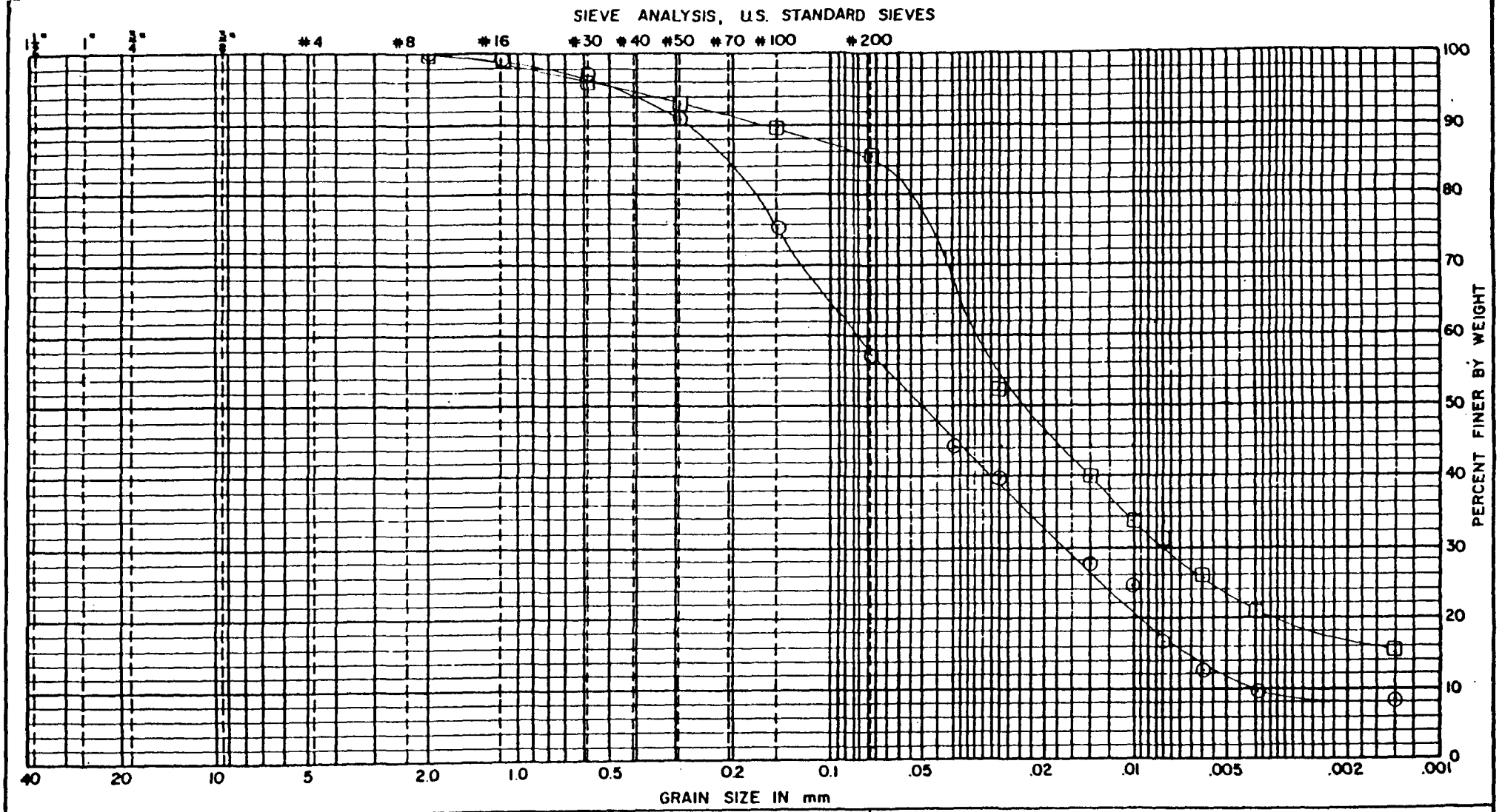
GRADATION CURVES

FIG. NO. F-13



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	BW-12	0'-2'	LOW PLASTIC ORGANIC (OL)
⊡	"	7'-9'	HIGHLY PLASTIC ORGANIC (OH)

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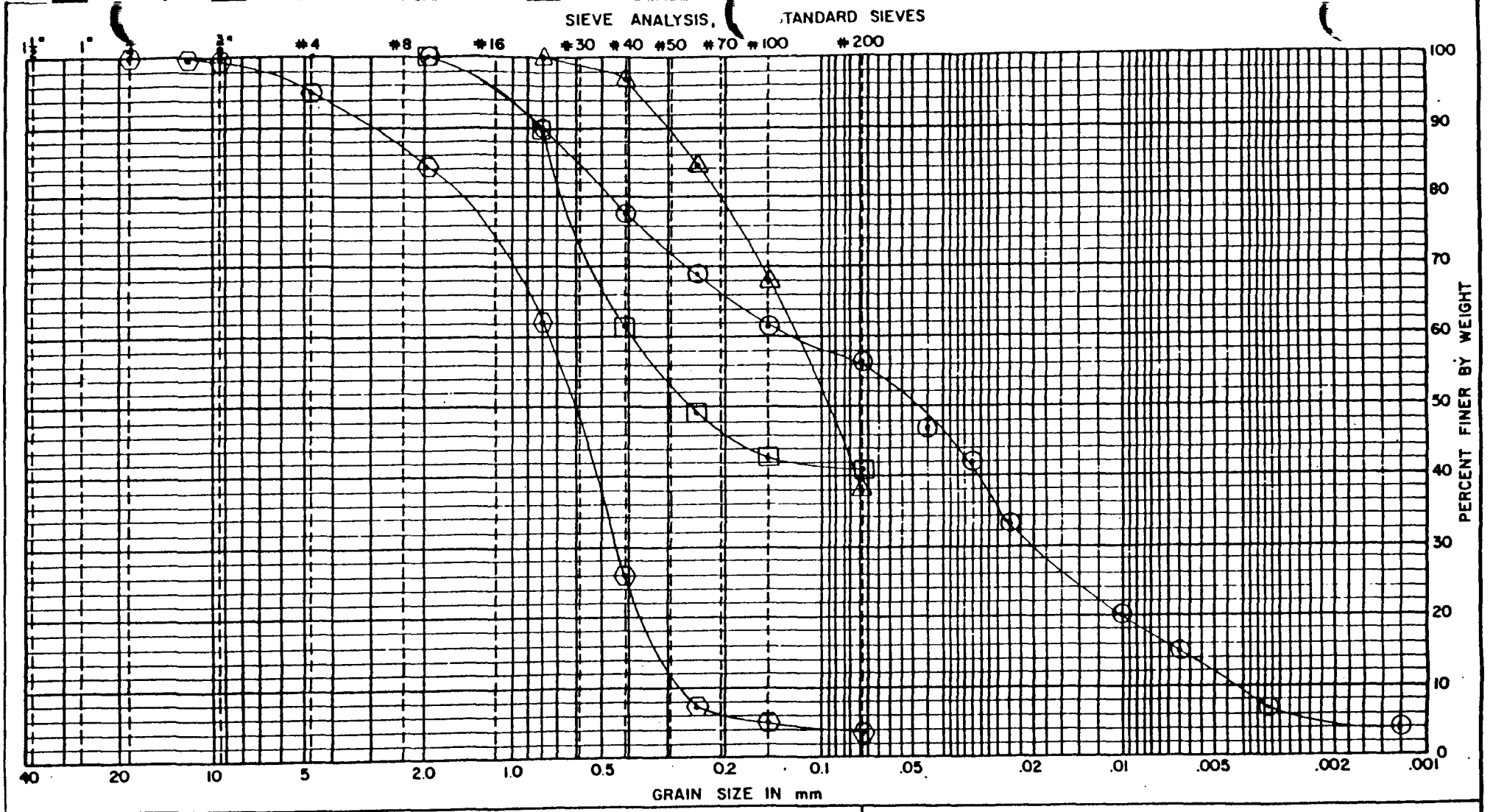
GRADATION CURVES

FIG. NO. F-17



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	BW - 12	12 - 14'	SILT (ML)
⊡	"	15 - 17'	SILTY SAND (SM)
⊙	"	20 - 22'	POORLY GRADED SAND (SP)
△	"	30 - 32'	SILTY SAND (SM)

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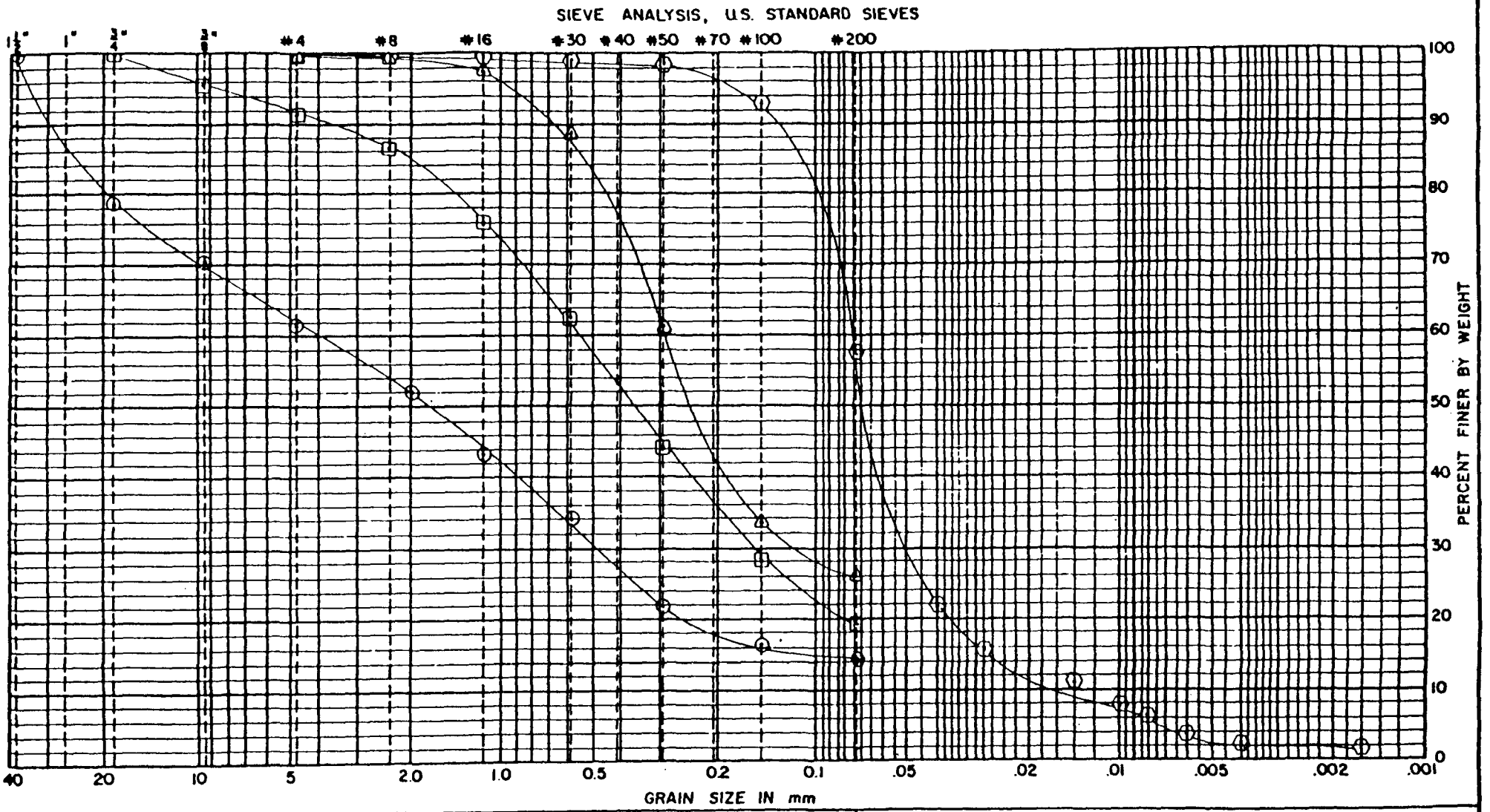
GRADATION CURVES

FIG. NO. F-18



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	BL-5	0'-2'	SILTY SAND (SM)
⊡	"	5'-7'	SILTY SAND (SM)
⬡	"	15'-17'	SILT (ML)
△	"	20'-22'	SILTY SAND (SM)

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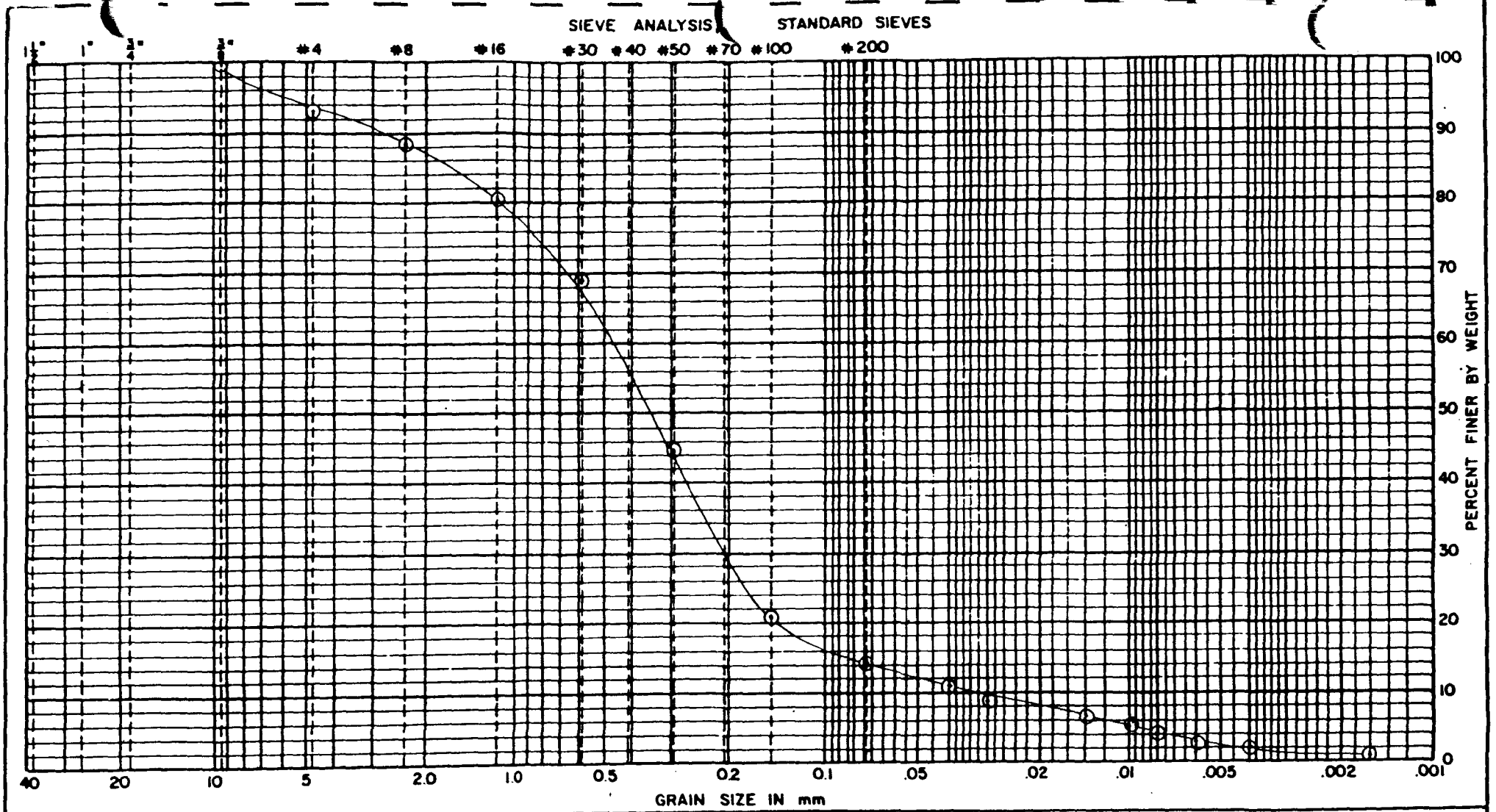
GRADATION CURVES

IG. NO. F-28



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-1	5'-7'	SILTY SAND (SM)

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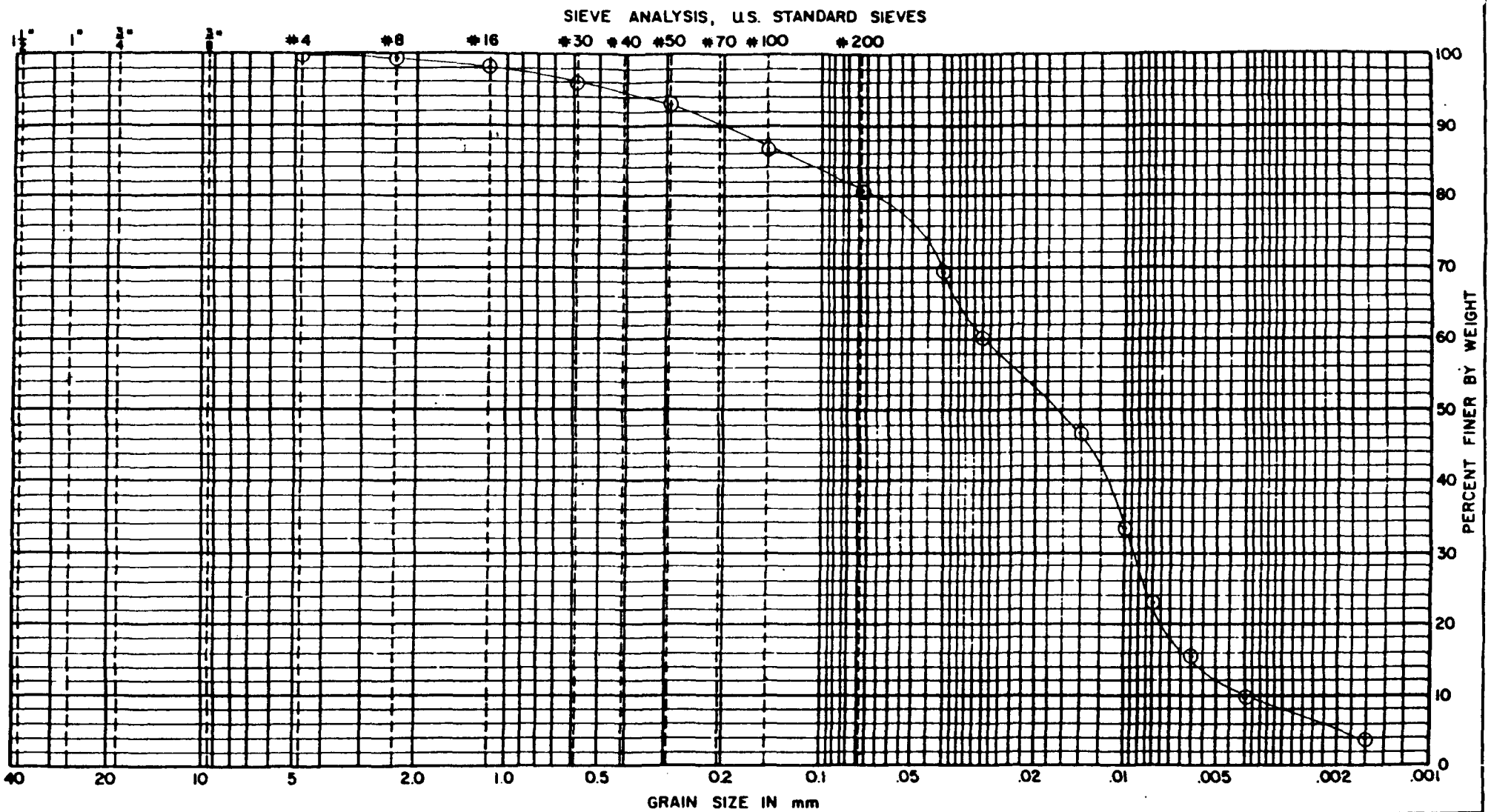
GRADATION CURVES

FIG. NO. G-1



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-2	5'-7'	HIGHLY PLASTIC ORGANIC (OH)

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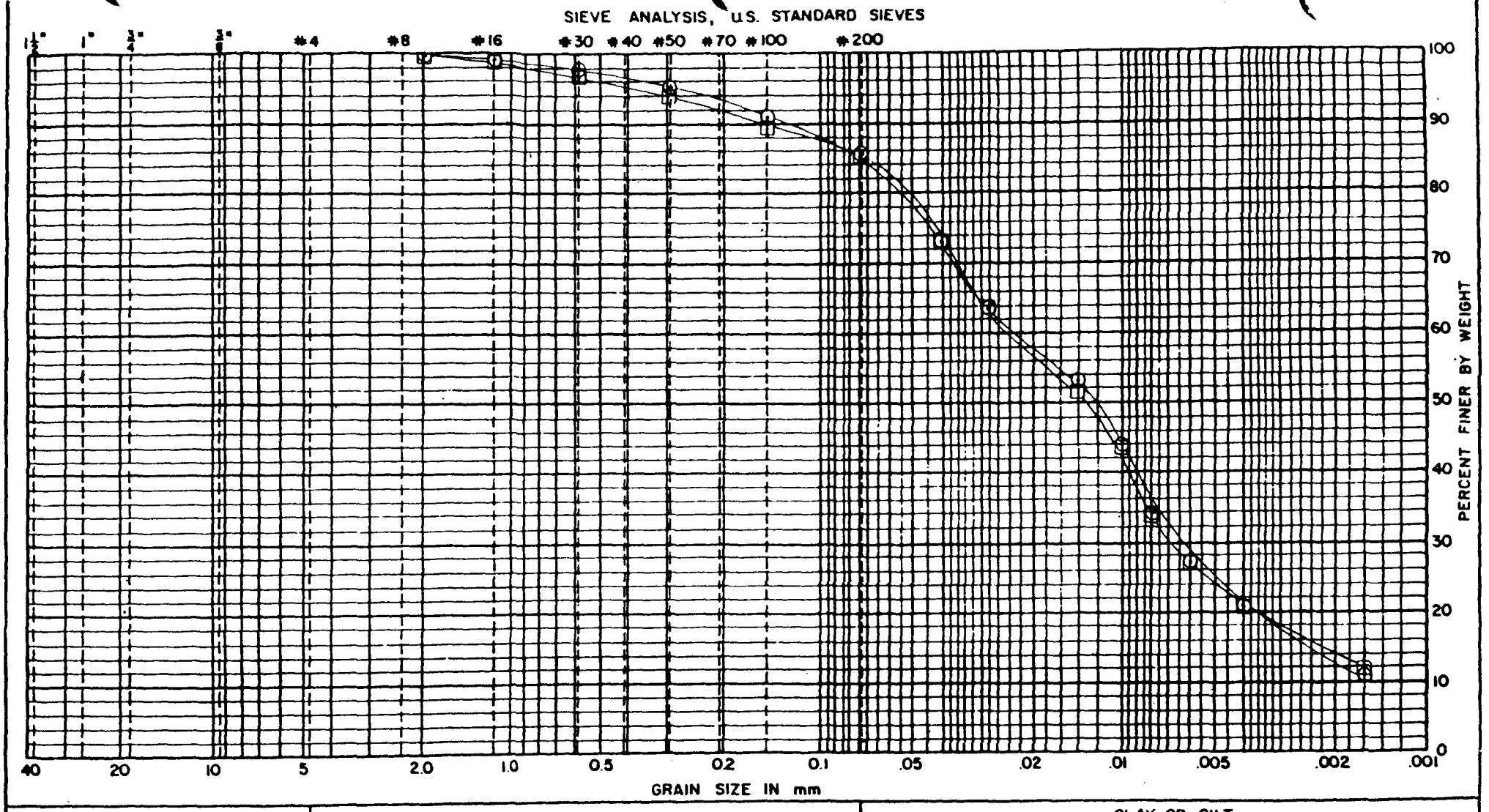
PROJECT NO.
86C8554 B1

GRADATION CURVES

FIG. NO.
G-2



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-6	5'-7'	HIGHLY PLASTIC ORGANIC (OH)
⊡	"	7'-9'	HIGHLY PLASTIC ORGANIC (OH)

NEW BEDFORD SUPERFUND SITE

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CONSULTING ENGINEERS, GEOLOGISTS
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CENTRAL REGION

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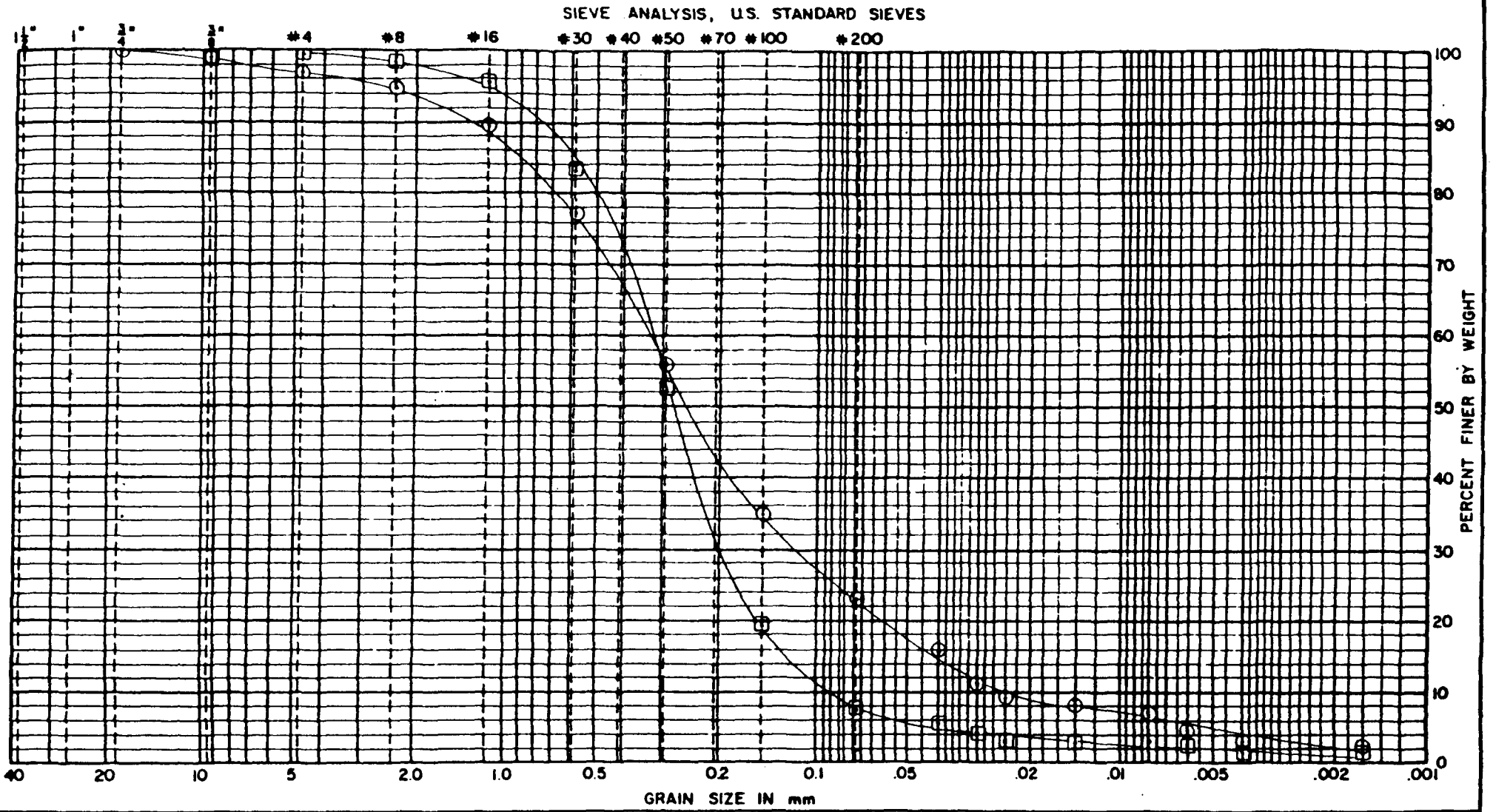
PROJECT NO. 86C8554 B1

GRADATION CURVES

FIG. NO. G-3



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-7	5'-7'	SILTY SAND (SM)
⊡	"	7'-9'	POORLY GRADED SAND TO SILTY SAND (SP-SM)

NEW BEDFORD SUPERFUND SITE

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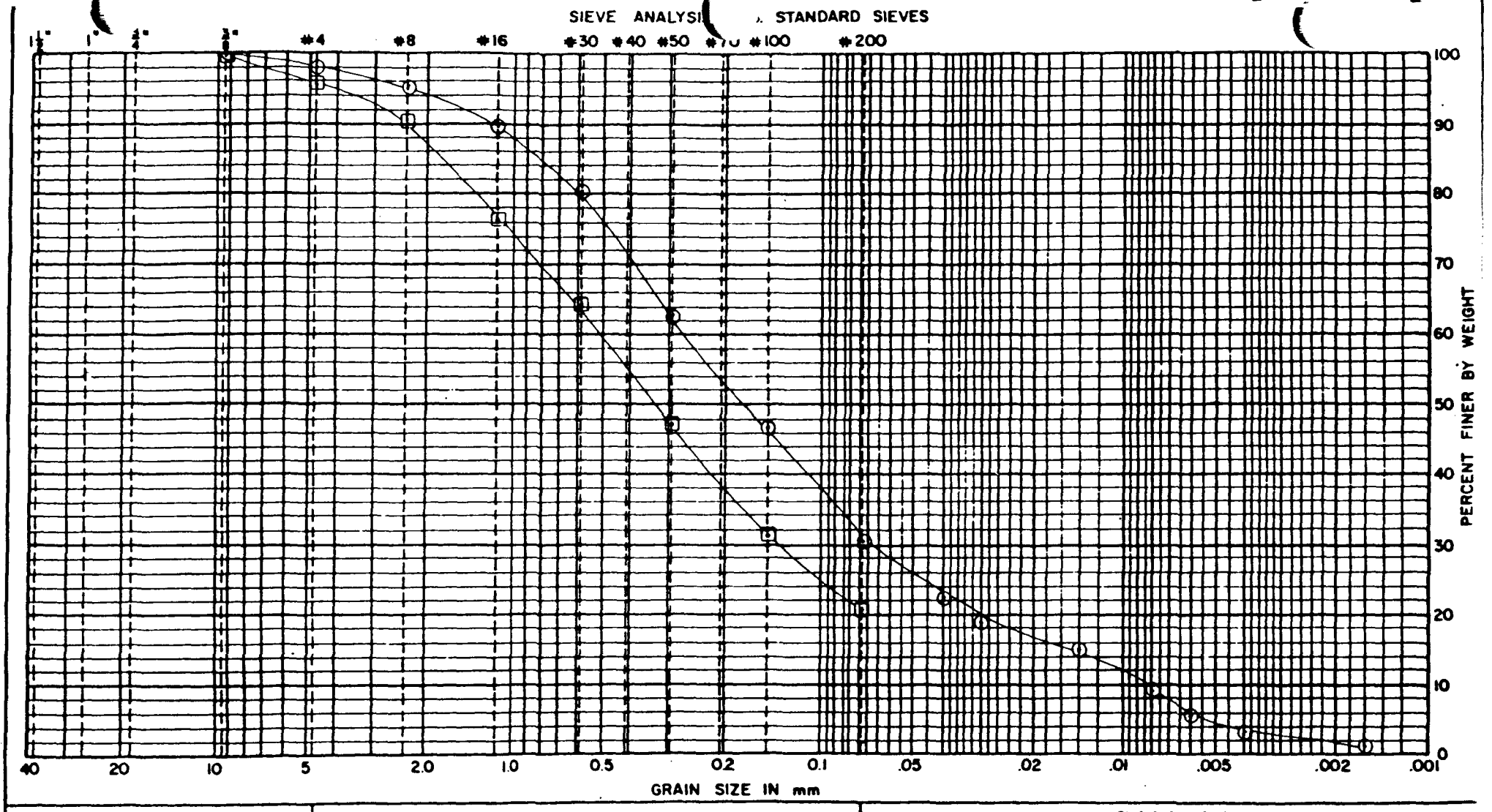
GRADATION CURVES

FIG. NO. G-4



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-10	5'-7'	SILTY SAND (SM)
⊡	"	7'-9'	SILTY SAND (SM)

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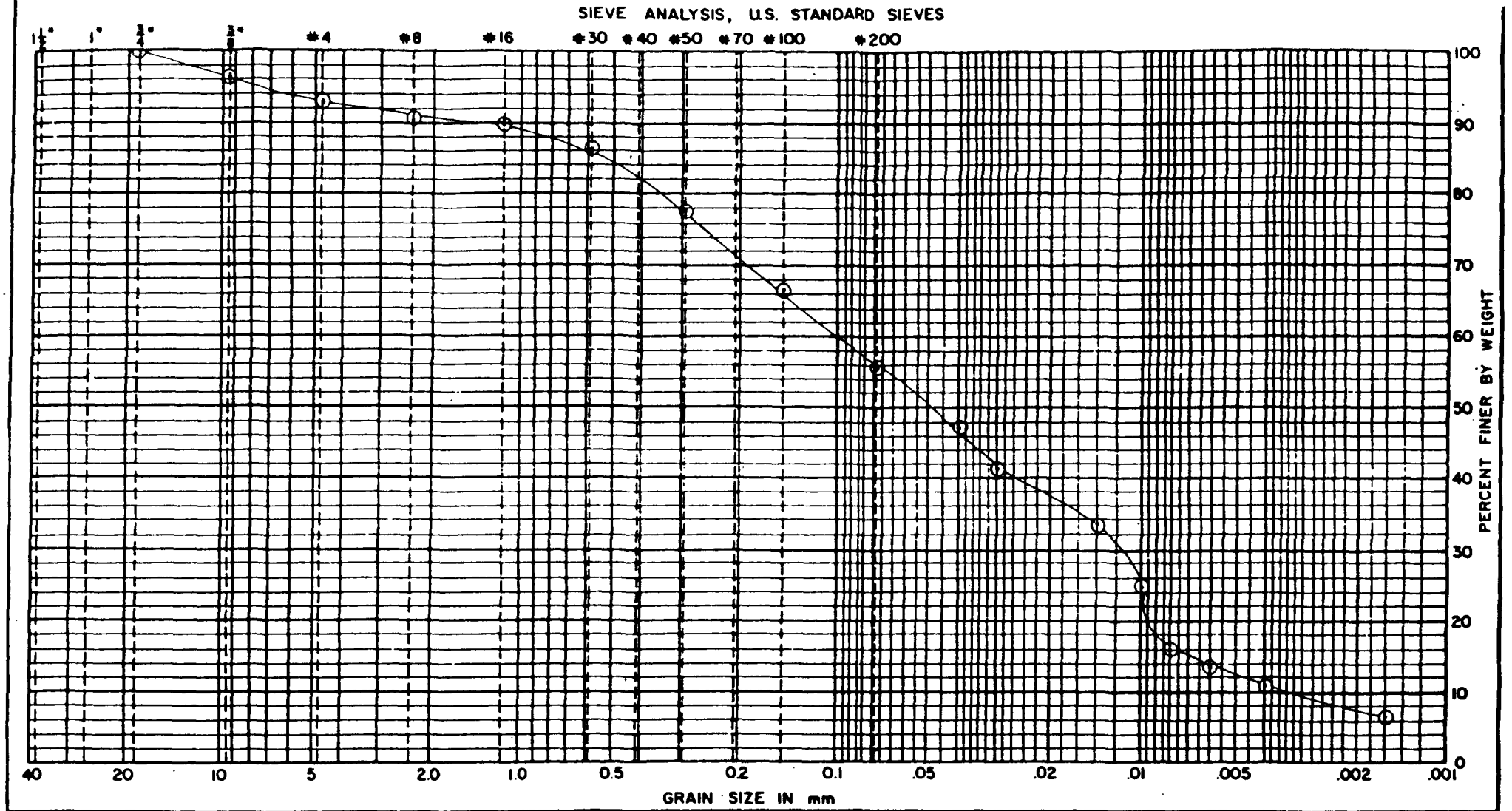
GRADATION CURVES

FIG. NO. G-5



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-12	0'-2'	LOW PLASTIC ORGANIC (OL)

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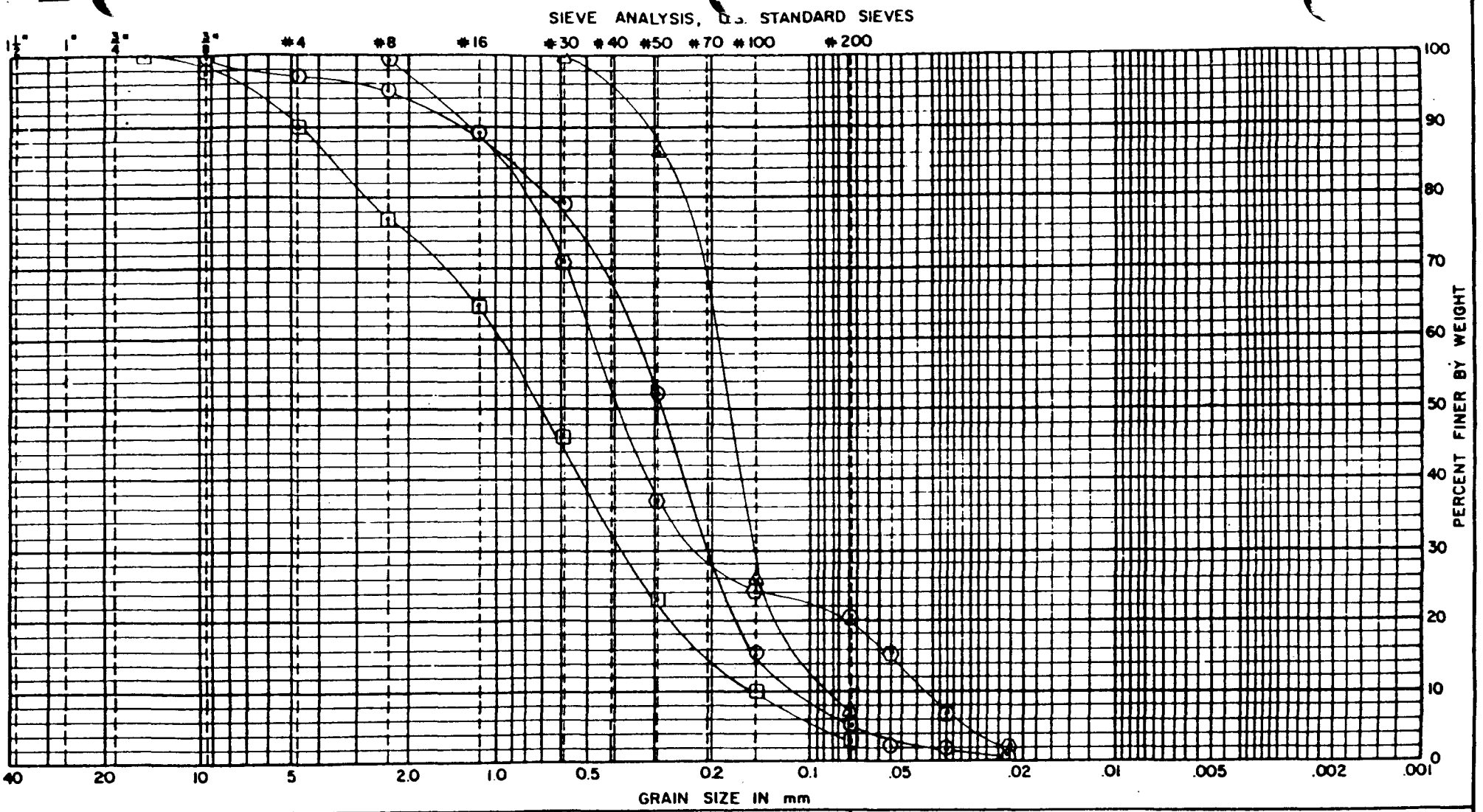
GRADATION CURVES

FIG. NO. G-7



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-12	4'-6'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
⊡	"	6'-8'	WELL GRADED SAND (SW)
△	"	10'-12'	SILTY SAND (SM)
⬡	"	15'-17'	POORLY GRADED SAND TO SILTY SAND (SP-SM)

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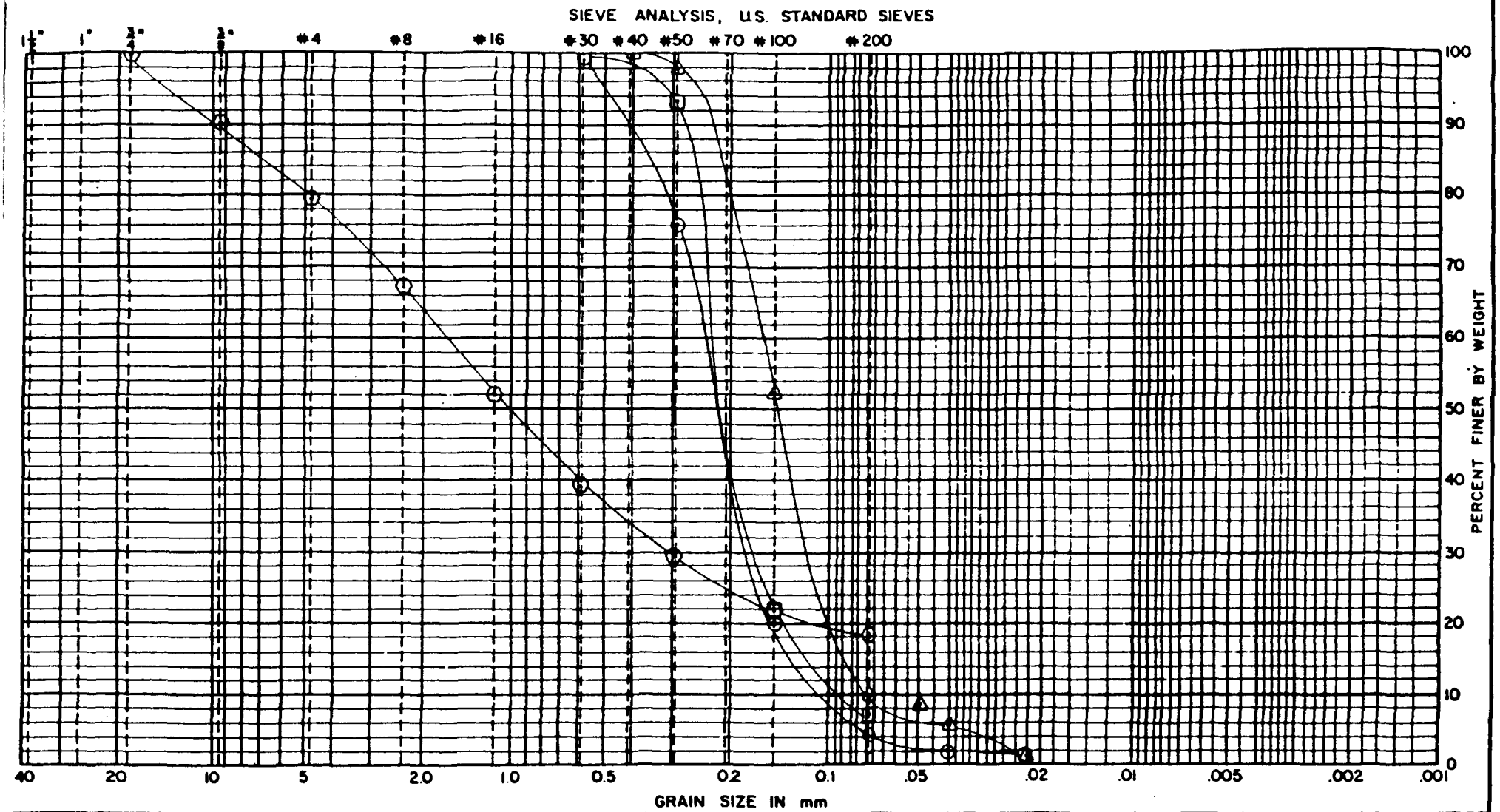
GRADATION CURVES

FIG. NO. G-8



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-12	15'-17'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
□	"	20'-22'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
△	"	25'-27'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
◯	"	30'-32'	SILTY SAND (SM)

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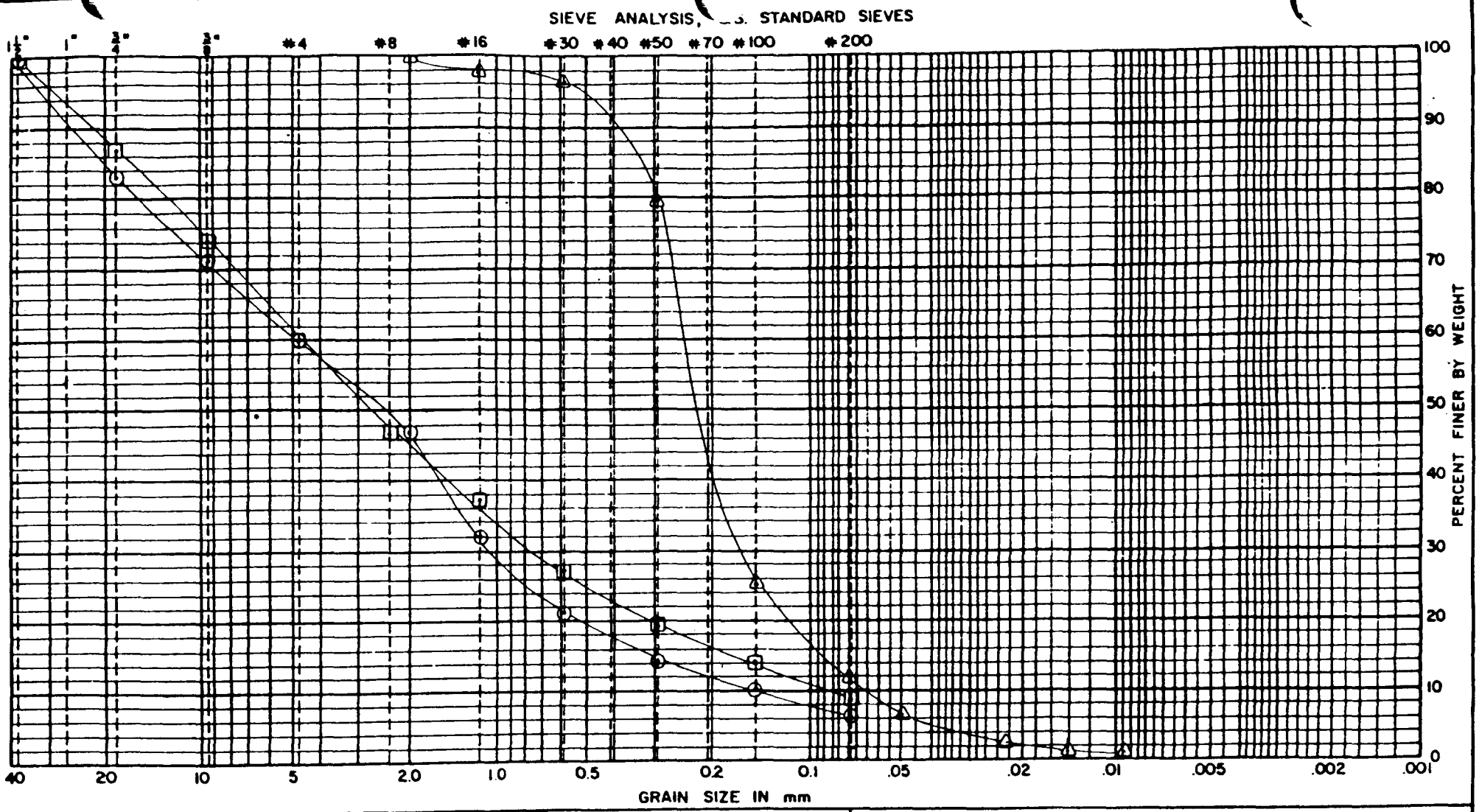
GRADATION CURVES

FIG. NO. -9



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-12	35'-37'	WELL GRADED SAND (SW)
□	"	40'-42'	WELL GRADED SAND (SW)
△	"	45'-47'	POORLY GRADED SAND TO SILTY SAND (SP-SM)

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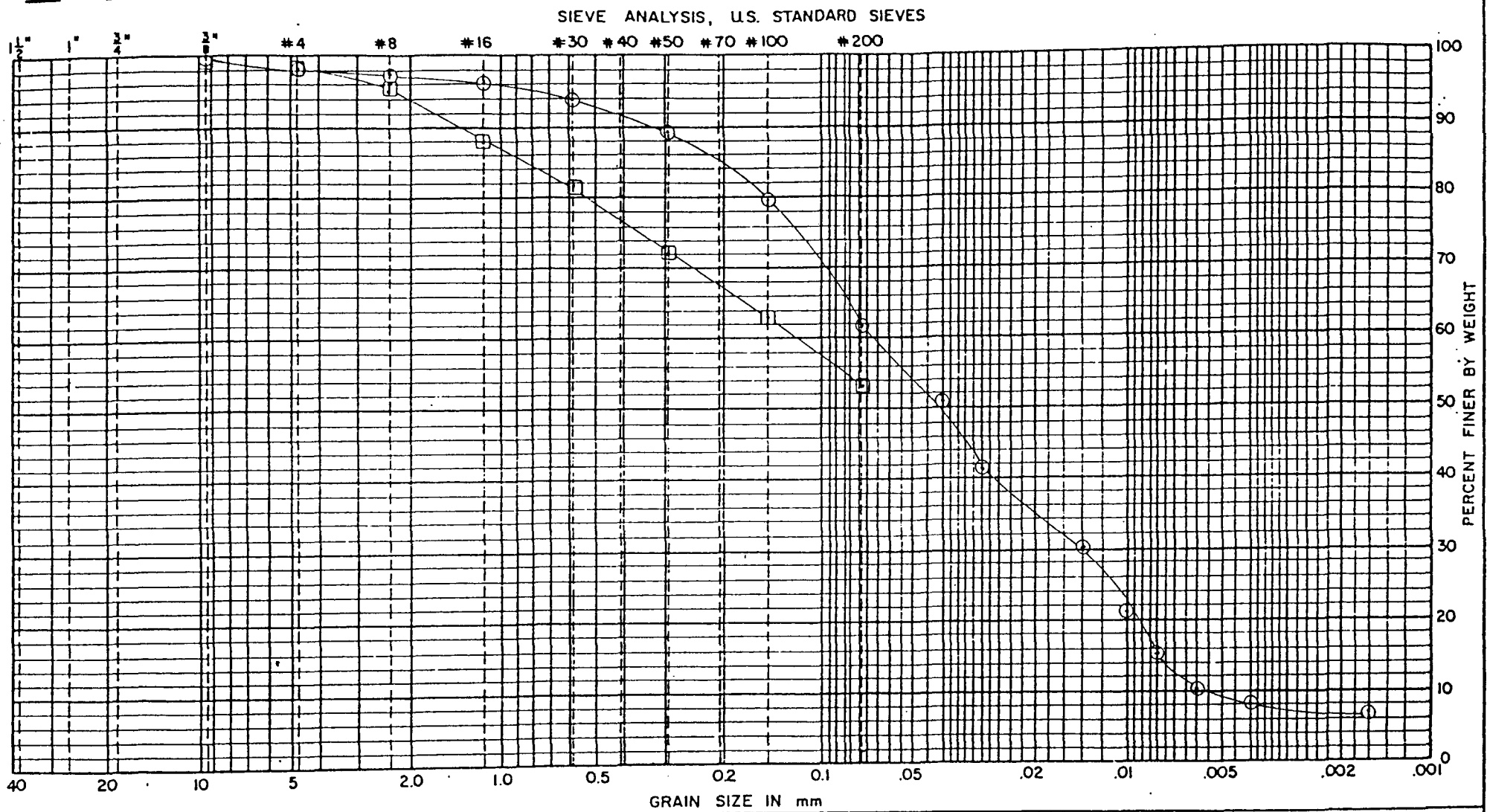
GRADATION CURVES

FIG. NO. G-10



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-13	0'-2'	LOW TO HIGHLY PLASTIC ORGANIC (OL-OH)
⊡	"	2'-4'	LOW PLASTIC ORGANIC (OL)

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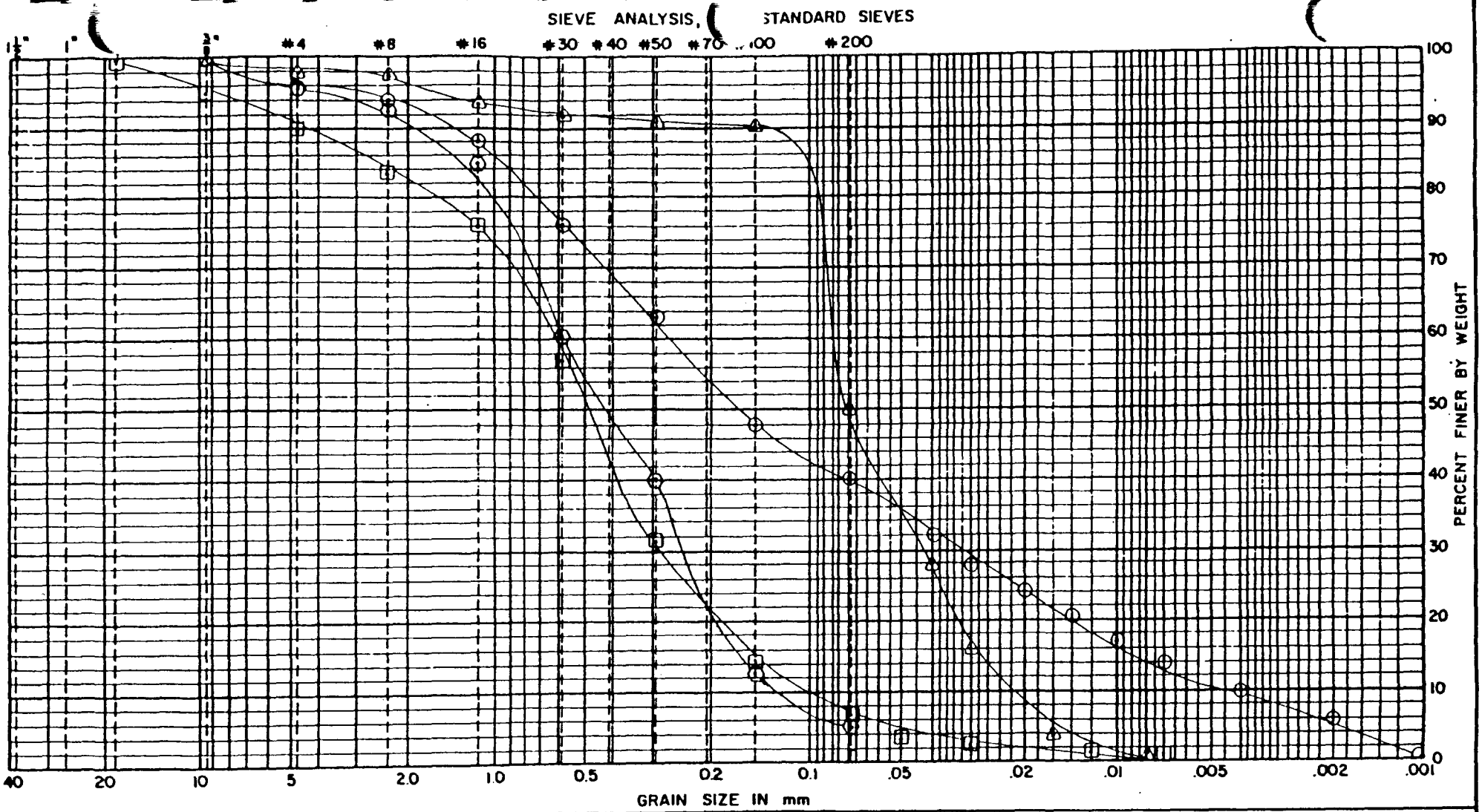
GRADATION CURVES

FIG. NO. G-11



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-13	4'-6'	SILTY SAND (SM)
⊡	"	6'-8'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
△	"	8'-10'	SILTY SAND (SM)
⬡	"	15'-17'	WELL GRADED SAND (SW)

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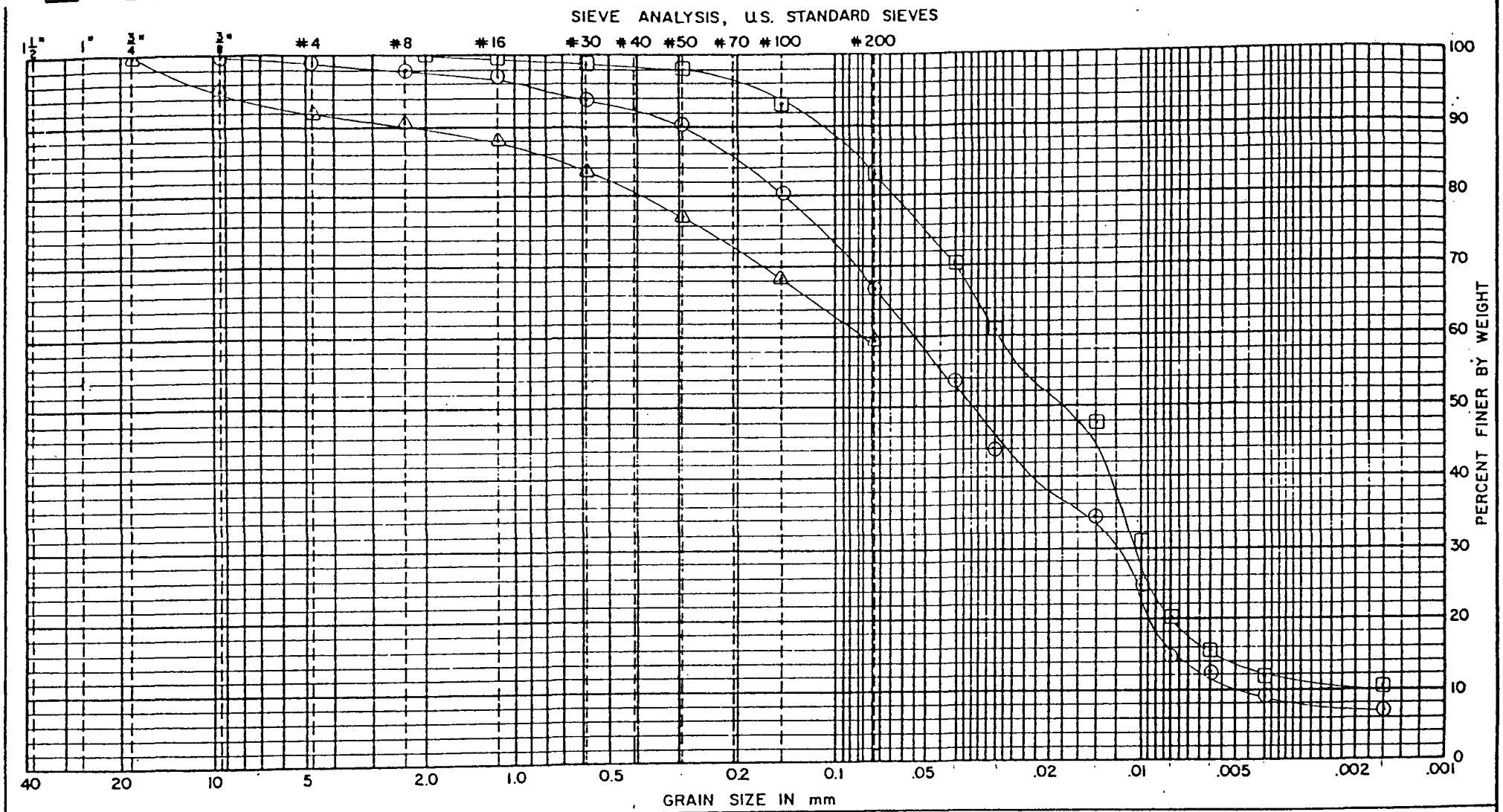
GRADATION CURVES

FIG. NO. G-12



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-14	0'-2'	HIGHLY PLASTIC ORGANIC (OH)
⊡	"	5'-7'	HIGHLY PLASTIC ORGANIC (OH)
△	"	7'-9'	HIGHLY PLASTIC ORGANIC (OH)

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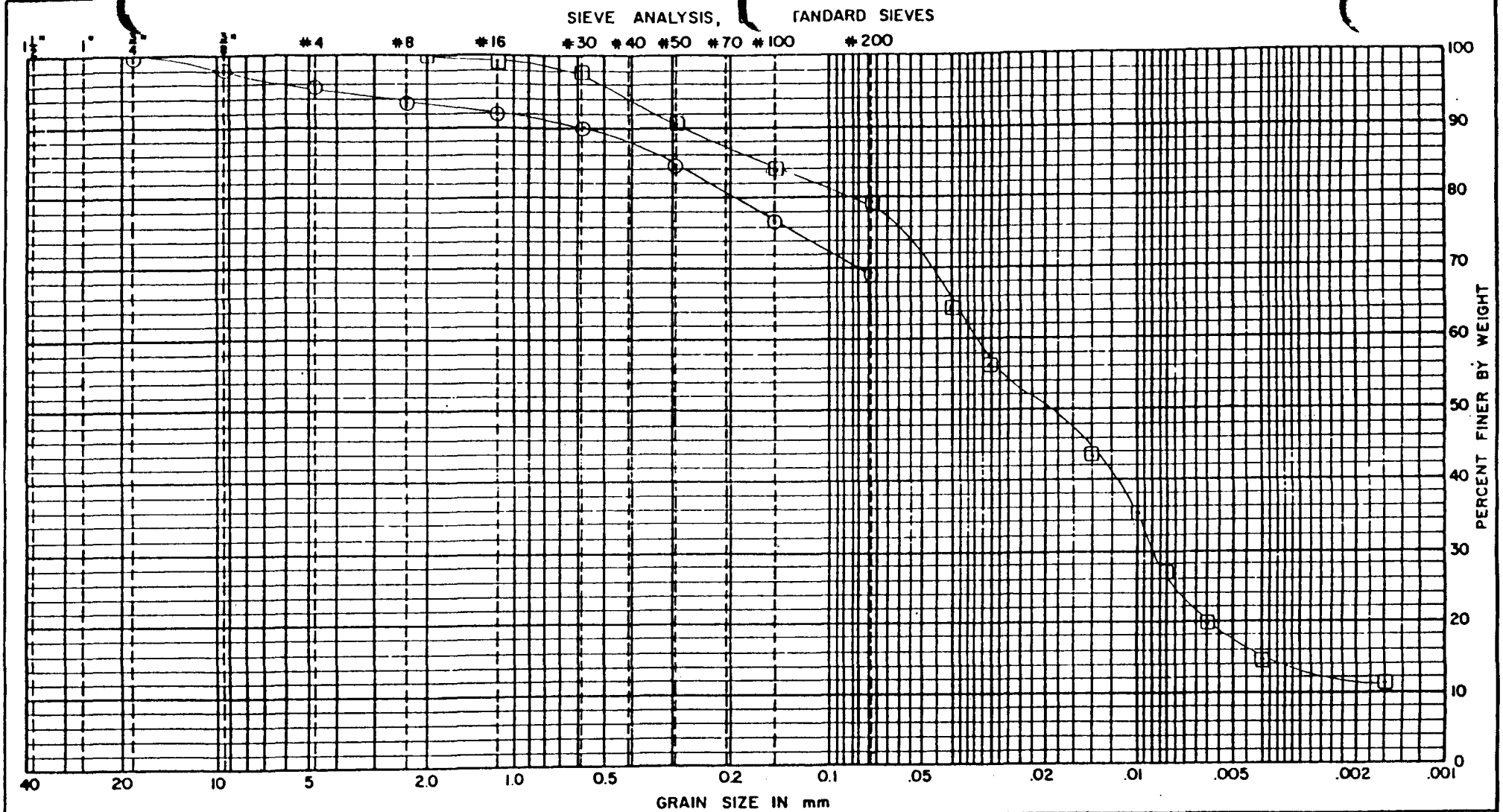
GRADATION CURVES

FIG. NO. G-13



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-14	9'-11'	HIGHLY PLASTIC ORGANIC (OH)
⊡	"	11'-13'	HIGHLY PLASTIC ORGANIC (OH)

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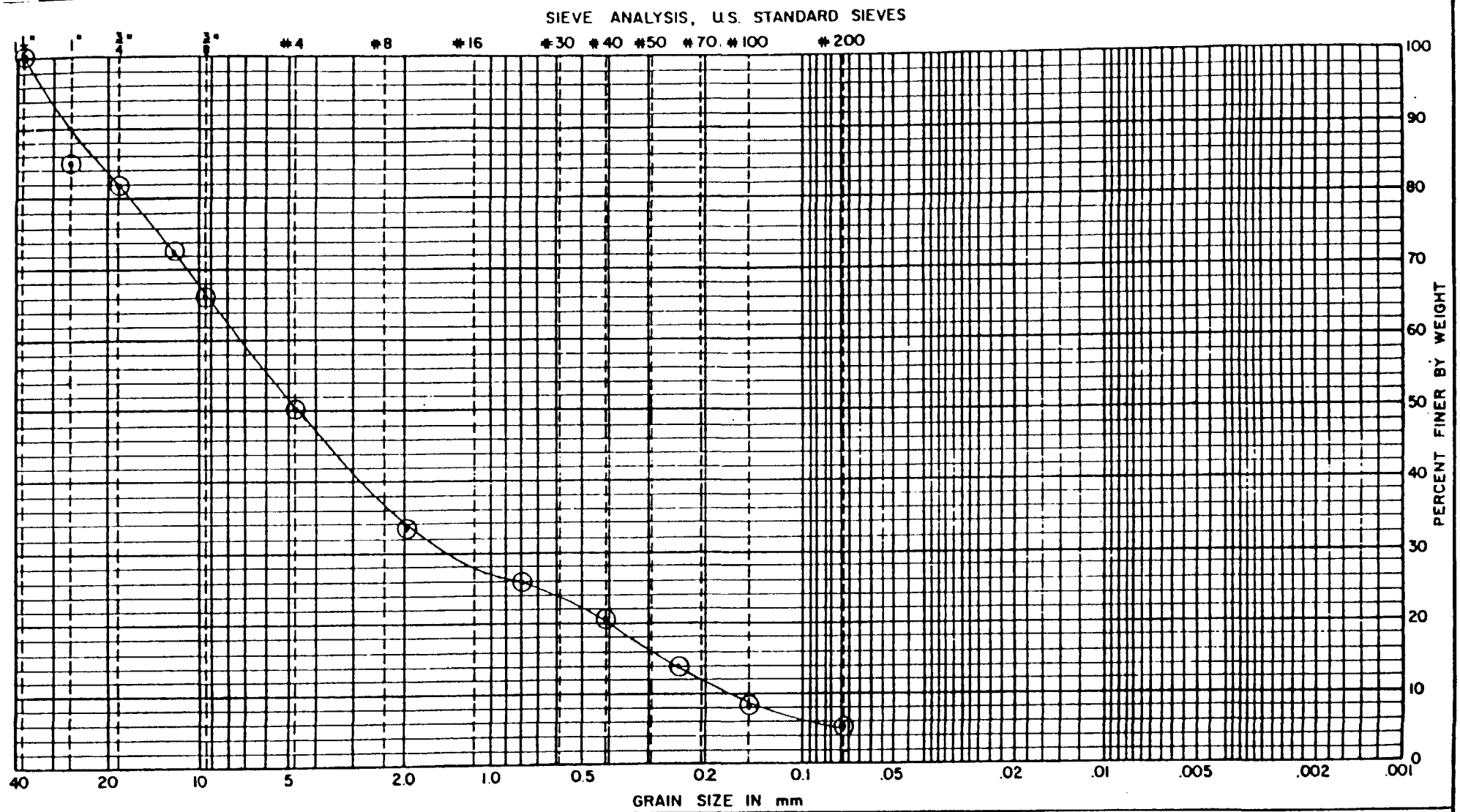
DRAWN BY:	PROJECT NO.
CHECKED BY:	86C8554B1
GRADATION CURVES	FIG. NO. G-14



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-14	15-17'	SILTY GRAVEL TO POORLY GRADED GRAVEL (GM-GP)

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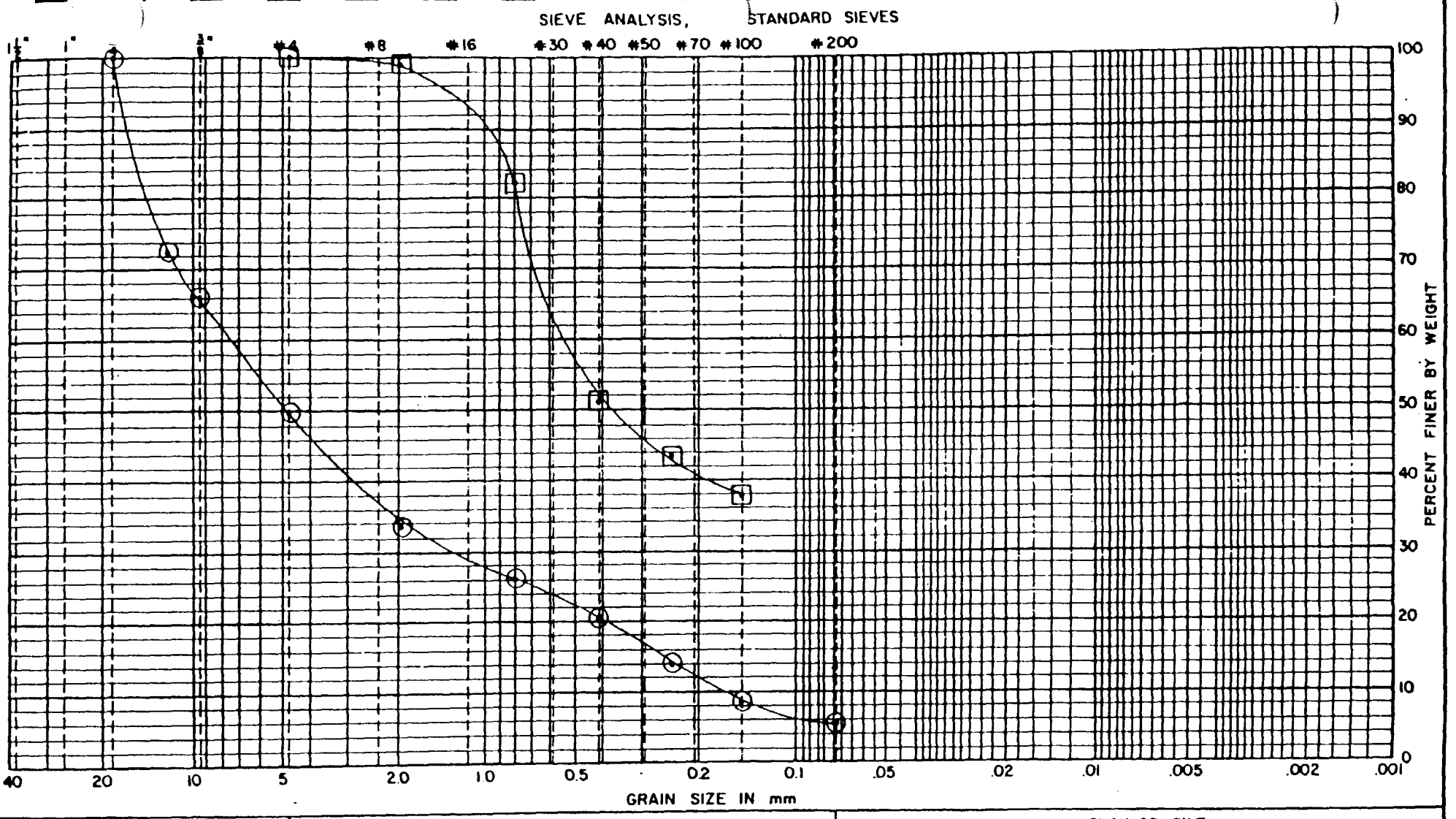
GRADATION CURVES

FIG. NO. G-15



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD - 14	20-22'	WELL GRADED GRAVEL (GW)
⊡	"	25-27'	SILTY SAND (SM)

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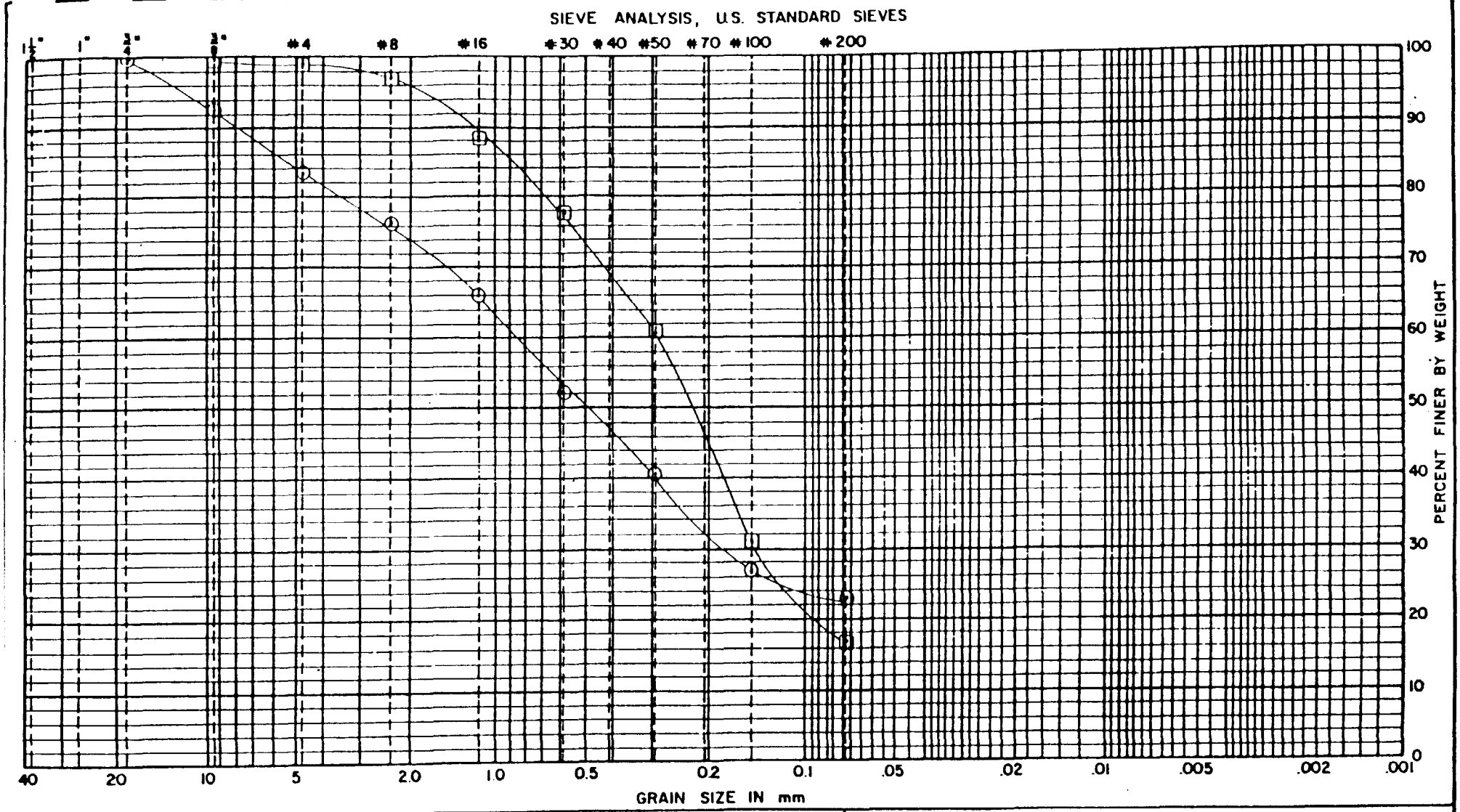
GRADATION CURVES

FIG. NO. G 16



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-15	5'-7'	SILTY SAND (SM)
□	"	10'-12'	SILTY SAND (SM)

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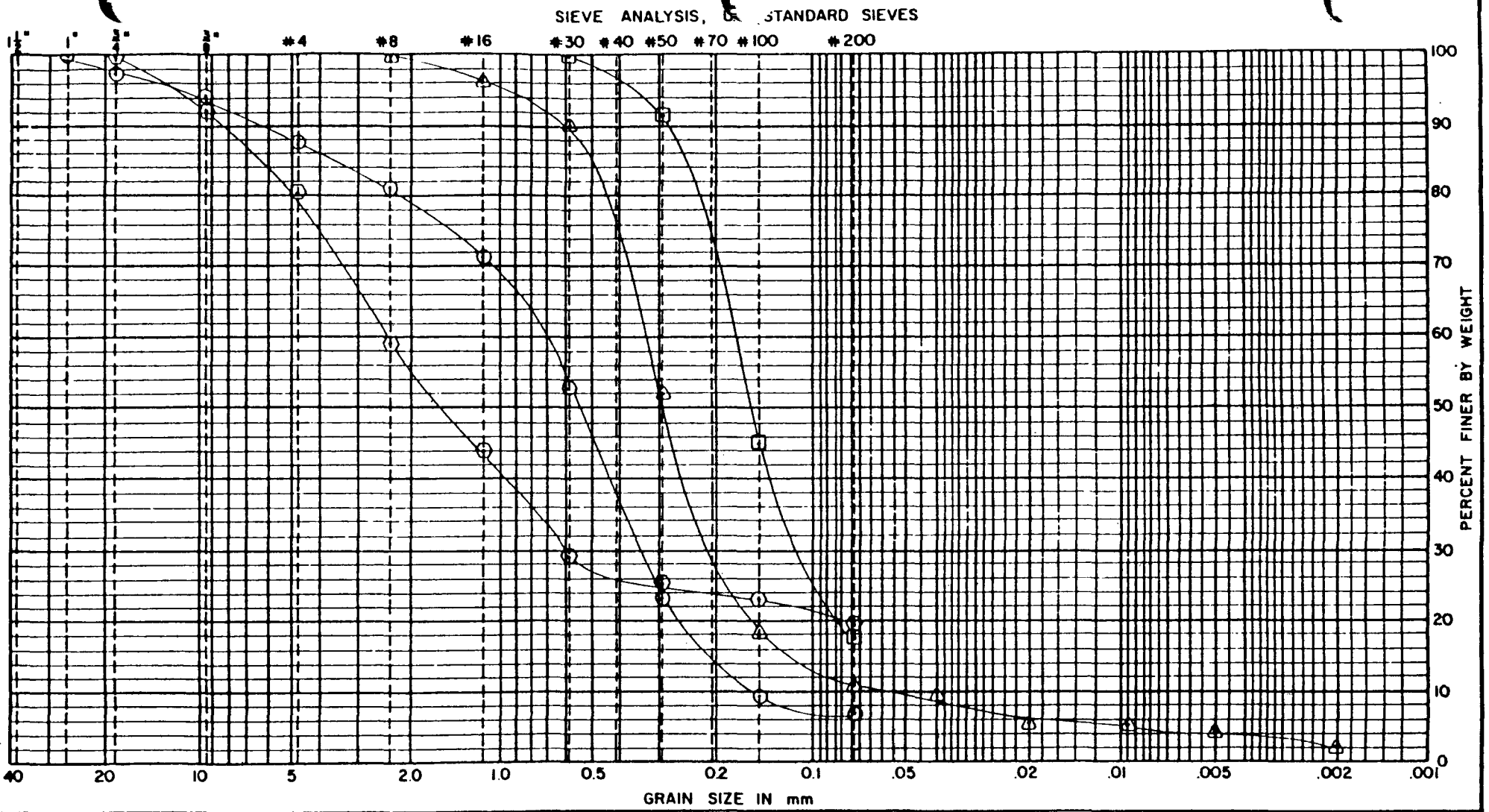
86C8554B1

GRADATION CURVES

FIG. NO.
G-17



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-15	15'-17'	WELL GRADED SAND (SW)
⊡	"	20'-22'	SILTY SAND (SM)
△	"	25'-27'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
⬡	"	30'-32'	SILTY SAND (SM)

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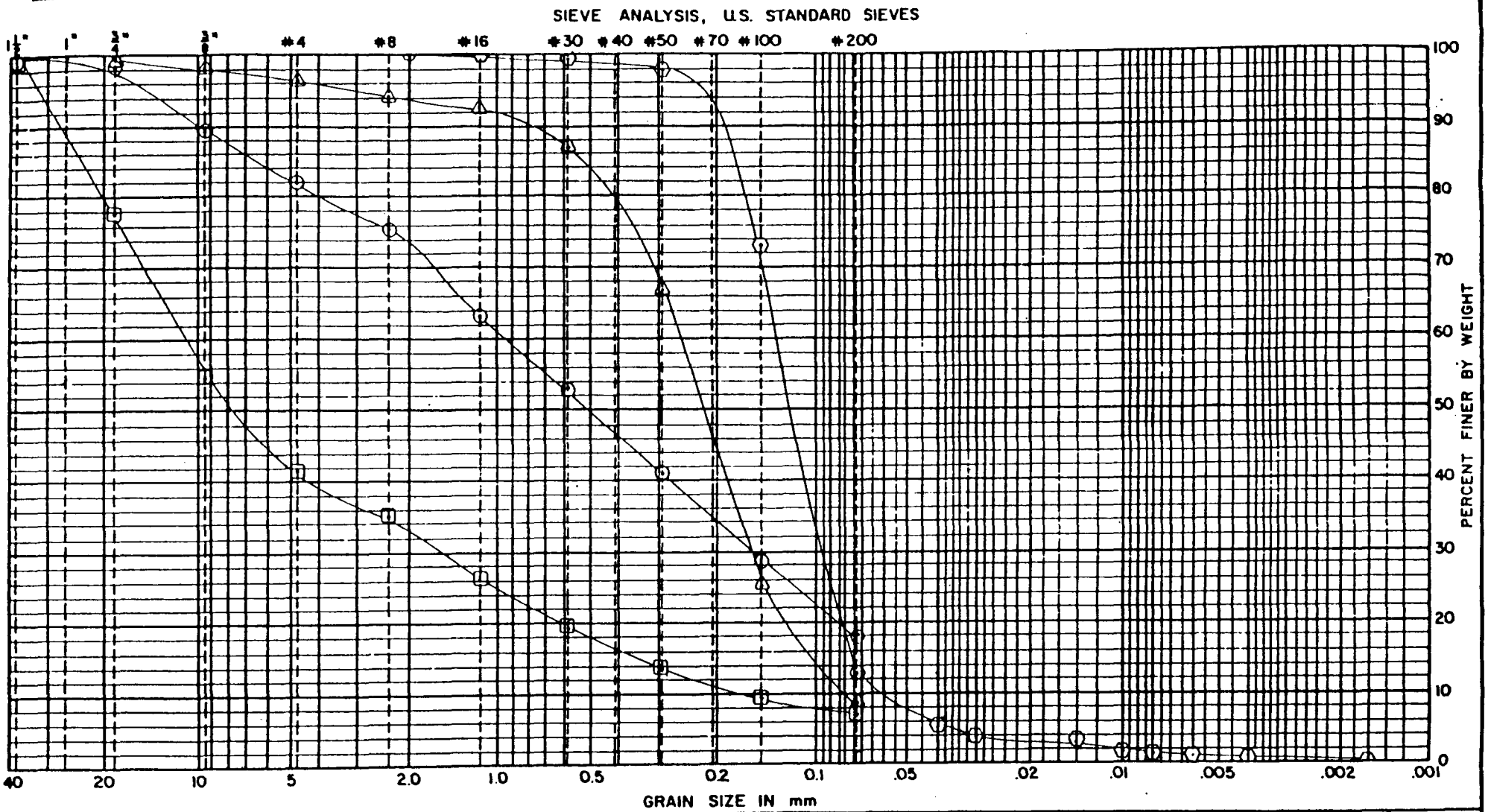
GRADATION CURVES

FIG. NO. G-18



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-16	0'-2'	SILTY SAND (SM)
⊡	"	5'-7'	POORLY GRADED GRAVEL TO SILTY GRAVEL (GP-GM)
△	"	10'-12'	POORLY GRADED SAND TO SILTY SAND (SP-SM)
⊖	"	15'-17'	POORLY GRADED SAND (SP)

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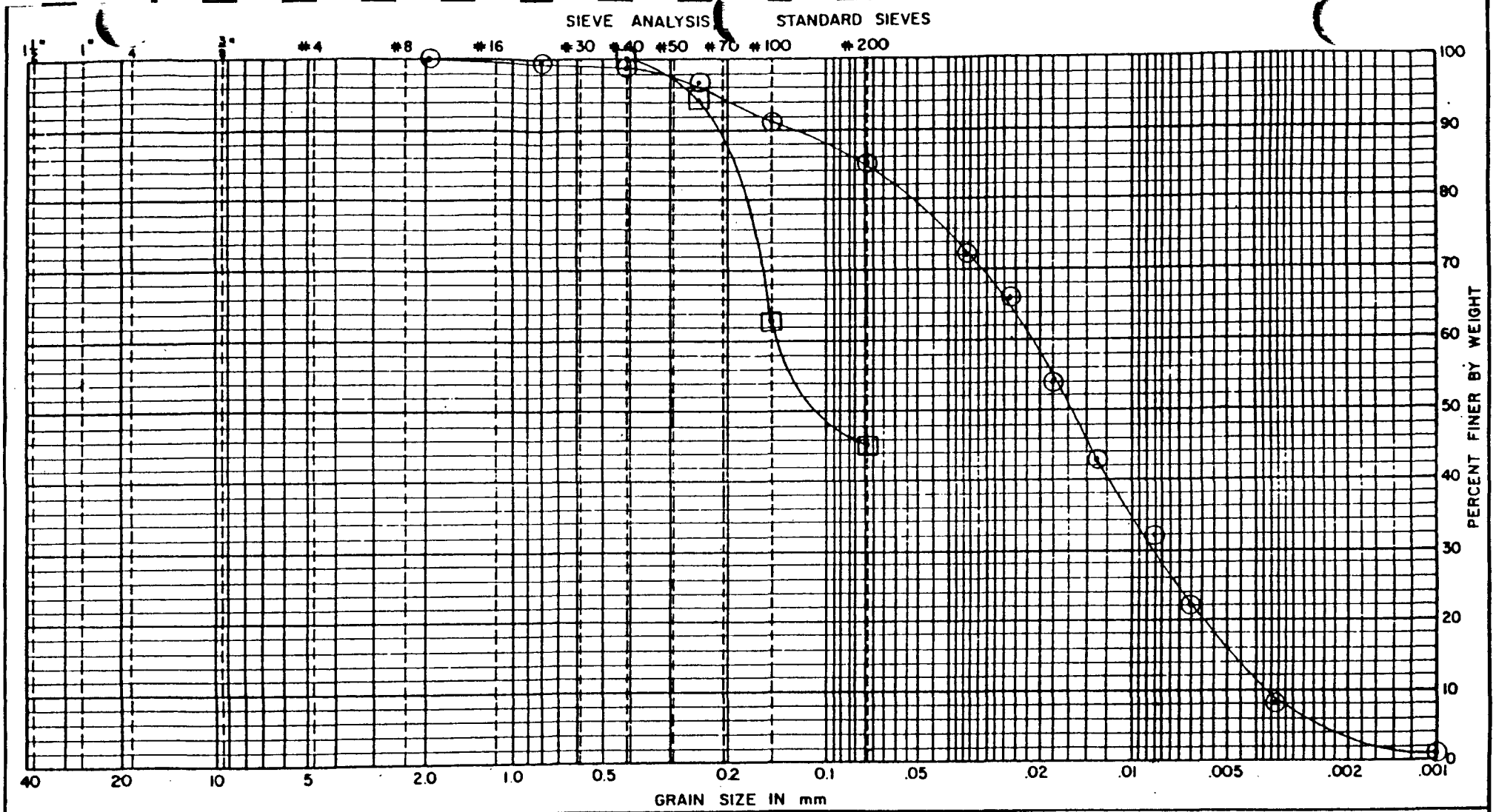
GRADATION CURVES

FIG. NO. G-19



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD - 16	25 - 27'	SILT (ML)
⊡	"	30 - 32	SILTY SAND (SM)

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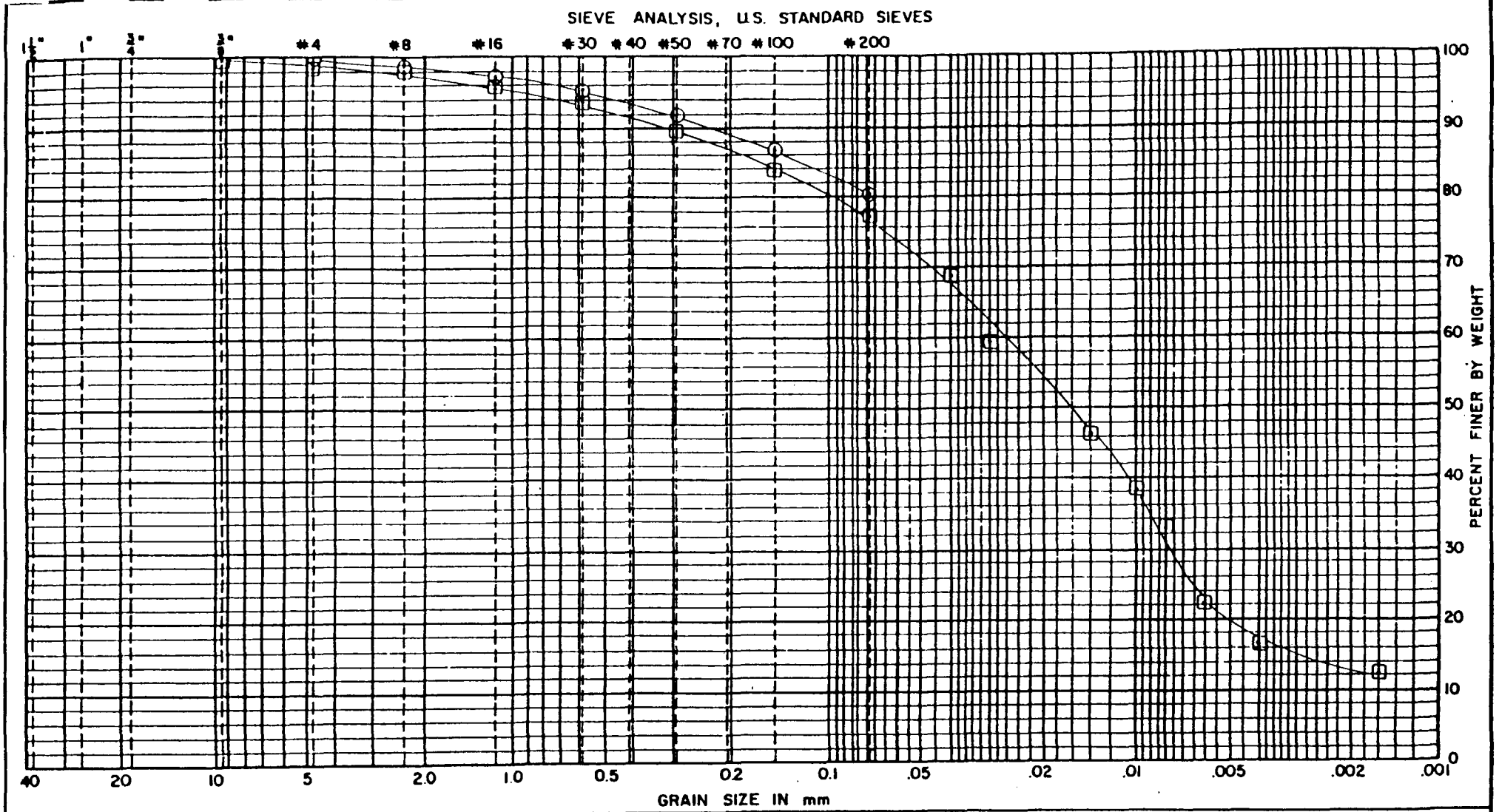
GRADATION CURVES	FIG. NO. G-20



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-17	0'-2'	HIGHLY PLASTIC ORGANIC (OH)
□	"	2'-4'	HIGHLY PLASTIC ORGANIC (OH)

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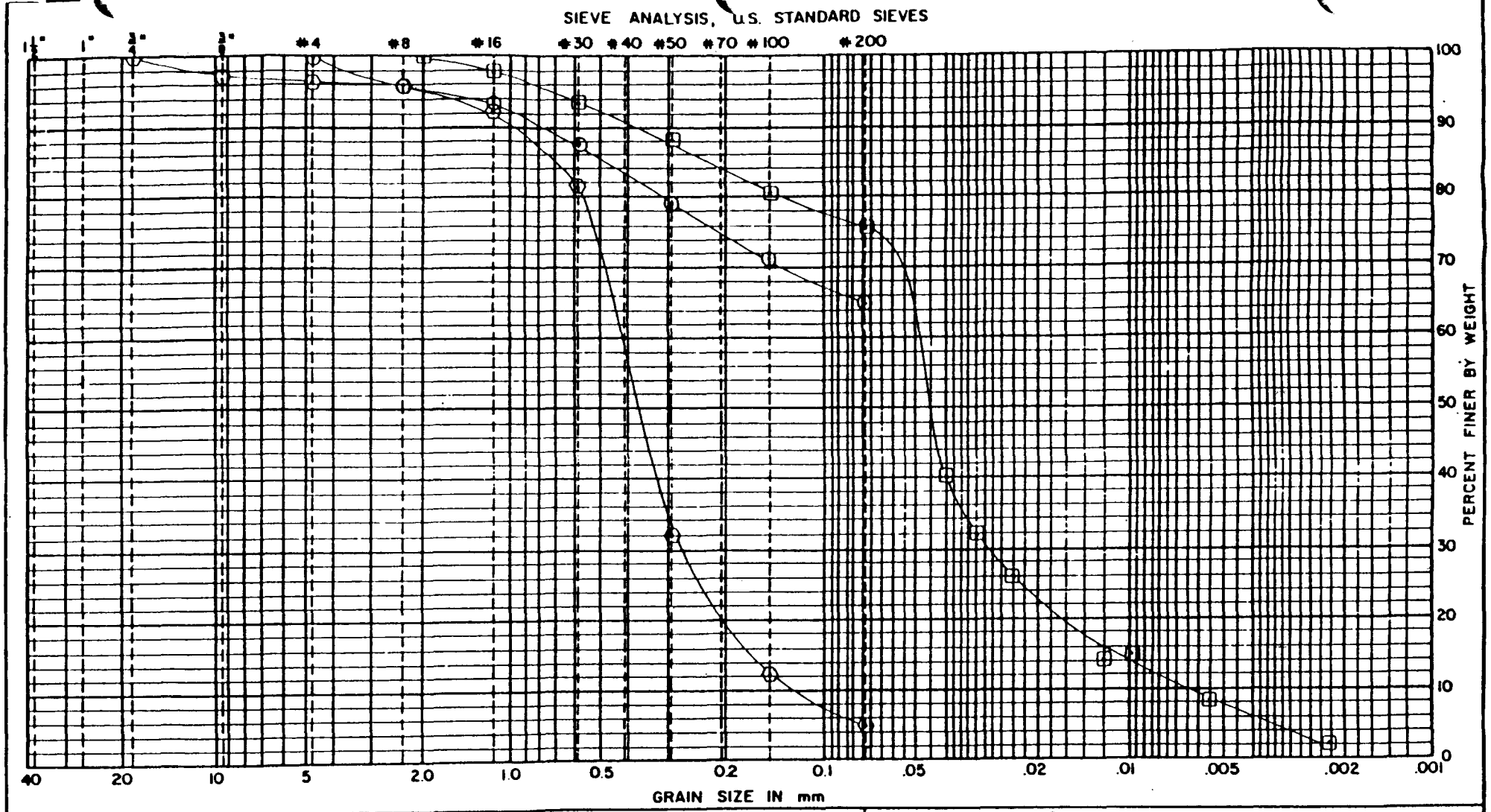
GRADATION CURVES

FIG. NO. G-21



GRAVEL		SAND			CLAY OR SILT
COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	BORING NO.	DEPTH	DESCRIPTION OF SAMPLE
⊙	PD-17	4'-6'	HIGHLY PLASTIC ORGANIC (OH)
□	"	6'-8'	LOW PLASTIC ORGANIC (OL)
○	"	15'-17'	POORLY GRADED SAND TO SILTY SAND (SP-SM)

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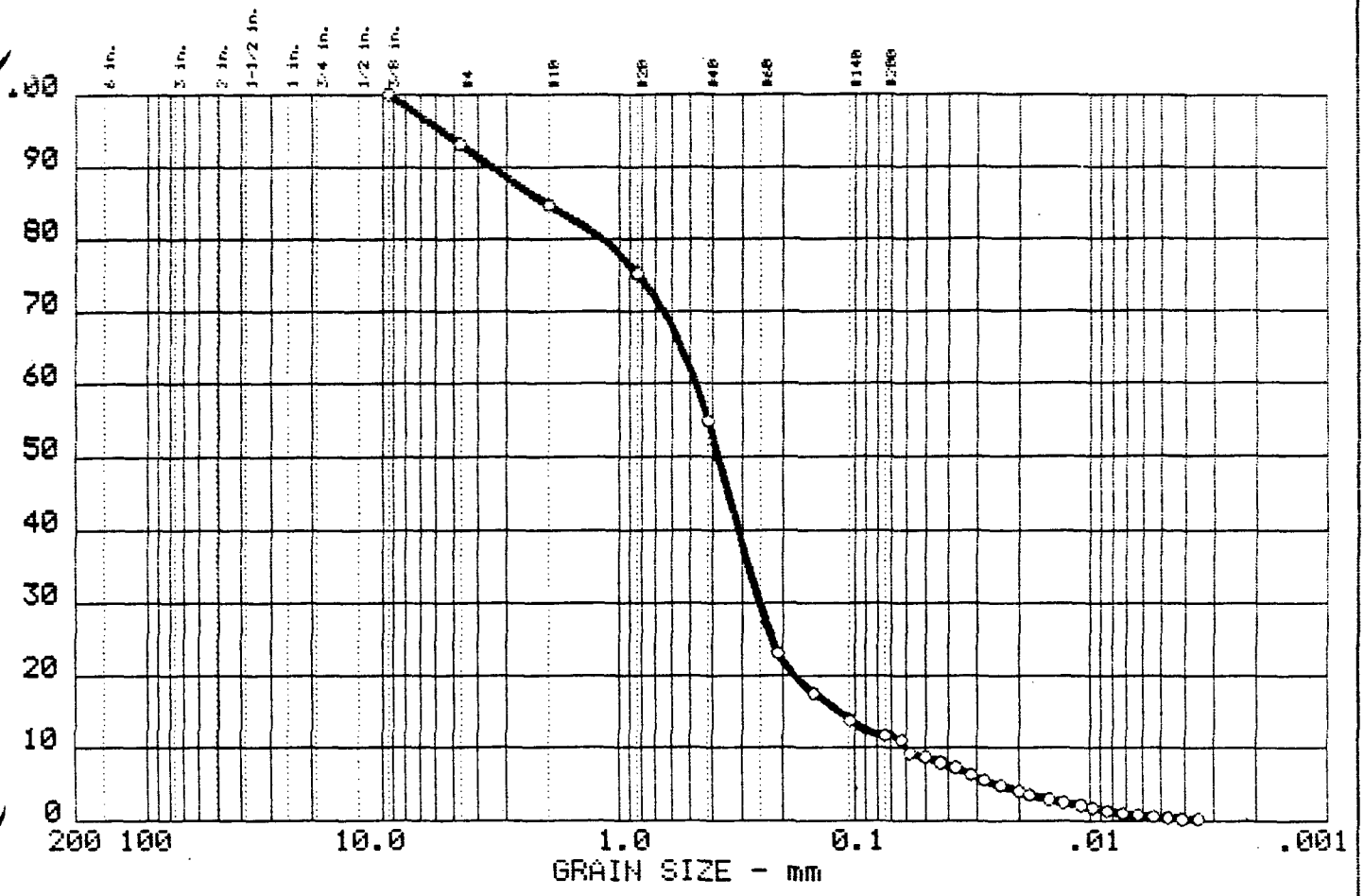
GRADATION CURVES

FIG. NO. G-22

NED Materials and Water Quality Lab

August 1987 to September 1987

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
2	0.0	6.8	81.4	11.3	0.5

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.82	0.47	0.38	0.253	0.2231	0.0600	2.26	7.9

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-1(0-12)

Remarks: Lab. Ser. No. 100-453-1

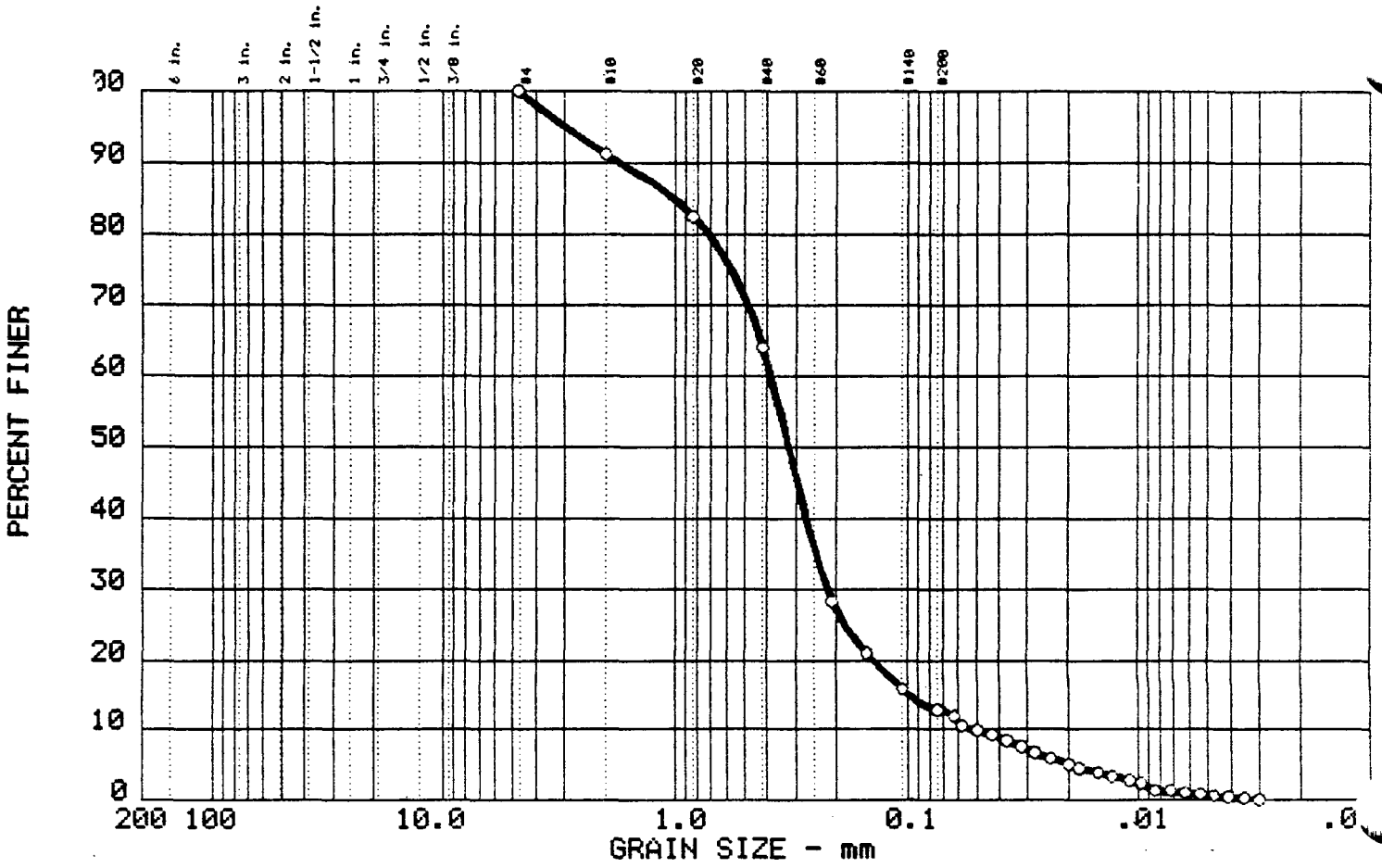
8/27/87

GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	6	0.0	0.0	87.2	12.1	0.7

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.57	0.39	0.32	0.219	0.1862	0.0513	2.41	7.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-1(12-24)

Date: 9/8/87

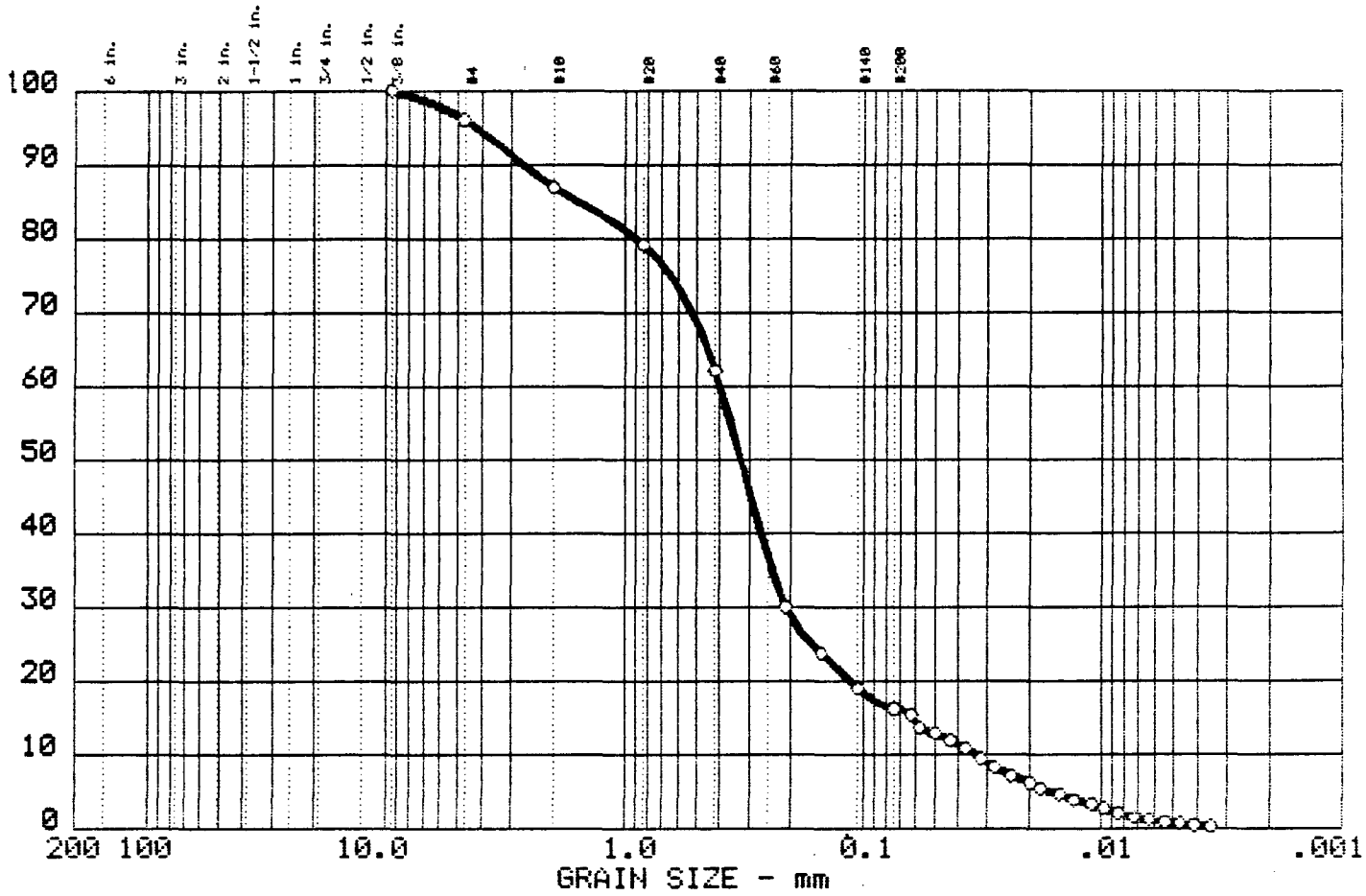
Remarks: Lab. Ser. No. 100-453-2

GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 12

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	7	0.0	3.9	79.8	15.5	0.8

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.64	0.40	0.33	0.210	0.1629	0.0337	3.29	11.8

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-1(24-36)

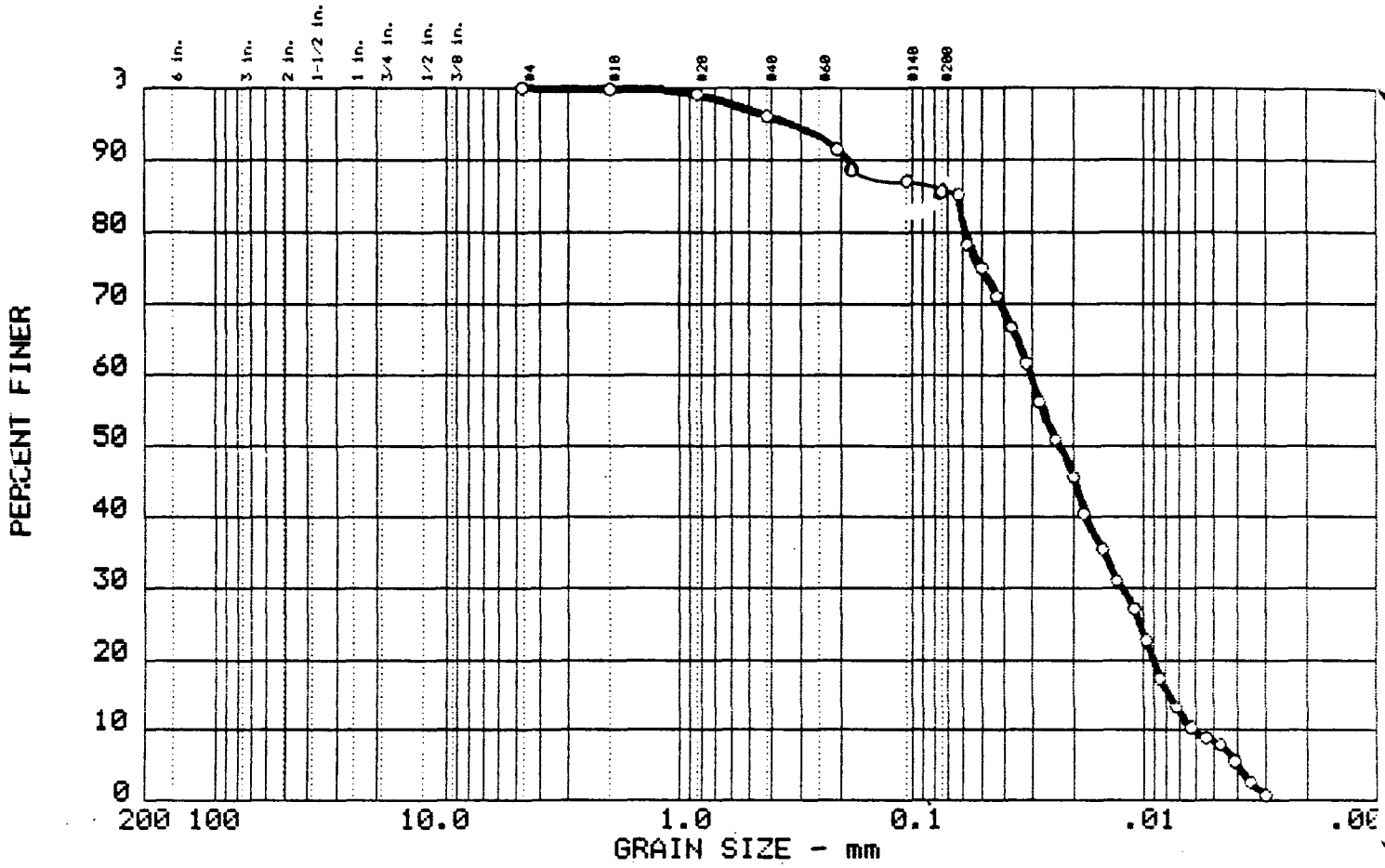
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-3

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 13

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
8	0.0	0.0	14.3	77.4	8.3

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.05	0.03	0.02	0.012	0.0103	0.0062	0.82	5.0

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-2(0-12)

Date: 9-8-87

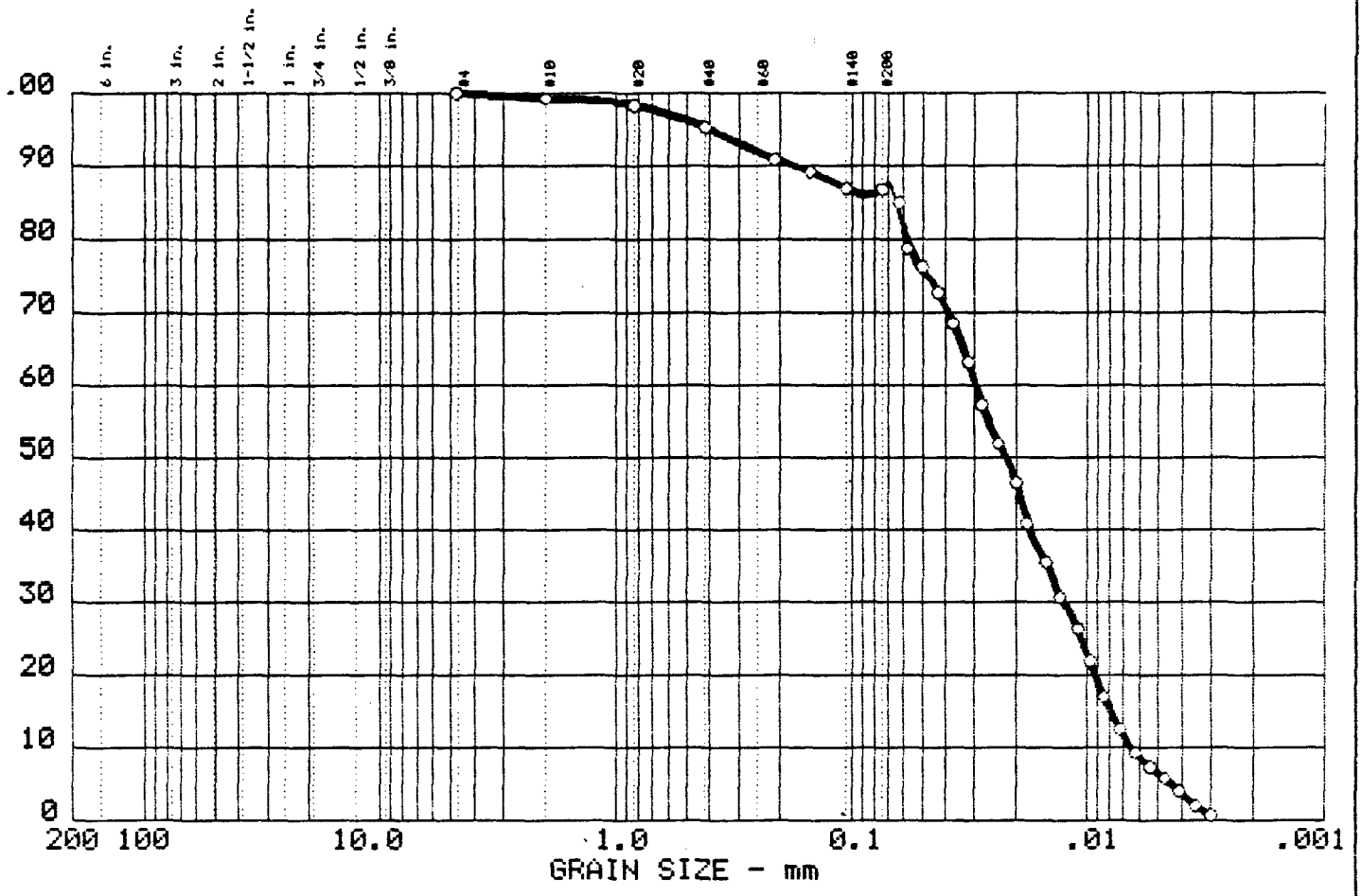
Remarks: Lab. Ser. No. 100-453-4

GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 4

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
5	0.0	0.0	13.2	80.3	6.5

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.05	0.03	0.02	0.013	0.0105	0.0065	0.83	4.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-2(12-24)

Remarks: Lab. Ser. No. 100-453-5

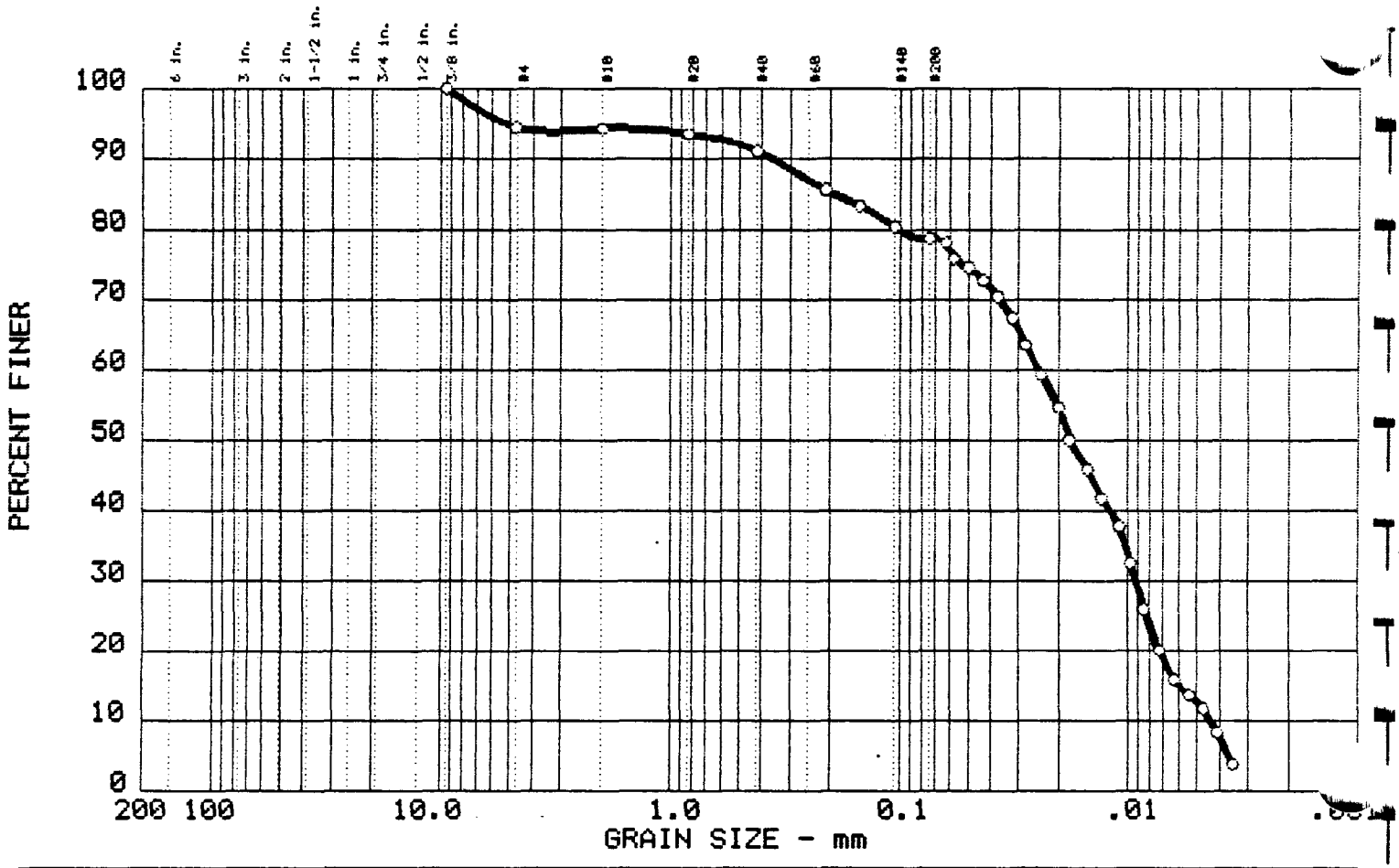
: 9/1/87

GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 5

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	6	0.0	5.5	15.8	66.0	12.7

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.05	0.02	0.02	0.009	0.0083	0.0043	0.81	5.7

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-2 (24-48)

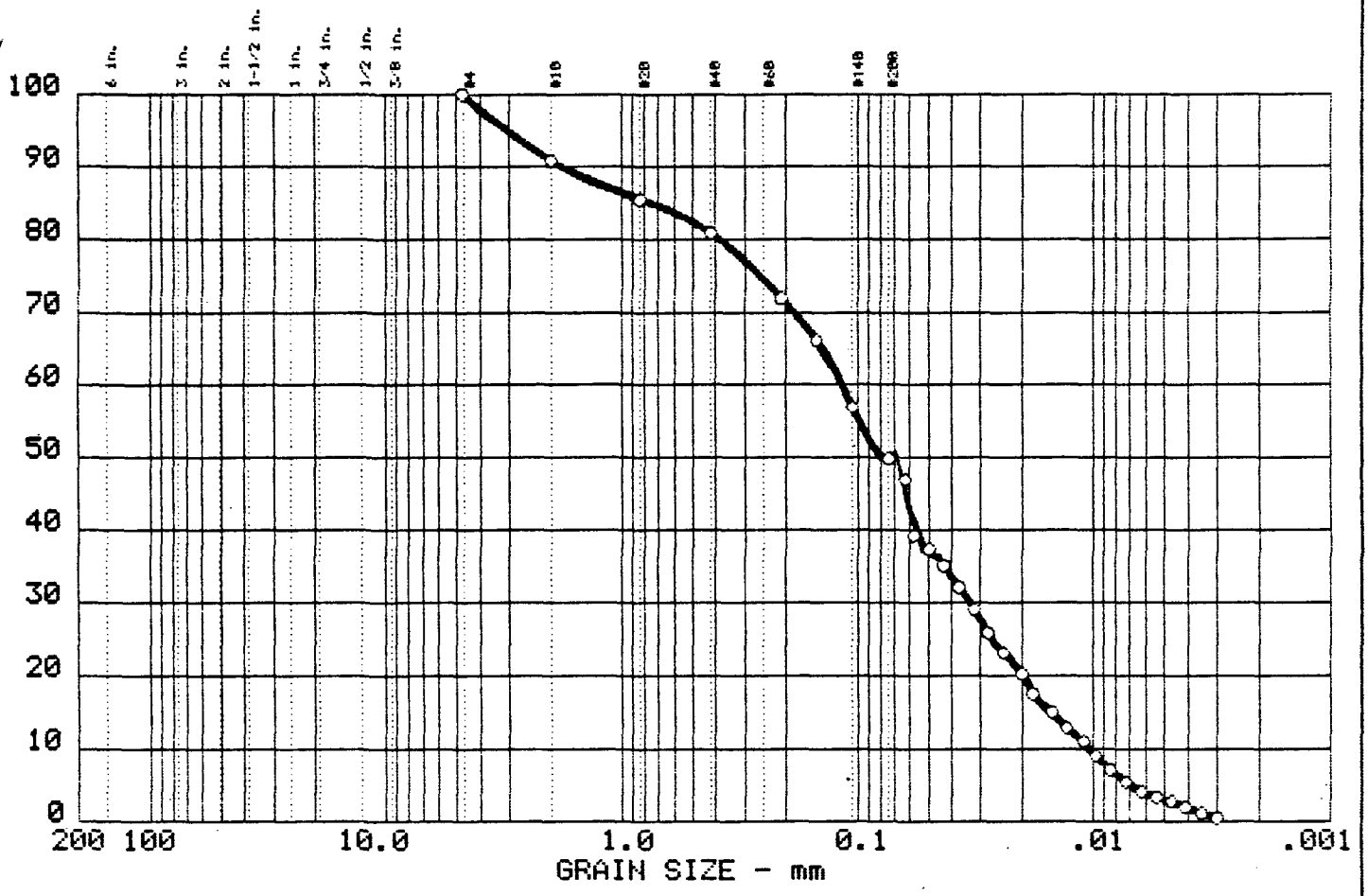
Remarks: Lab. Ser. No. 100-453-6

a: 9/2/87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 6

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	7	0.0	0.0	50.1	46.9	3.0

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.26	0.12	0.07	0.033	0.0266	0.0102	0.92	11.4

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-3 (0-12)

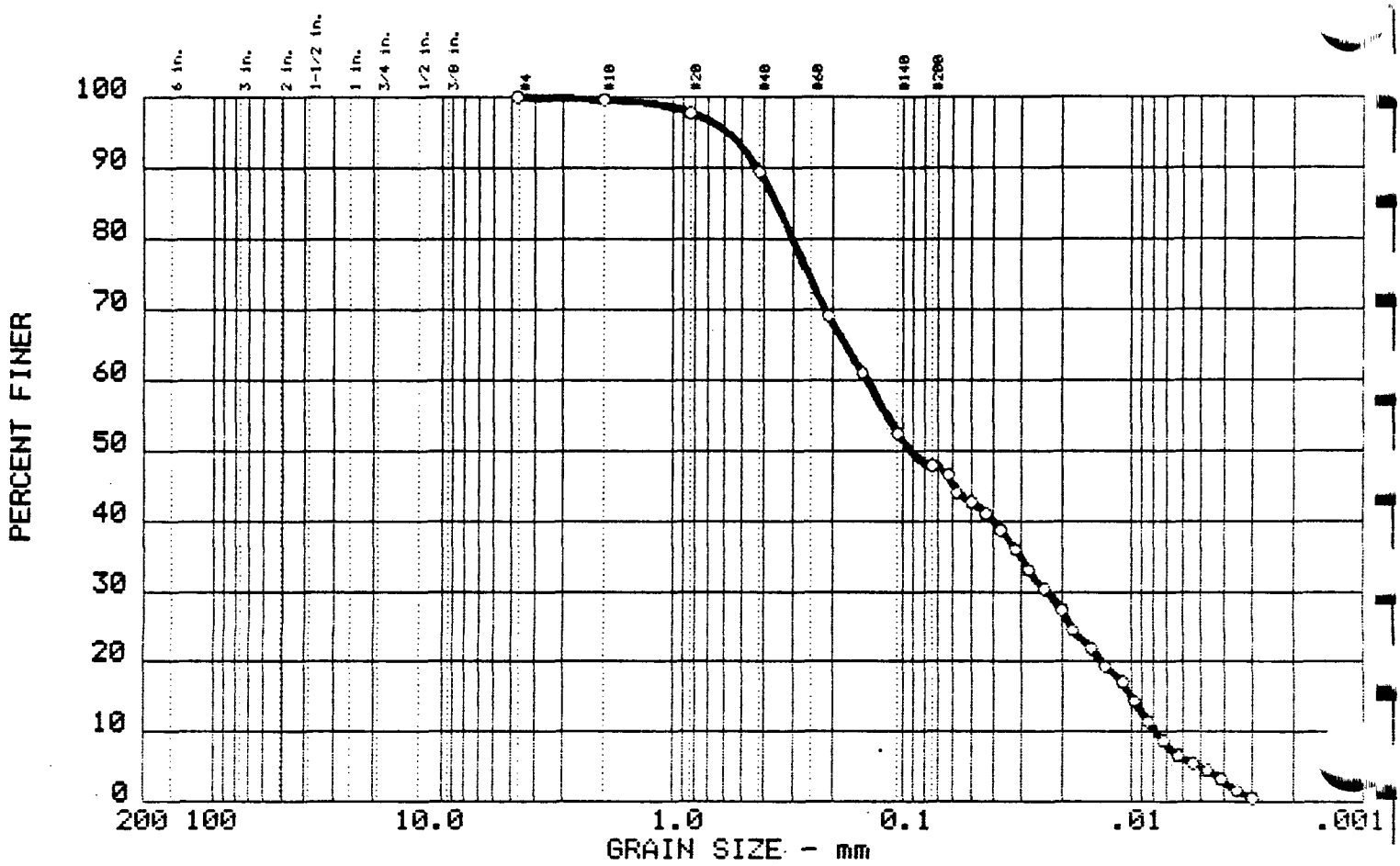
Remarks: Lab. Ser. No. 100-453-7

: 9/3/87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 7

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	8	0.0	0.0	52.1	43.0	4.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.26	0.14	0.09	0.023	0.0183	0.0078	0.49	18.1

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-3 (12-24)

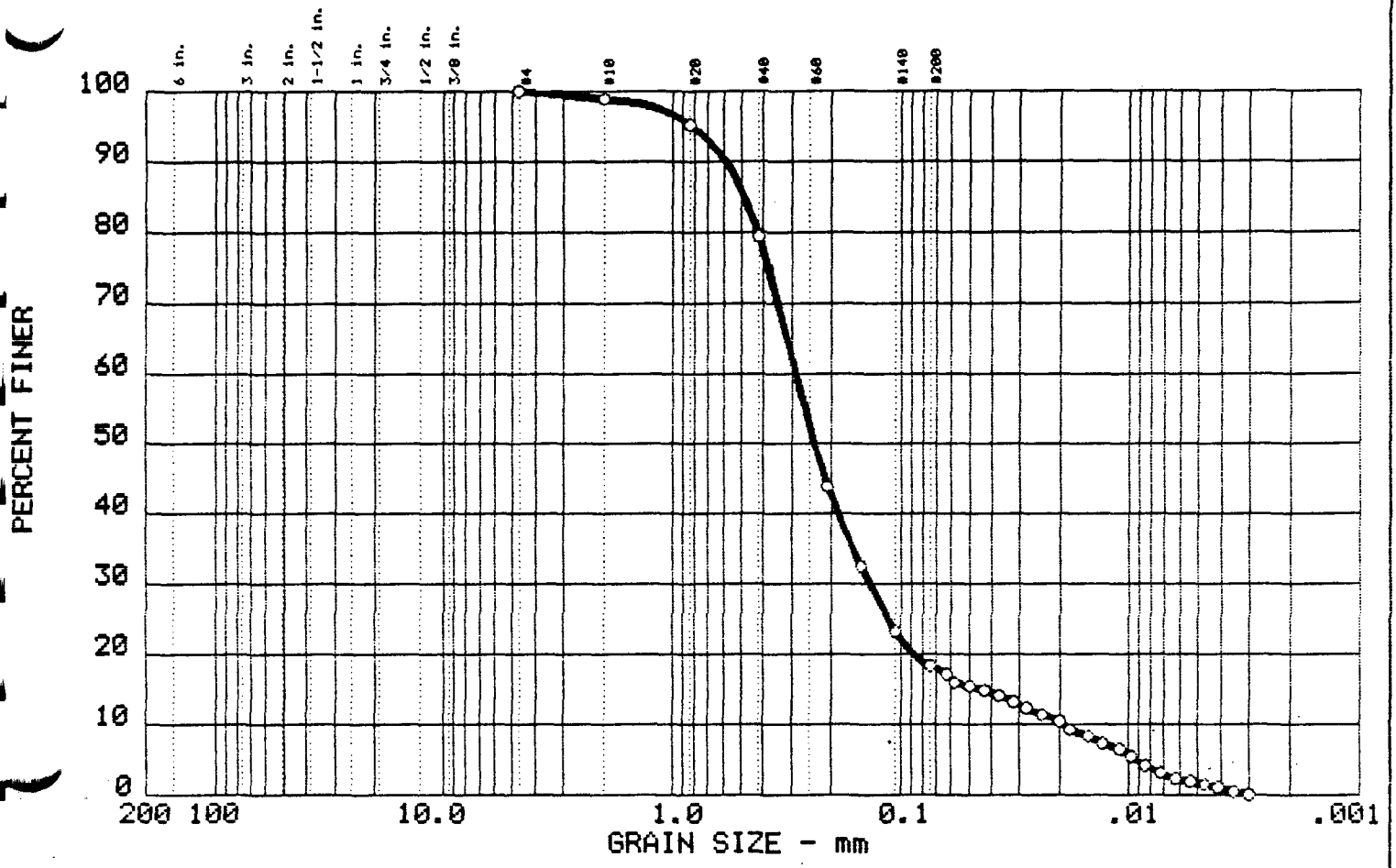
.e: 9/3/87

Remarks: Lab. Ser No. 100-453-8

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 8

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	9	0.0	0.0	81.7	16.6	1.7

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.38	0.29	0.24	0.136	0.1131	0.0192	3.34	15.0

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-3 (24-48)

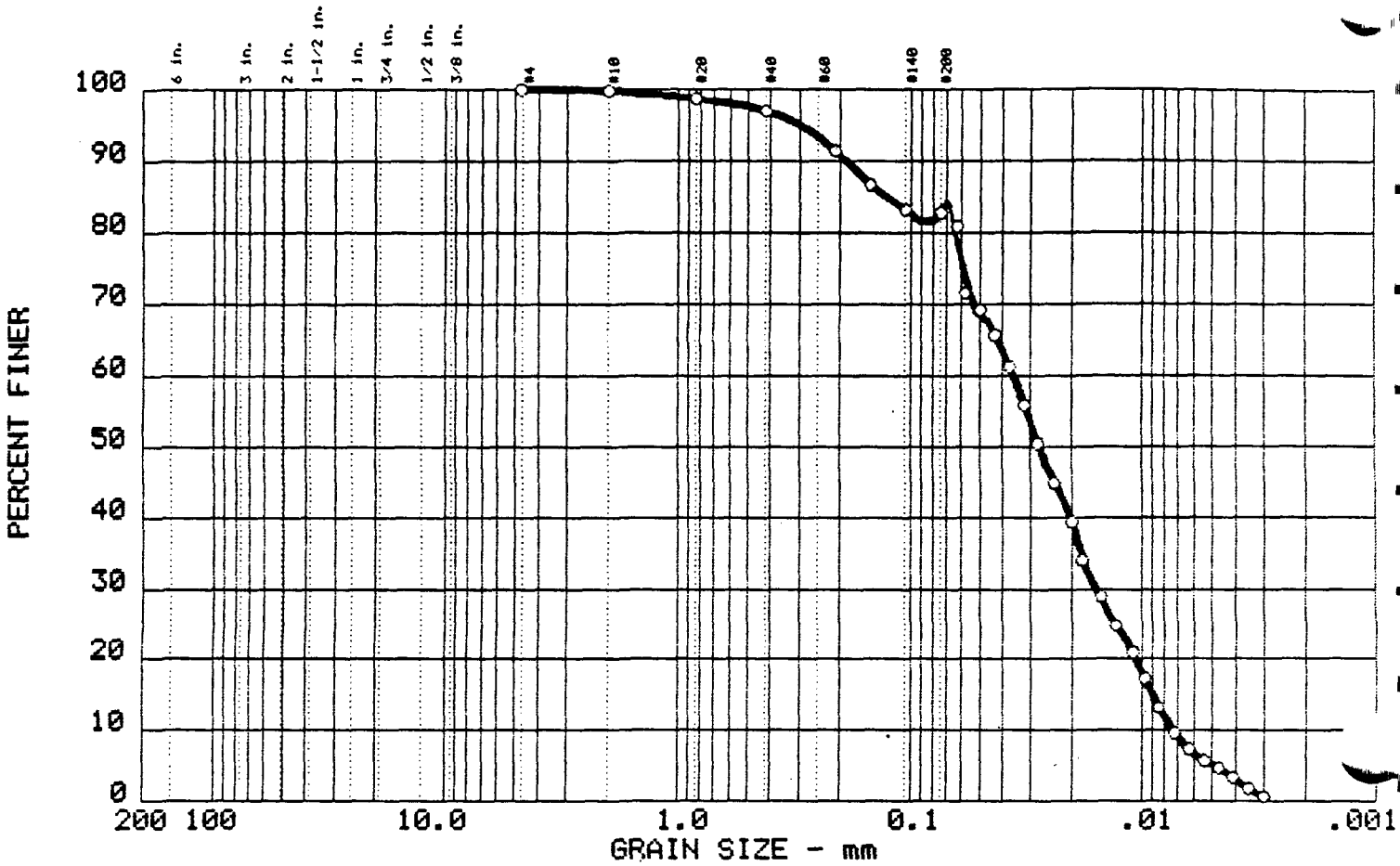
Remarks: Lab. Ser No 100-453-9

Date: 9/3/87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 9

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	10	0.0	0.0	17.2	77.7	5.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.06	0.04	0.03	0.016	0.0132	0.0074	0.92	4.8

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-4 (0-12)

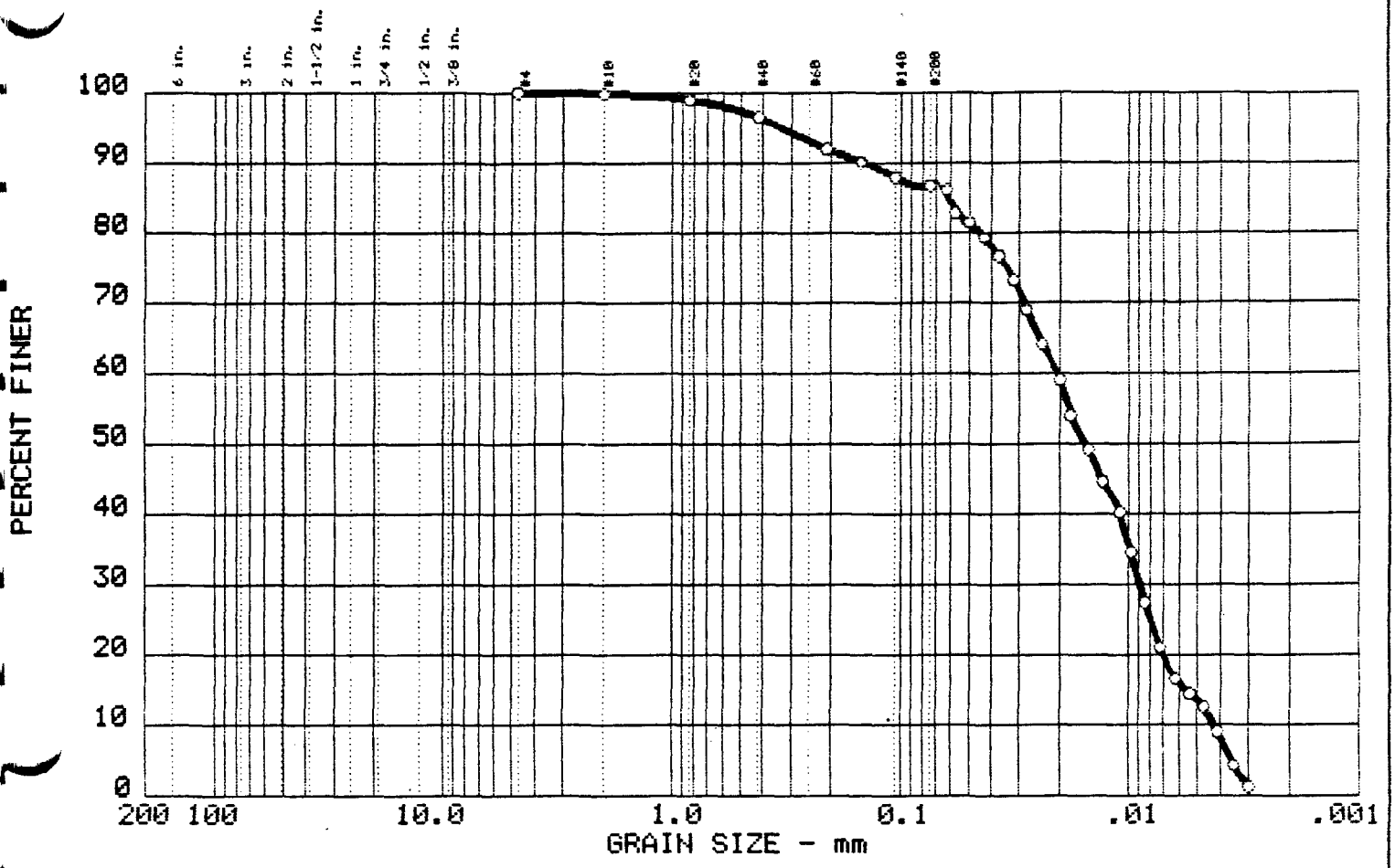
Date: 9/3/87

Remarks: Lab. Ser. No. 100-453-10

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 10

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	11	0.0	0.0	13.3	73.2	13.5

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.03	0.02	0.02	0.009	0.0080	0.0042	0.93	4.9

	MATERIAL DESCRIPTION	USCS	AASHTO
○			

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-4 (12-24)

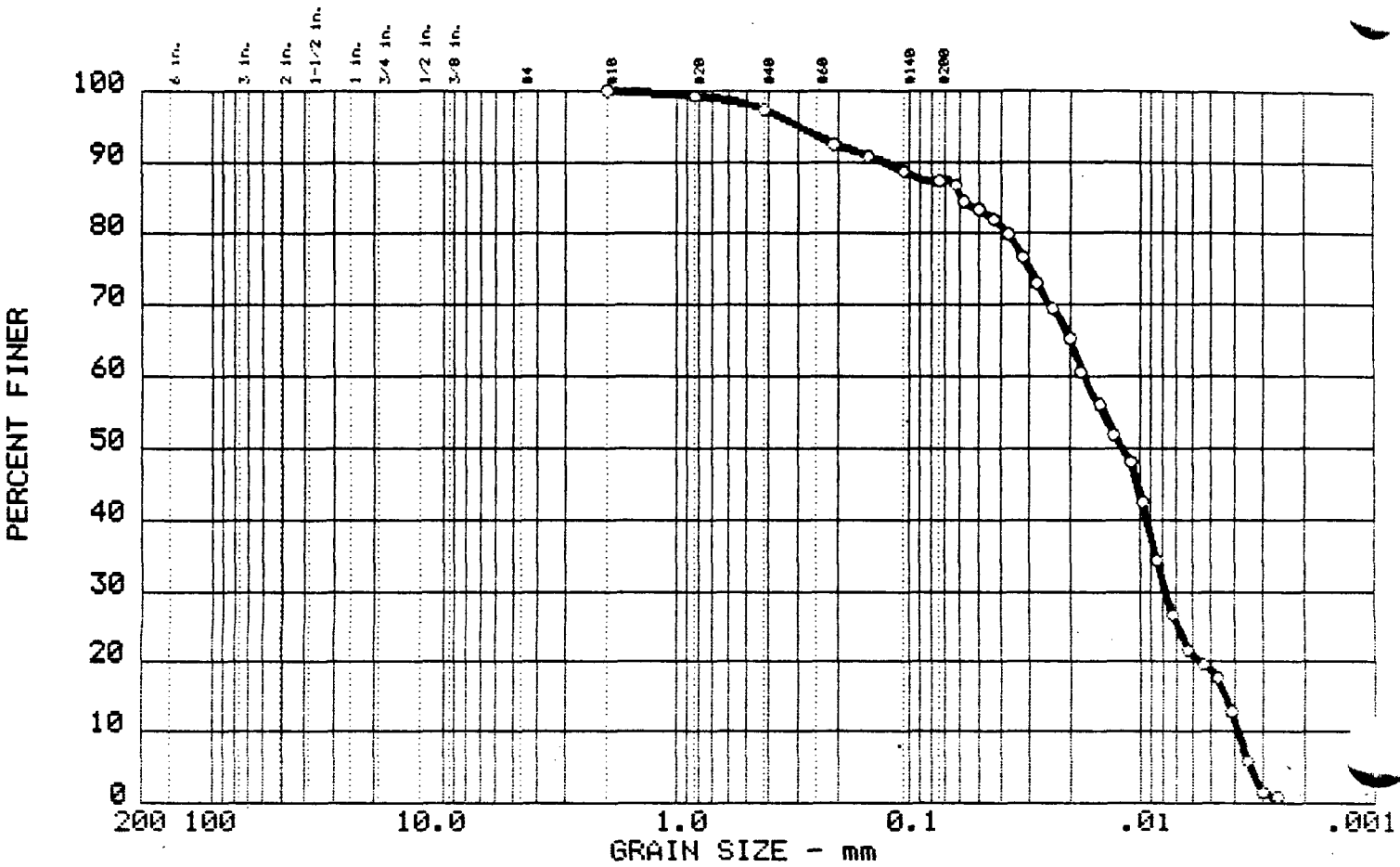
Date: 9/3/87

Remarks: Lab. Ser. No. 100-453-11

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 11

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	12	0.0	0.0	12.7	68.6	18.7

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.03	0.02	0.01	0.008	0.0070	0.0039	0.90	4.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-4 (24-48)

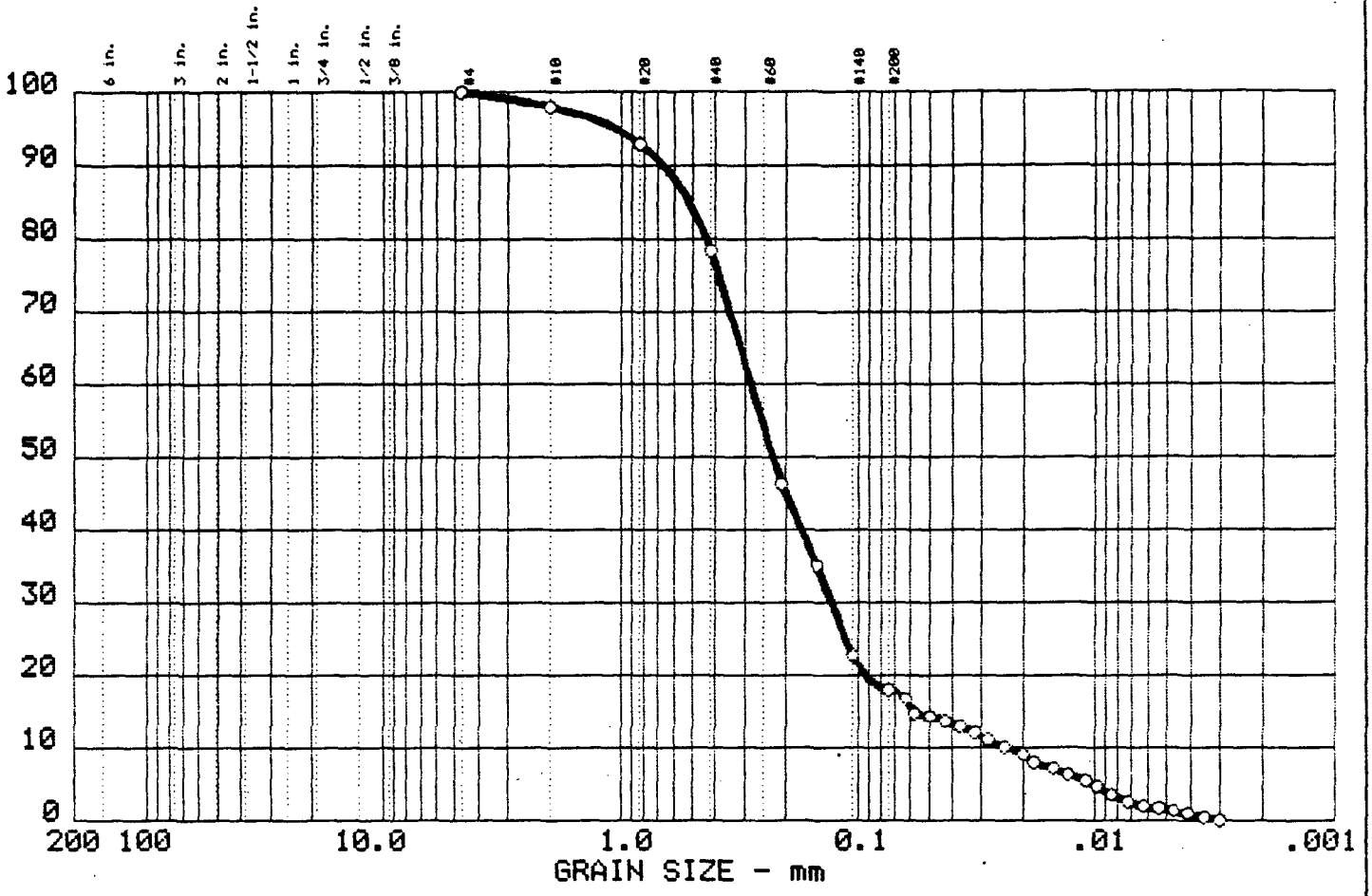
Date: 9/3/87

Remarks: Lab. Ser. No. 100-453-12

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 12

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	13	0.0	0.0	82.1	16.4	1.5

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.39	0.28	0.23	0.129	0.1126	0.0233	2.53	12.2

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-5 (0-12)

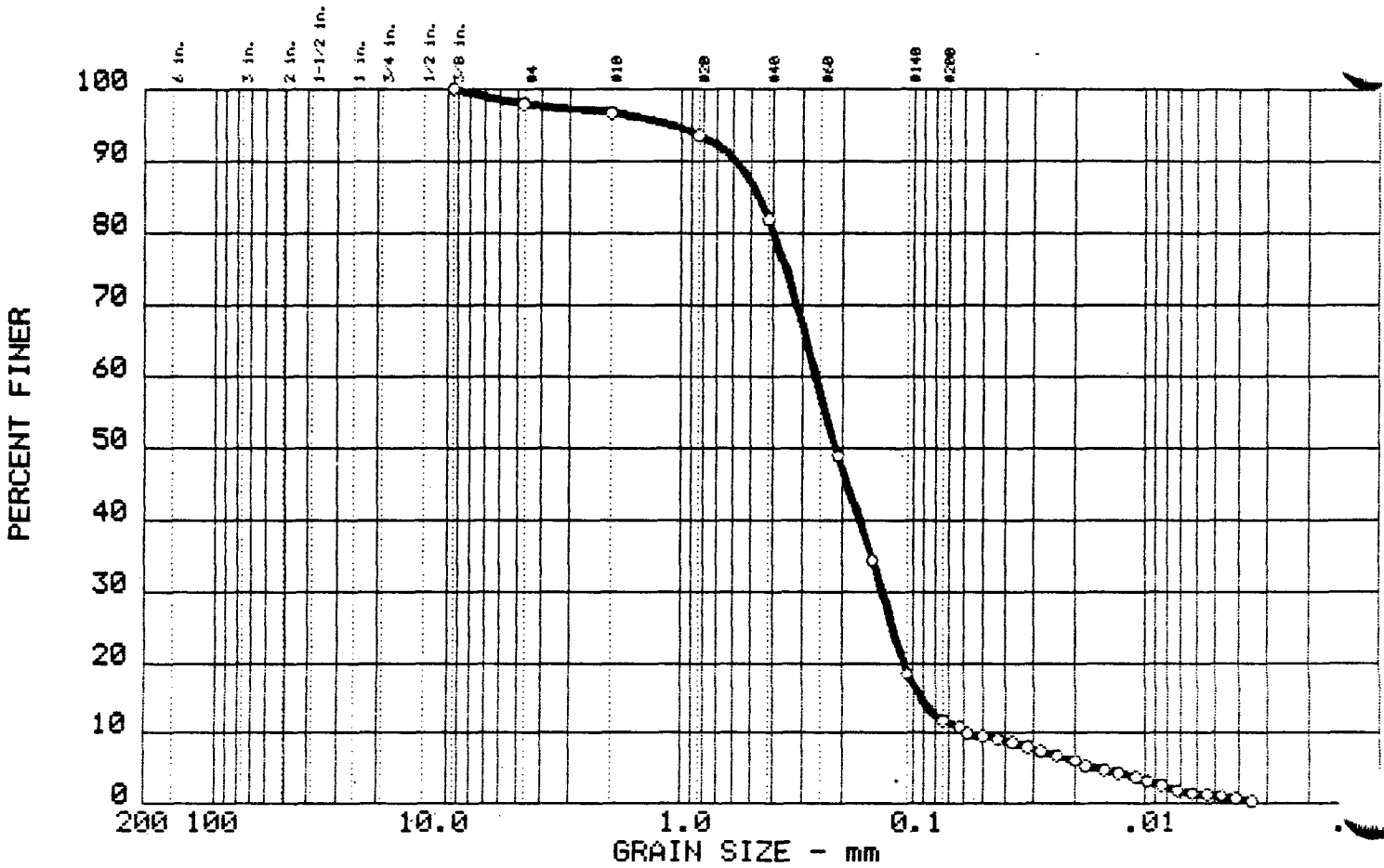
Date: 9/3/87

Remarks: Lab. Ser No. 100-453-13

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 13

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	14	0.0	2.0	86.3	10.6	1.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.35	0.26	0.22	0.136	0.1223	0.0585	1.20	4.5

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-5 (12-24)

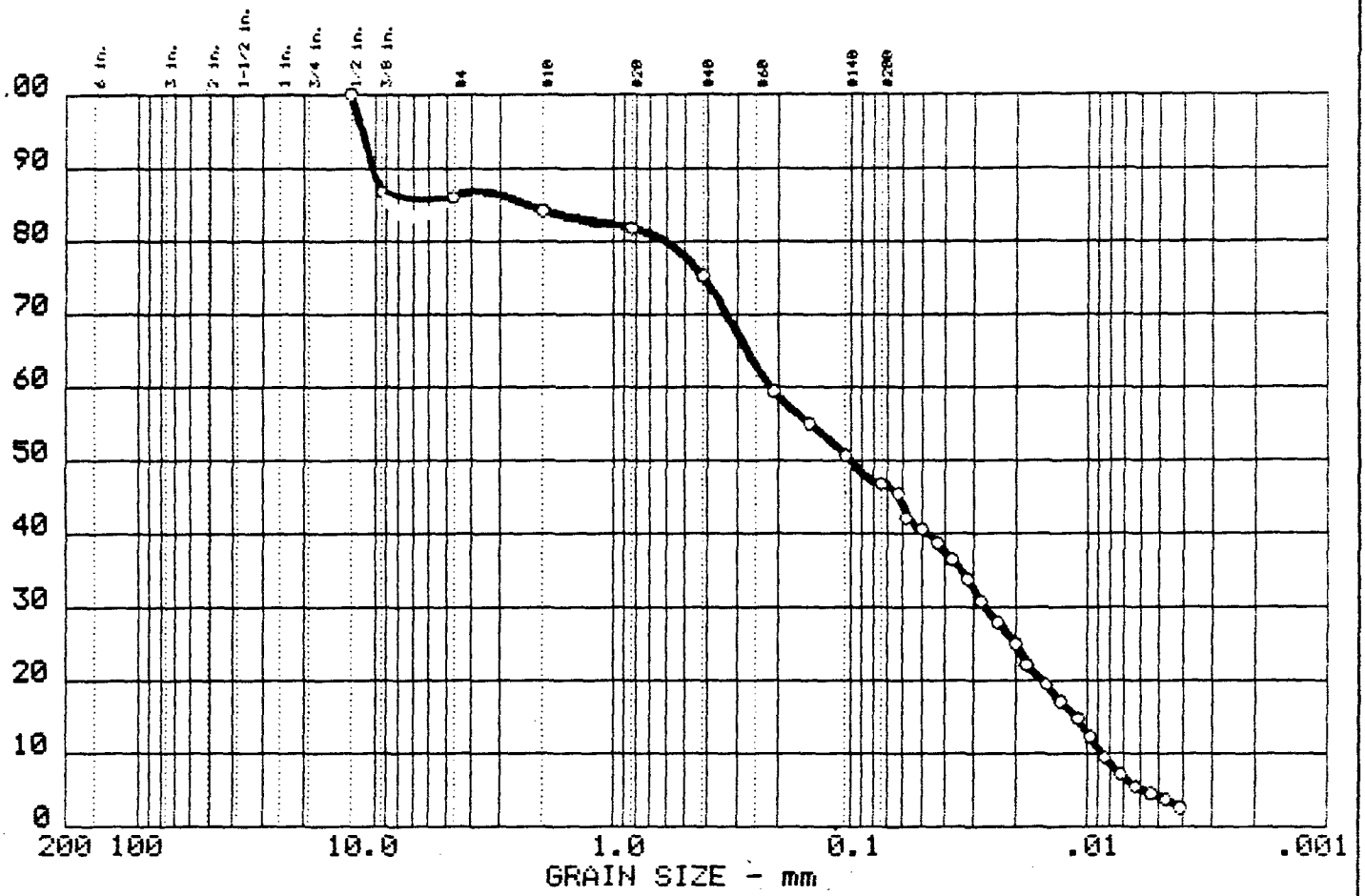
Remarks: Lab. Ser. No. 100-453-14

: 9/3/87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 14

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	9	0.0	14.0	39.2	42.7	4.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.41	0.22	0.10	0.027	0.0200	0.0087	0.38	24.8

	MATERIAL DESCRIPTION	USCS	AASHTO
○			

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-6(0-12)

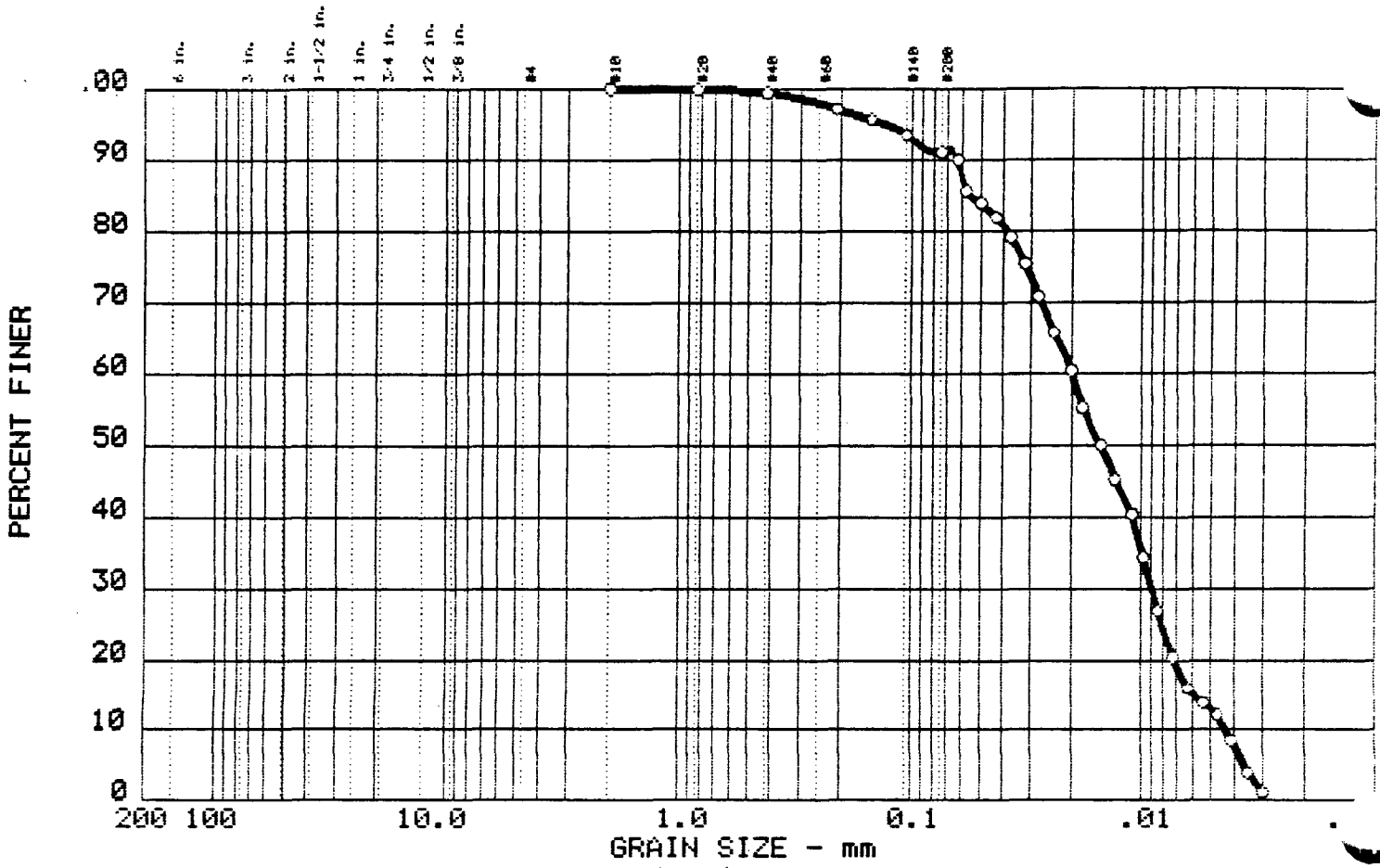
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-15

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 15

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	10	0.0	0.0	8.9	78.2	12.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.03	0.02	0.01	0.009	0.0081	0.0043	0.95	4.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-6(12-24)

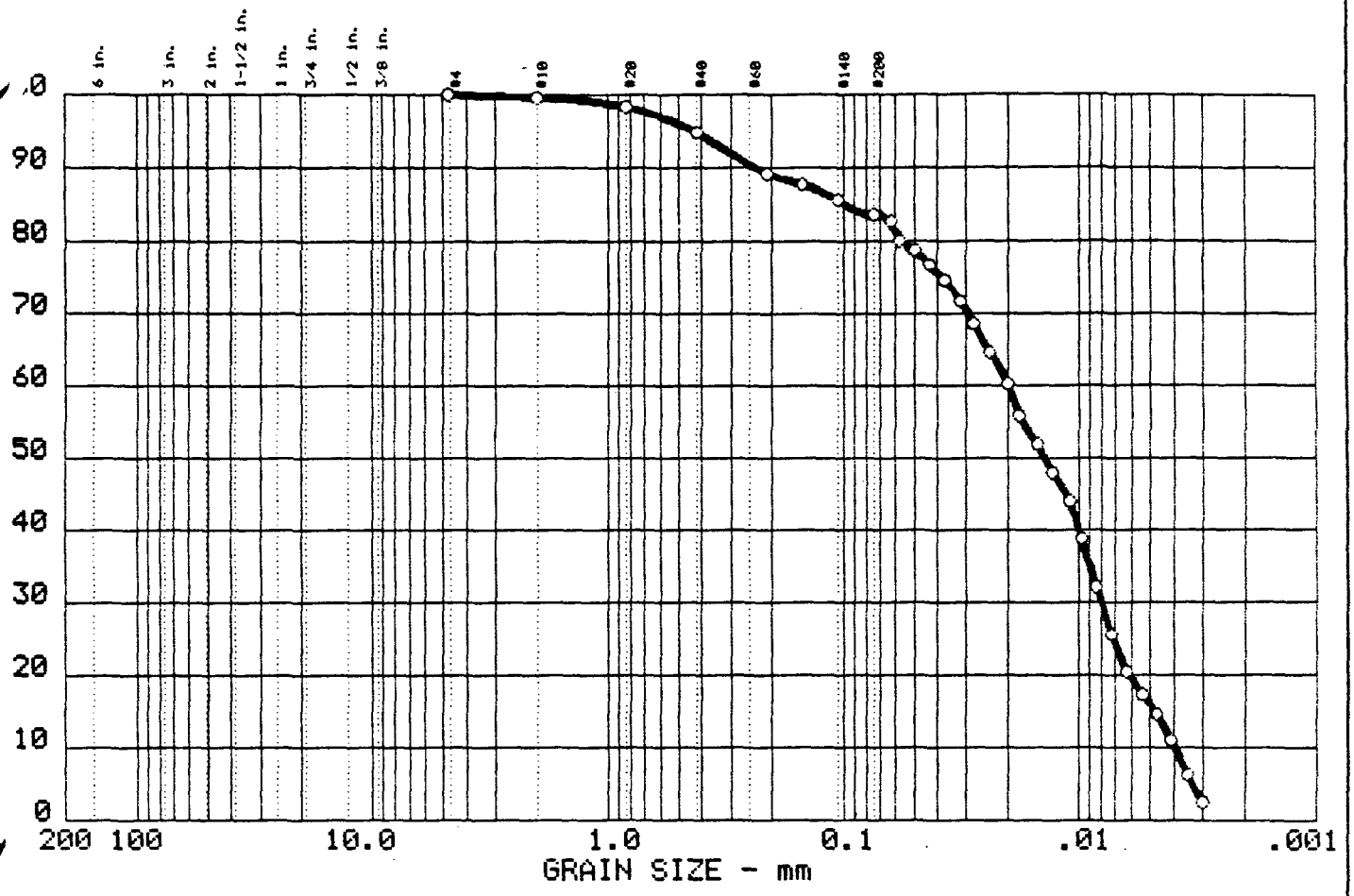
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-16

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 16

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
11	0.0	0.0	16.4	67.6	16.0

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.04	0.02	0.01	0.008	0.0072	0.0039	0.83	5.0

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD6(24-48)

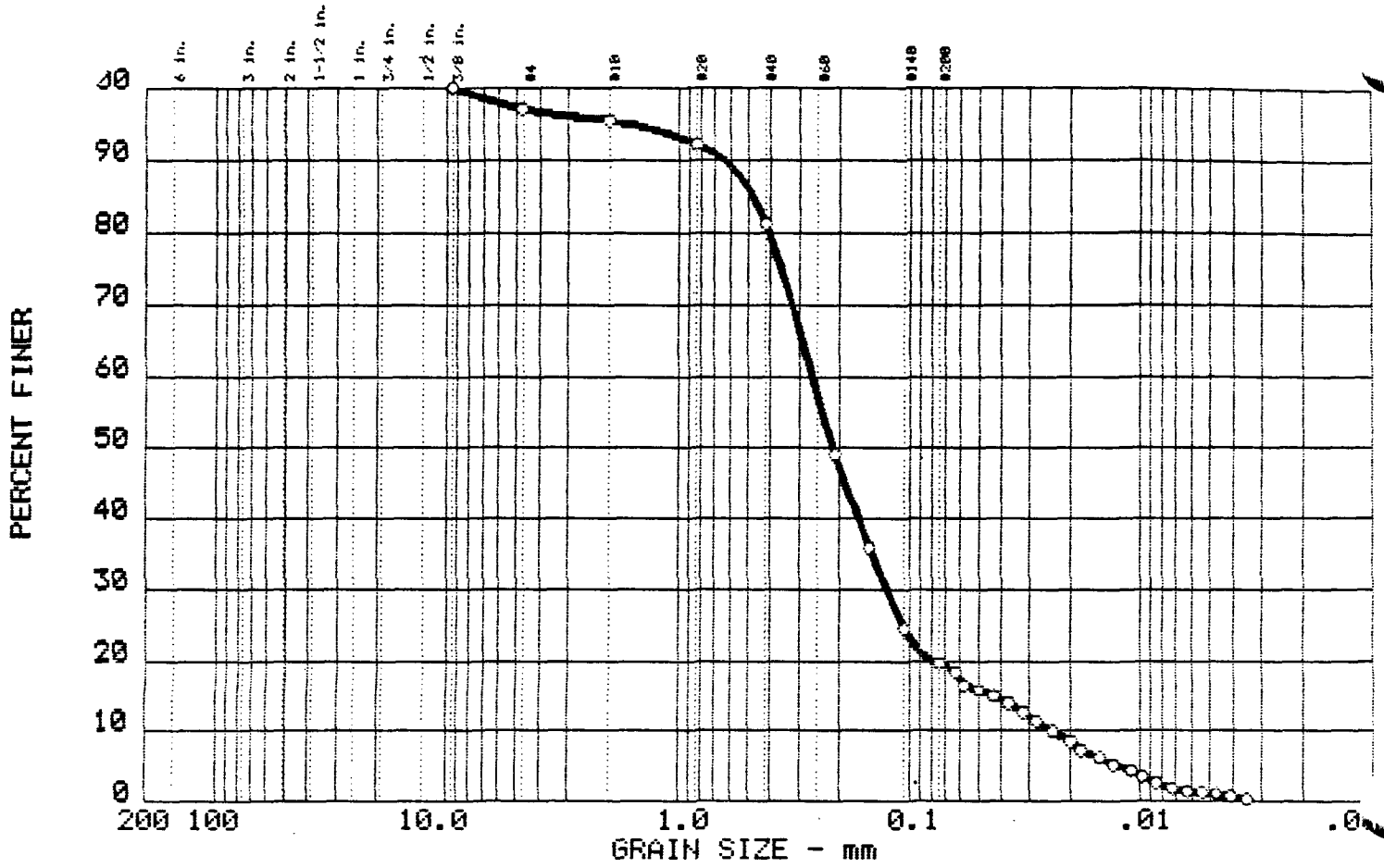
9-8-87

Remarks: Lab. Ser. No. 100-453-17

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 17

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	5	0.0	2.9	77.4	18.6	1.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.36	0.26	0.21	0.126	0.1070	0.0245	2.46	10.7

	MATERIAL DESCRIPTION	USCS	AASHTO
○			

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-7(0-12)

Remarks: Lab. Ser No. 100-453-18

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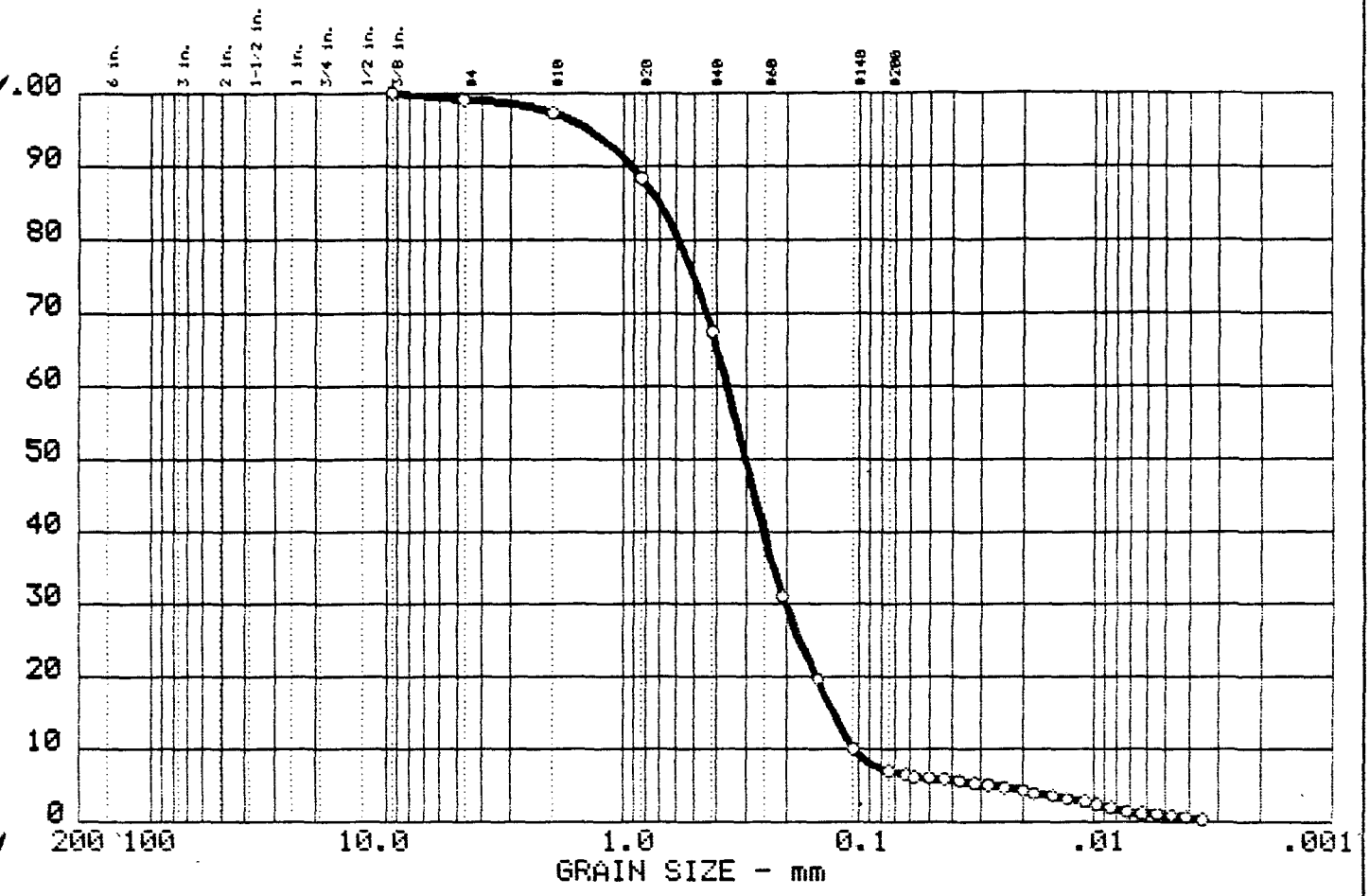
GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 18

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
13	0.0	0.8	92.2	6.1	0.9

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.50	0.36	0.30	0.205	0.1774	0.1045	1.11	3.5

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-7(12-24)

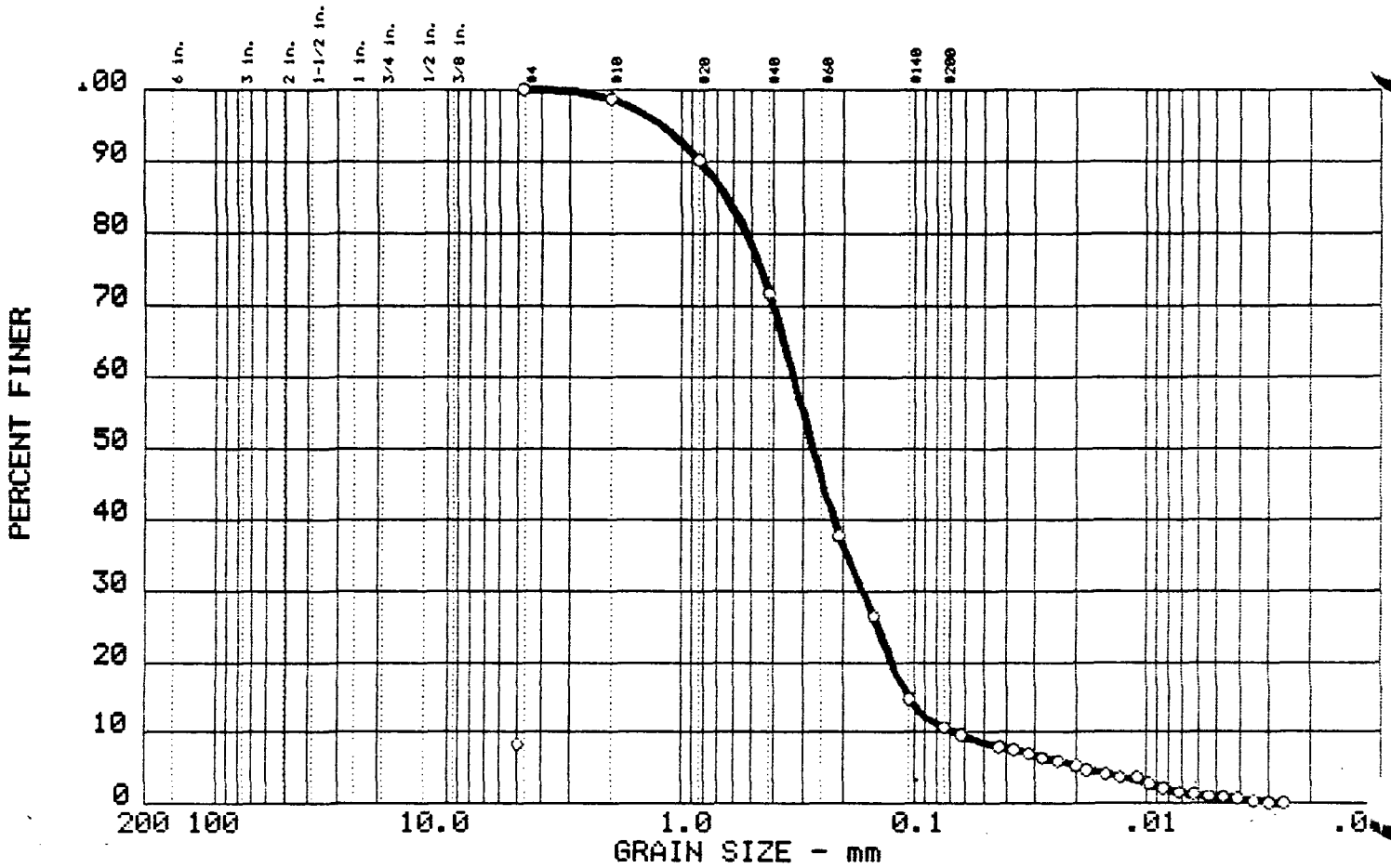
: 9-8-87

Remarks: Lab. Ser. No. 100-453-19

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 19

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	14	0.0	0.0	89.4	9.7	0.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.45	0.33	0.27	0.166	0.1427	0.0652	1.28	5.1

	MATERIAL DESCRIPTION	USCS	AASHTO
○			

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-7(24-48)

Remarks: Lab. Ser. No. 100-453-20

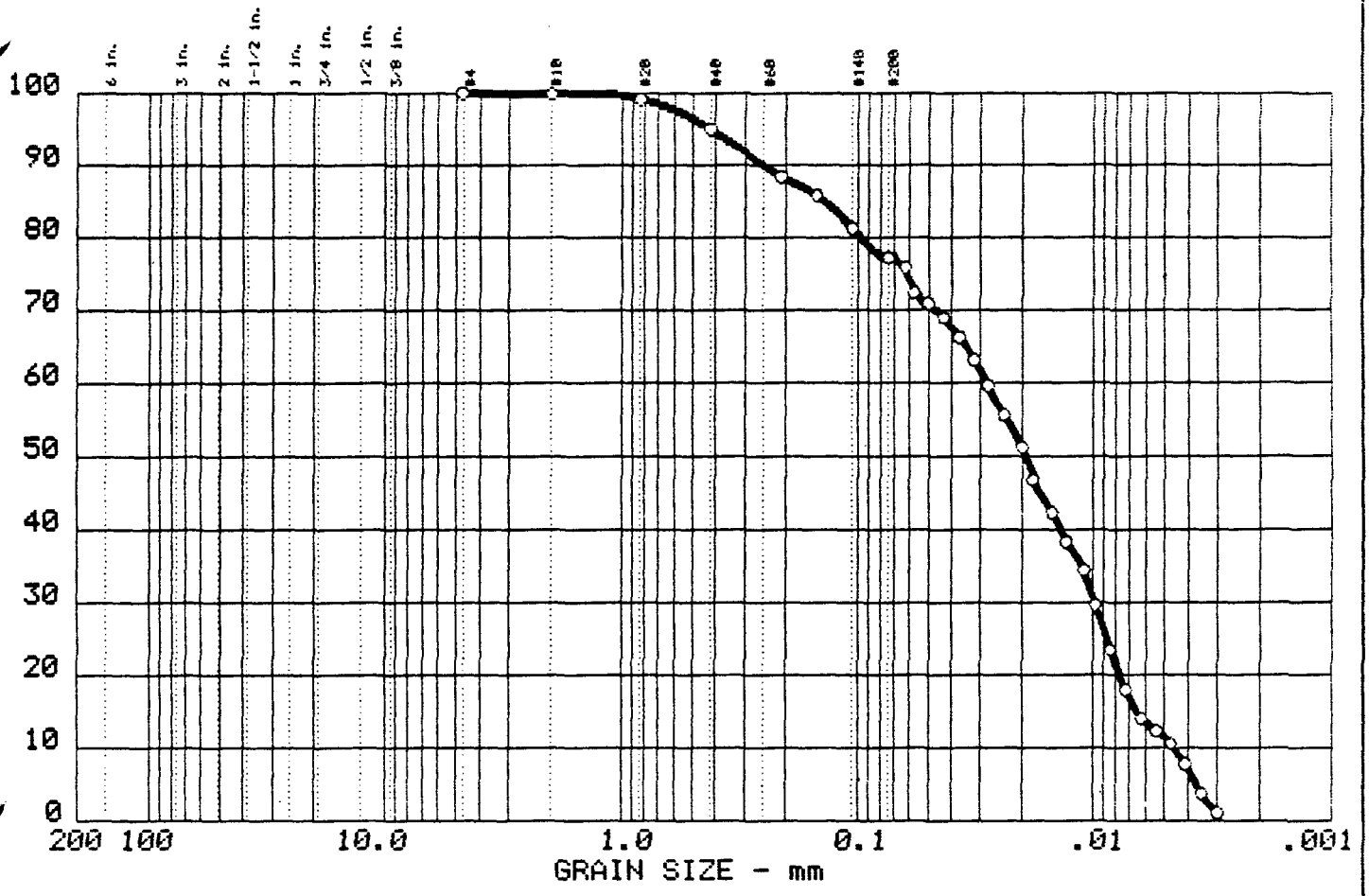
I 9-8-87

GRAIN SIZE DISTRIBUTION TEST REPORT

CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 20

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
15	0.0	0.0	22.8	65.7	11.5

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.06	0.03	0.02	0.010	0.0088	0.0045	0.75	6.2

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-8(0-12)

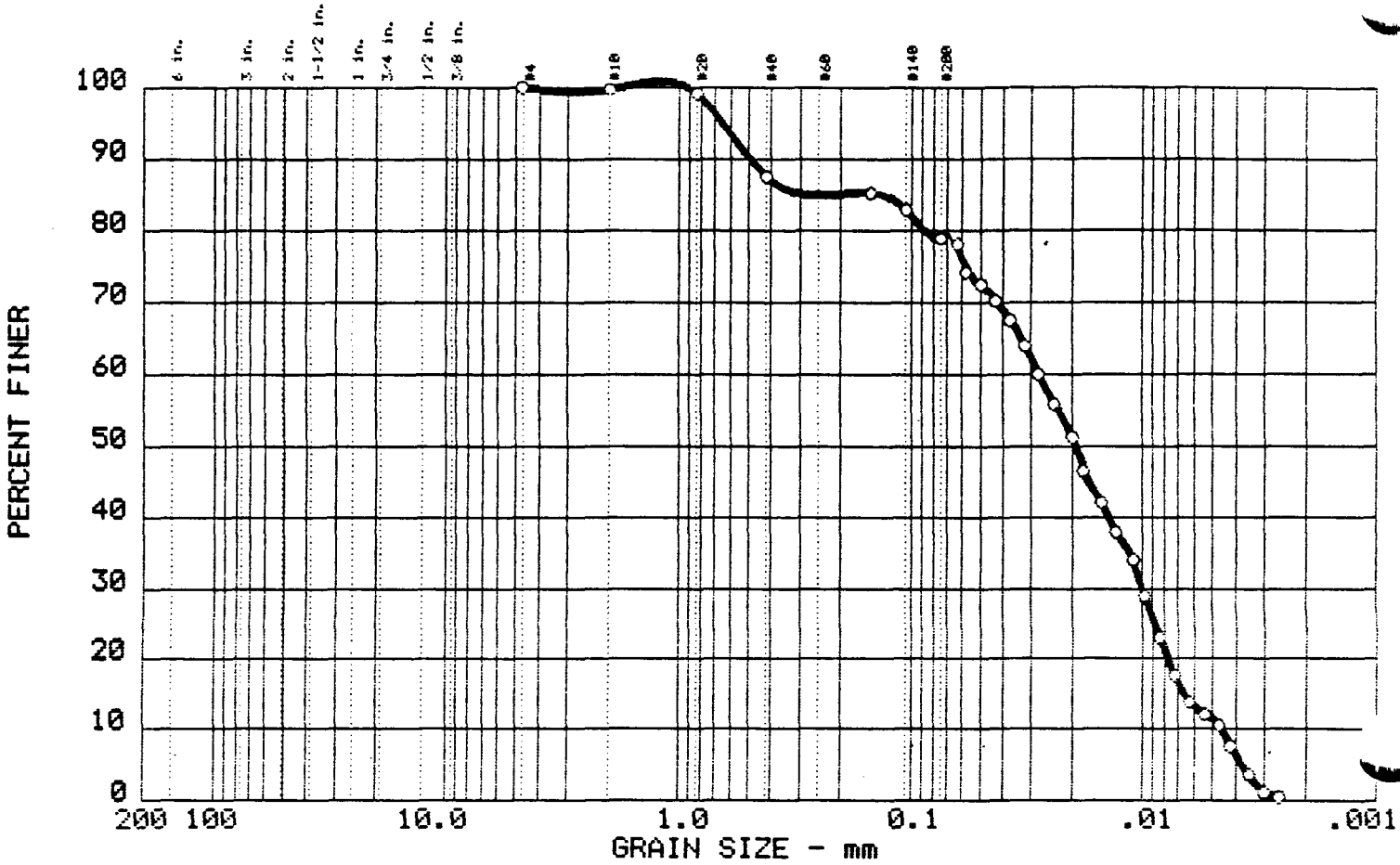
Remarks: Lab. Ser. No. 100-453-21

: 9-8-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 21

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	16	0.0	0.0	21.1	67.6	11.3

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.06	0.03	0.02	0.010	0.0089	0.0046	0.79	6.1

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-8(12-24)

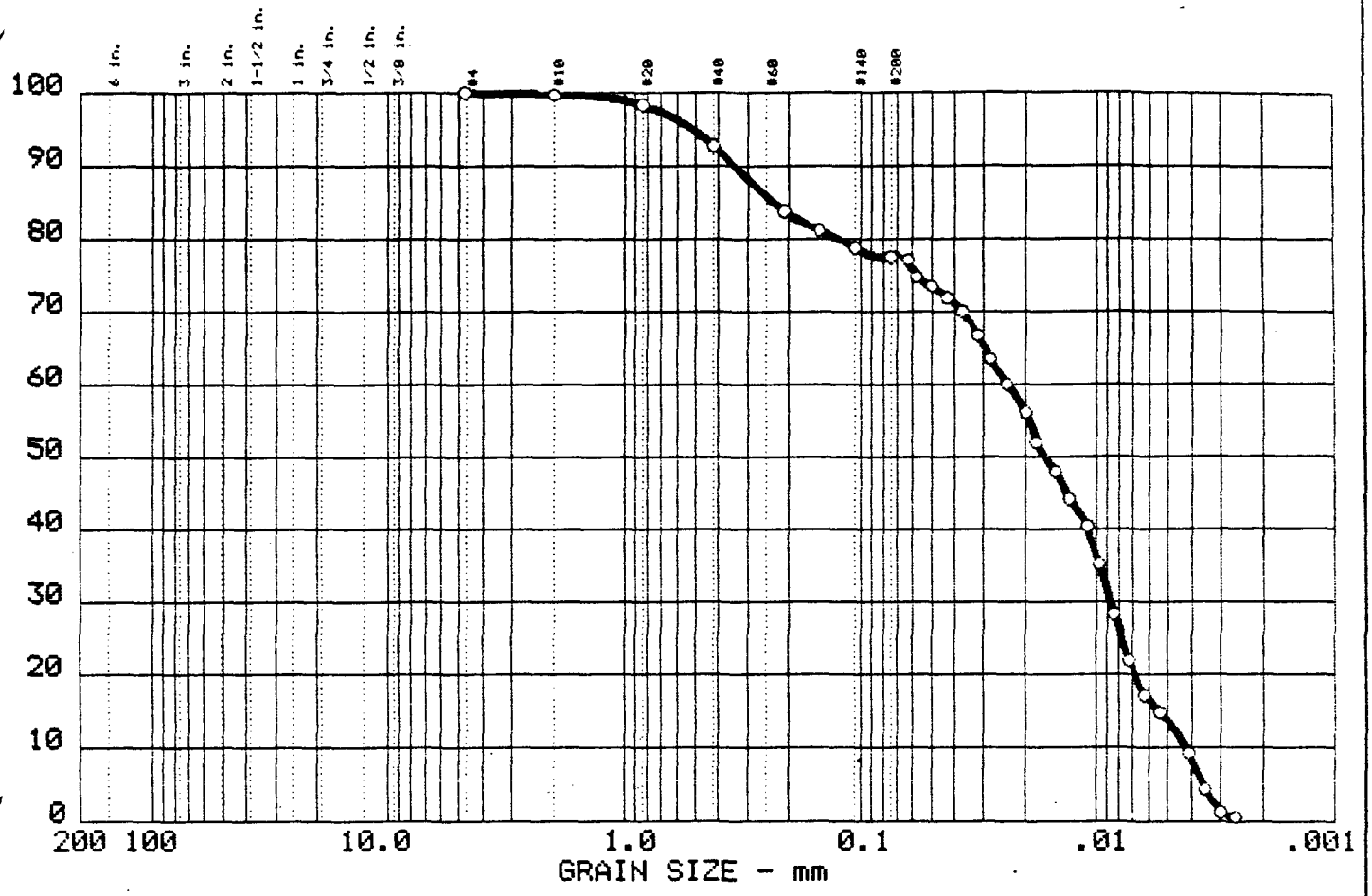
Remarks: Lab. Ser. No. 100-453-22

1 : 9-8-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 22

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
17	0.0	0.0	22.4	63.9	13.7

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.06	0.02	0.02	0.009	0.0079	0.0042	0.77	5.7

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-8(24-48)

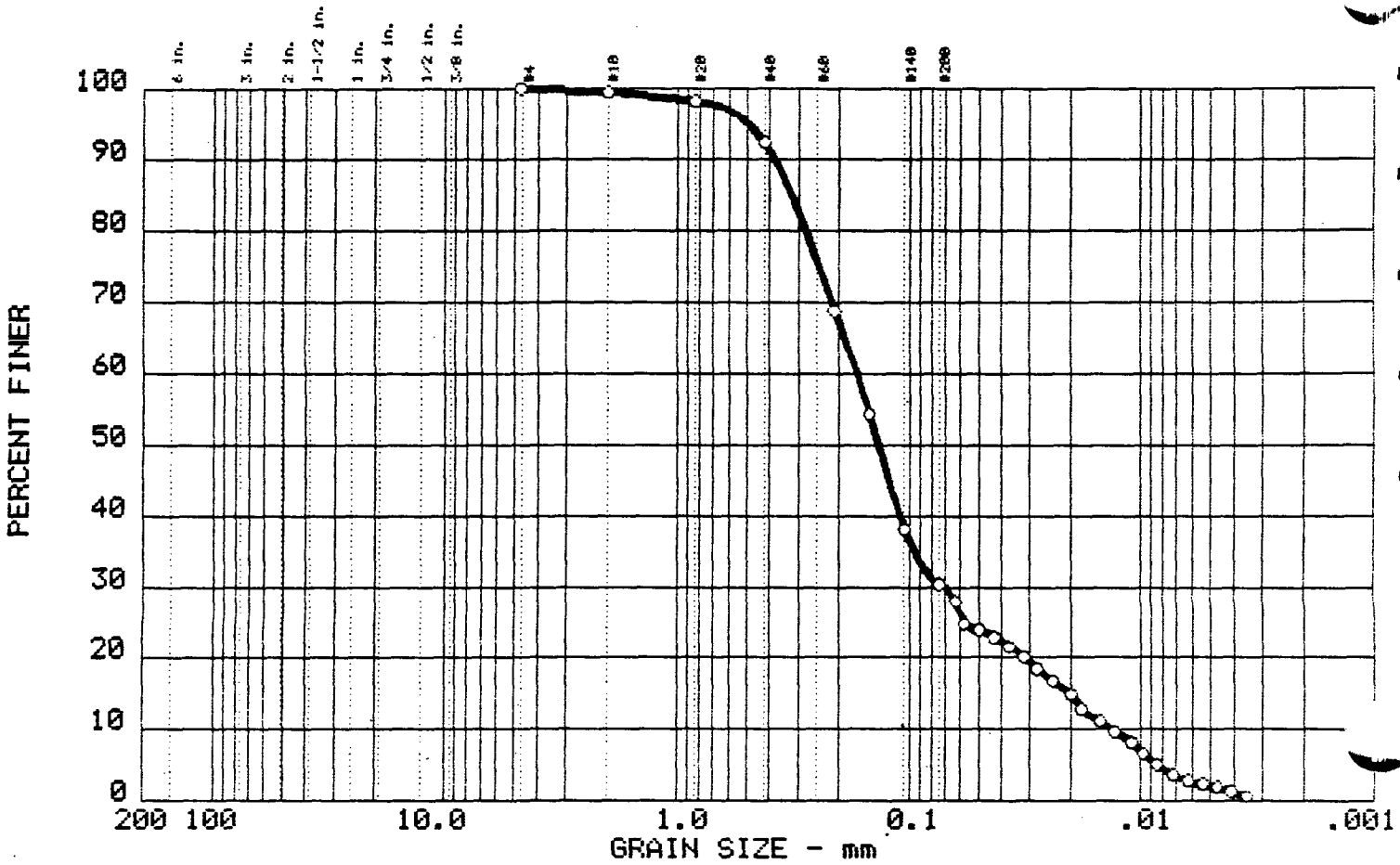
Remarks: Lab. Ser. No. 100-453-23

Date: 9-8-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 23

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	18	0.0	0.0	69.5	28.4	2.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.25	0.17	0.14	0.067	0.0586	0.0133	2.02	12.7

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-9(0-12)

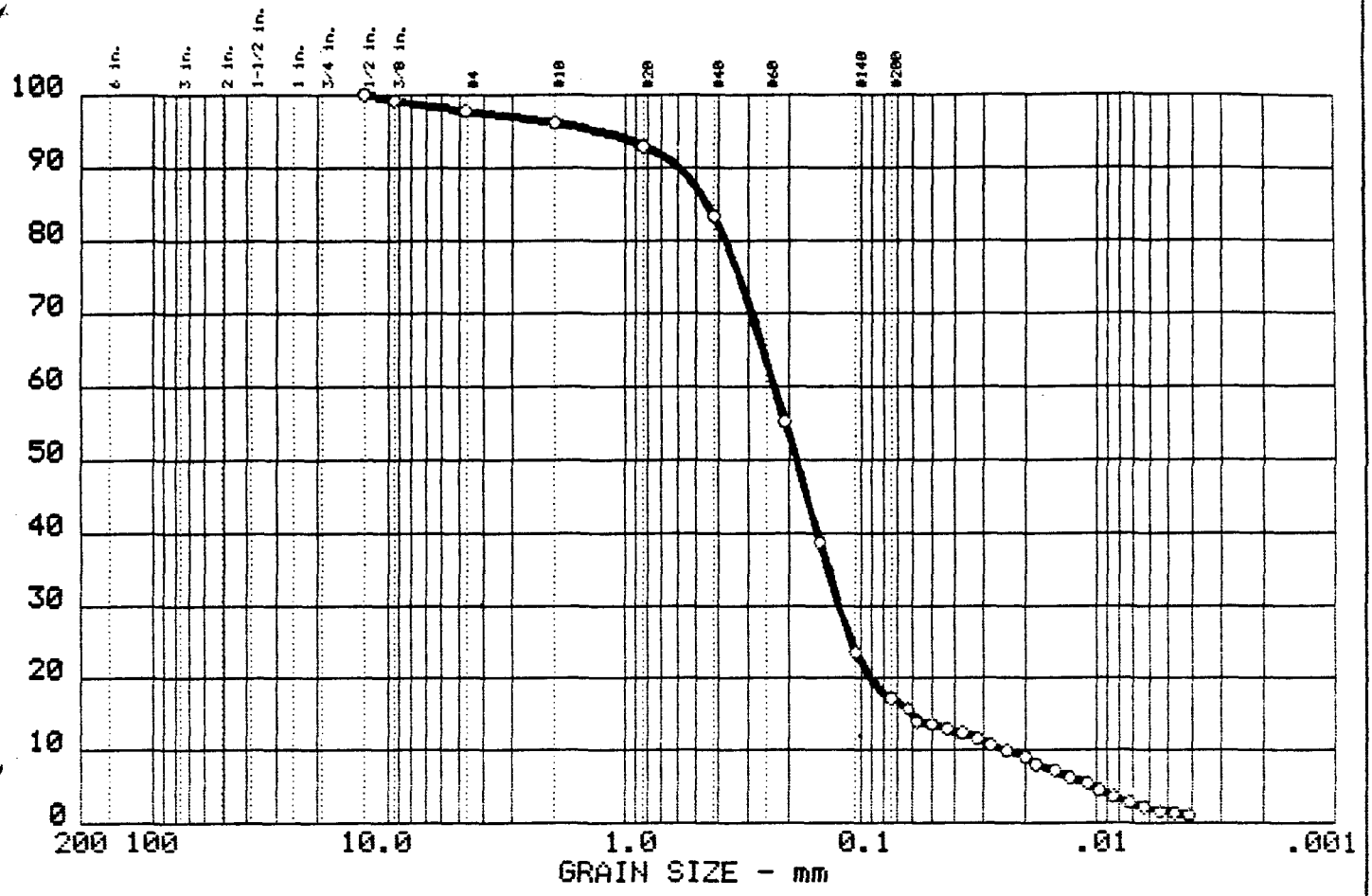
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-24

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 24

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
19	0.0	2.3	80.5	15.8	1.4

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.33	0.23	0.19	0.124	0.1089	0.0244	2.70	9.5

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-9(12-24)

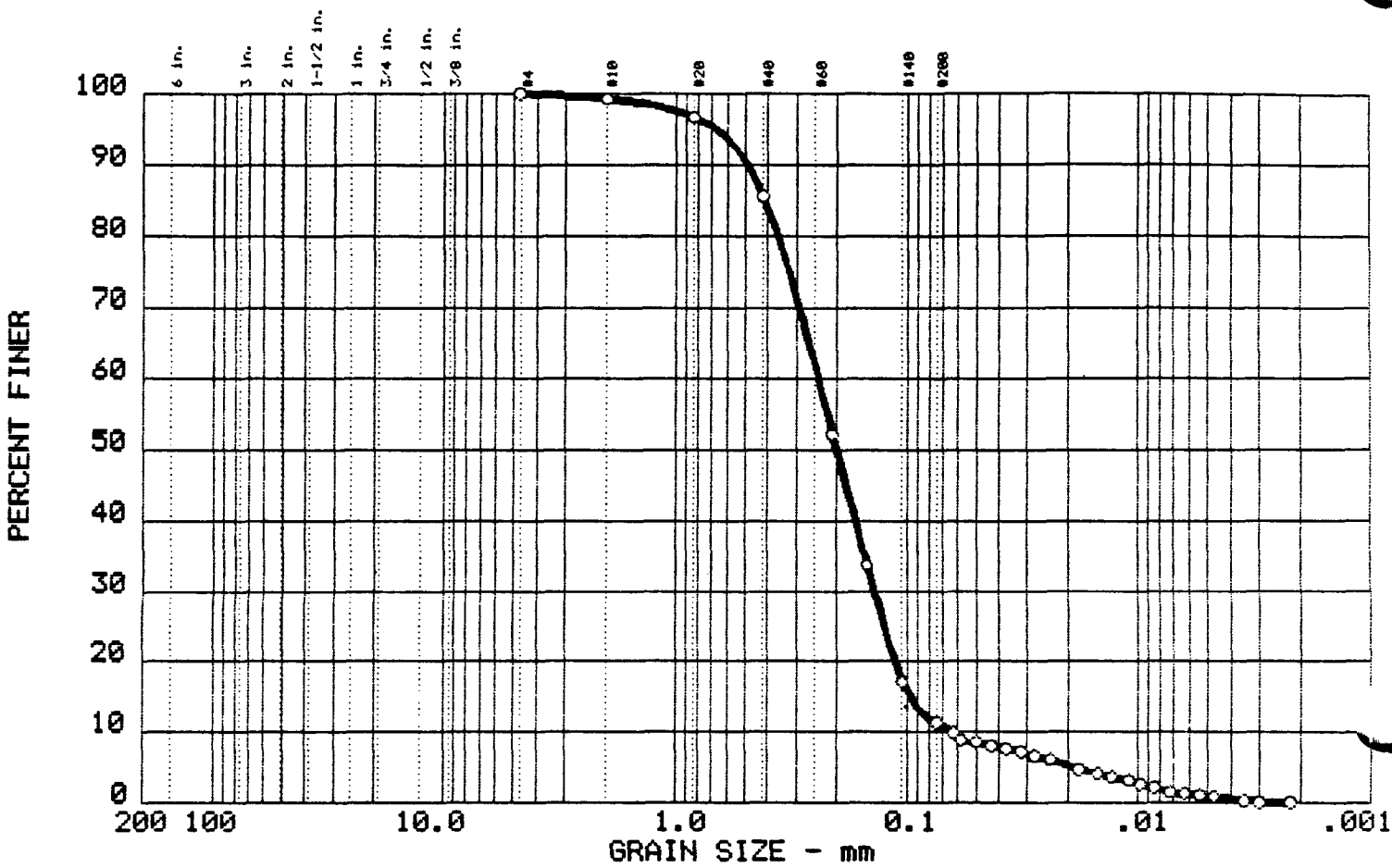
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-25

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 25

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	5	0.0	0.0	88.8	10.3	0.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.32	0.24	0.20	0.139	0.1262	0.0632	1.25	3.8

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-9(24-48)

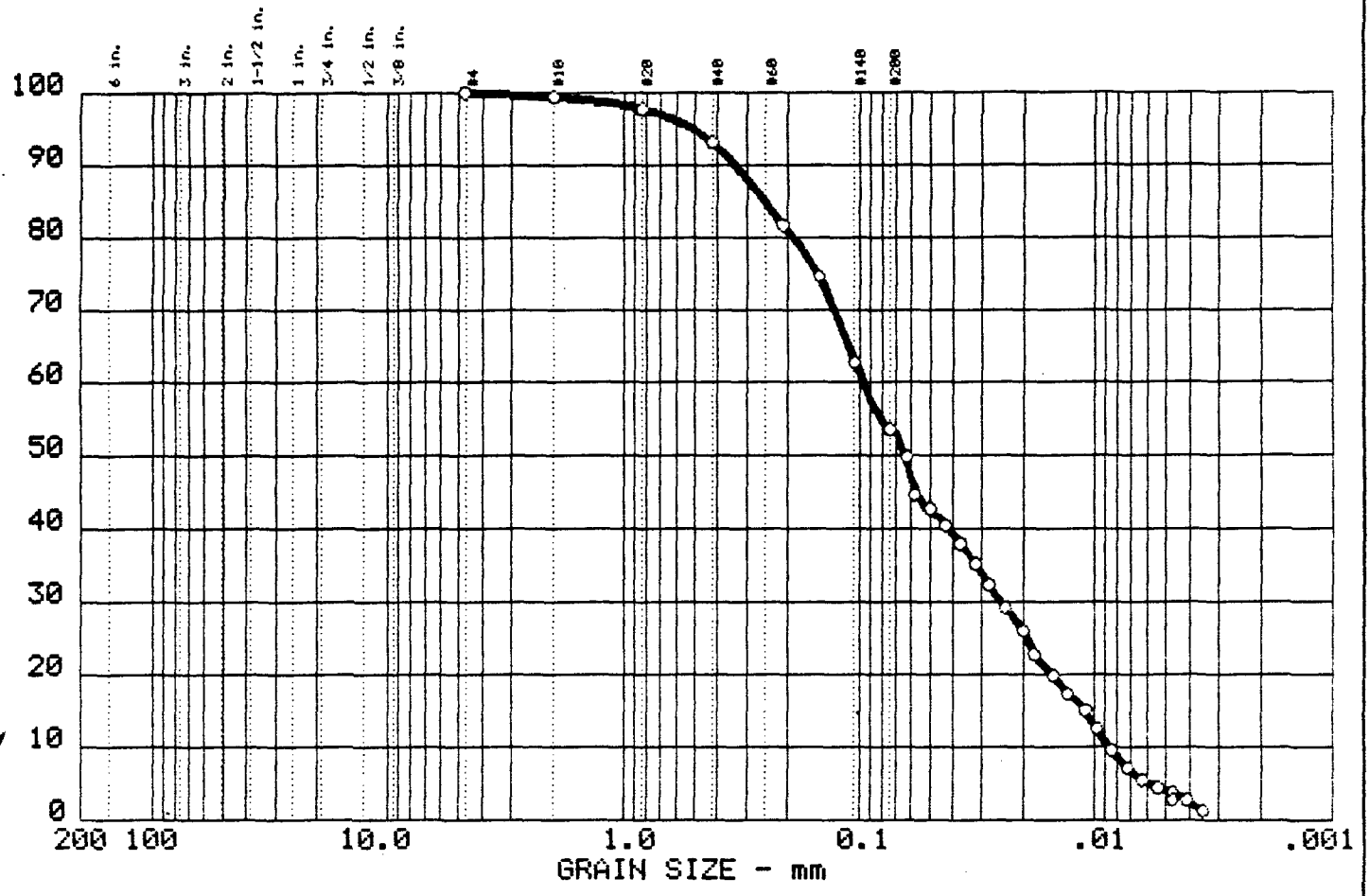
Remarks: Lab. Ser. No. 100-453-26

Date: 9-8-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 26

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
6	0.0	0.0	46.4	49.5	4.1

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.15	0.10	0.06	0.025	0.0193	0.0086	0.75	11.2

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-10(0-12)

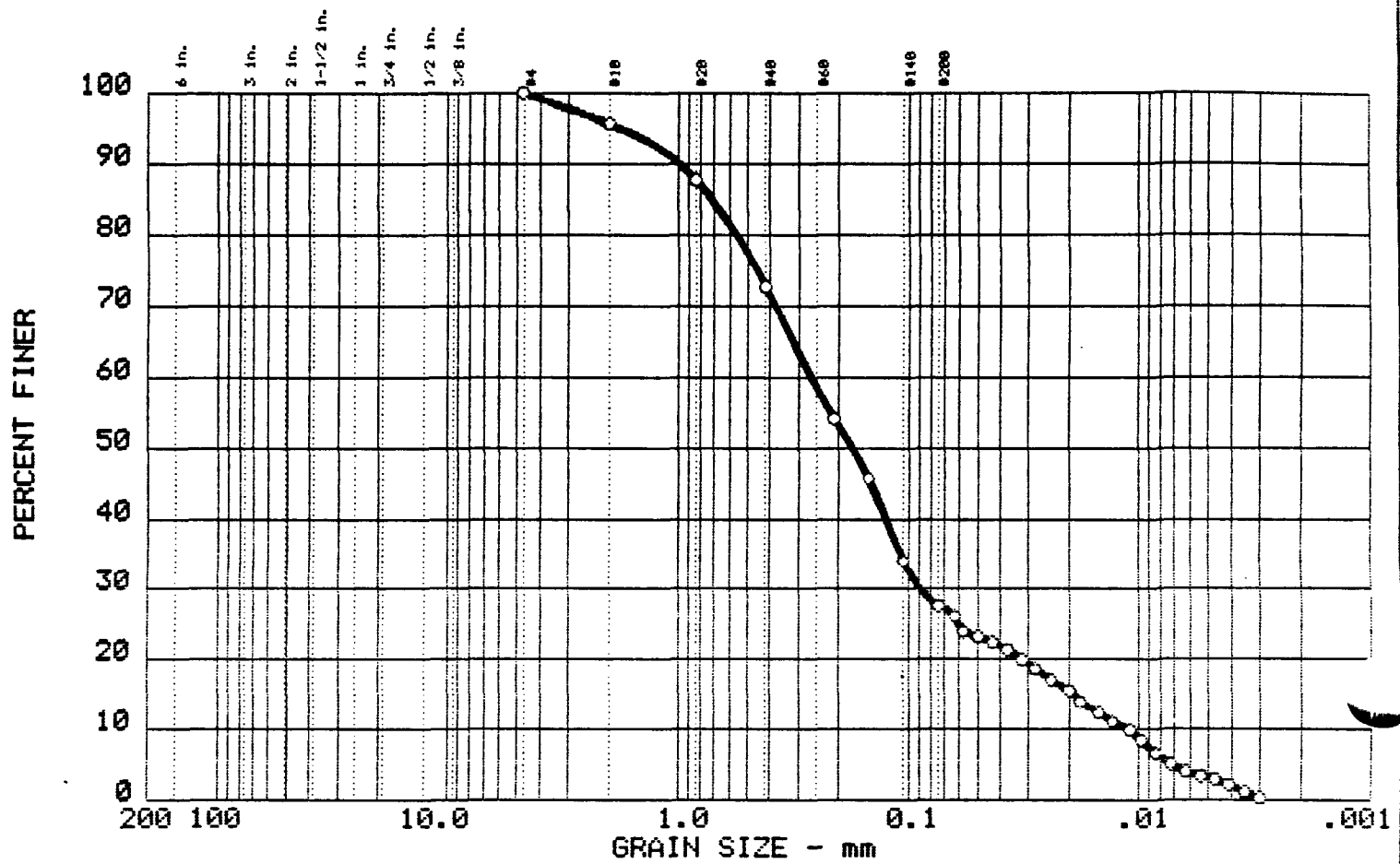
Date: 9-8-87

Remarks: Lab. Ser No. 100-453-27

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 27

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	7	0.0	0.0	72.4	24.4	3.2

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.46	0.26	0.17	0.089	0.0602	0.0112	2.69	23.4

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
Location: PD-10(12-24)

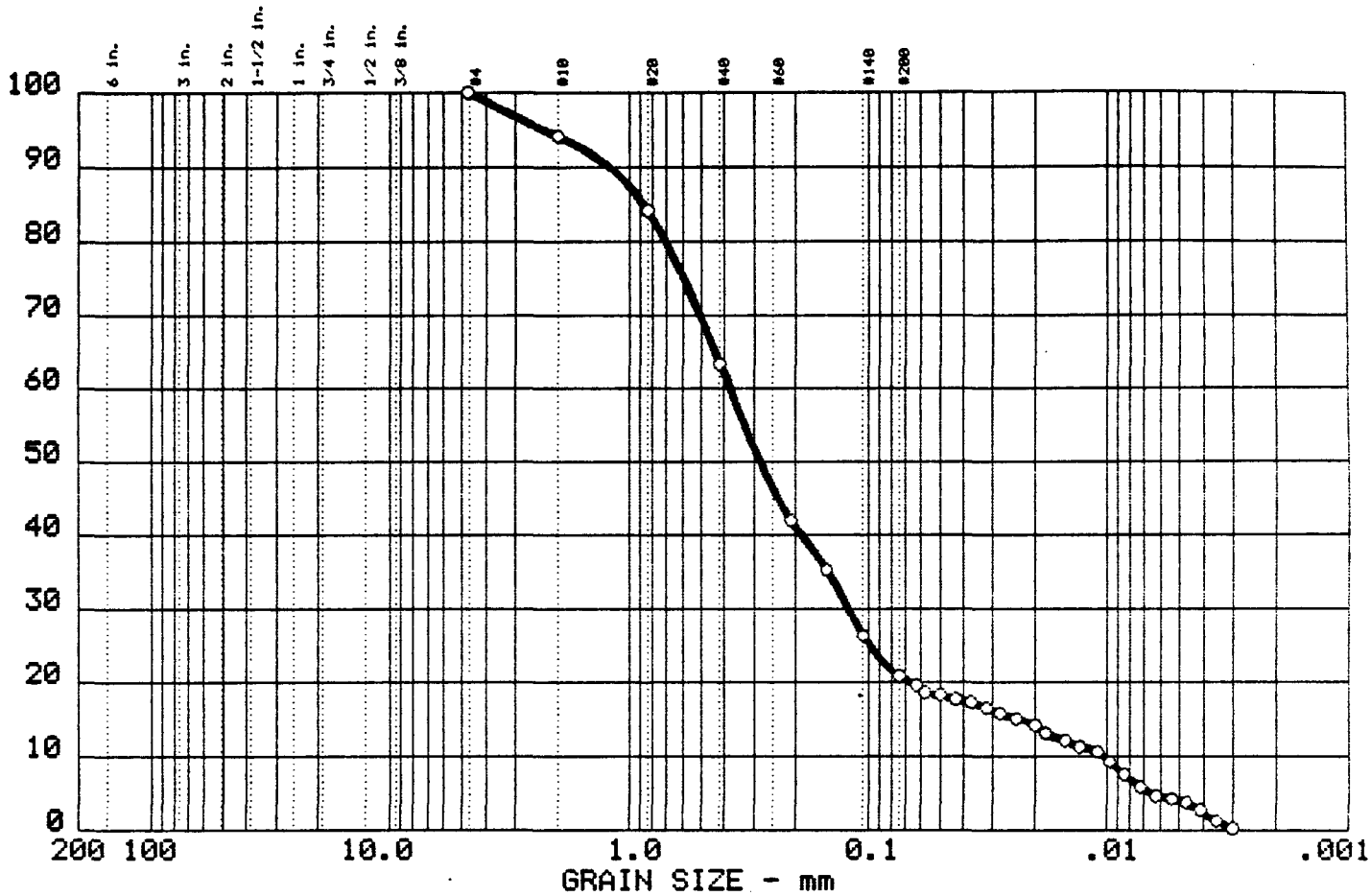
Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 28

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
8	0.0	0.0	79.1	16.8	4.1

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.59	0.38	0.28	0.121	0.0983	0.0103	3.75	36.9

MATERIAL DESCRIPTION	USCS	AASHTO

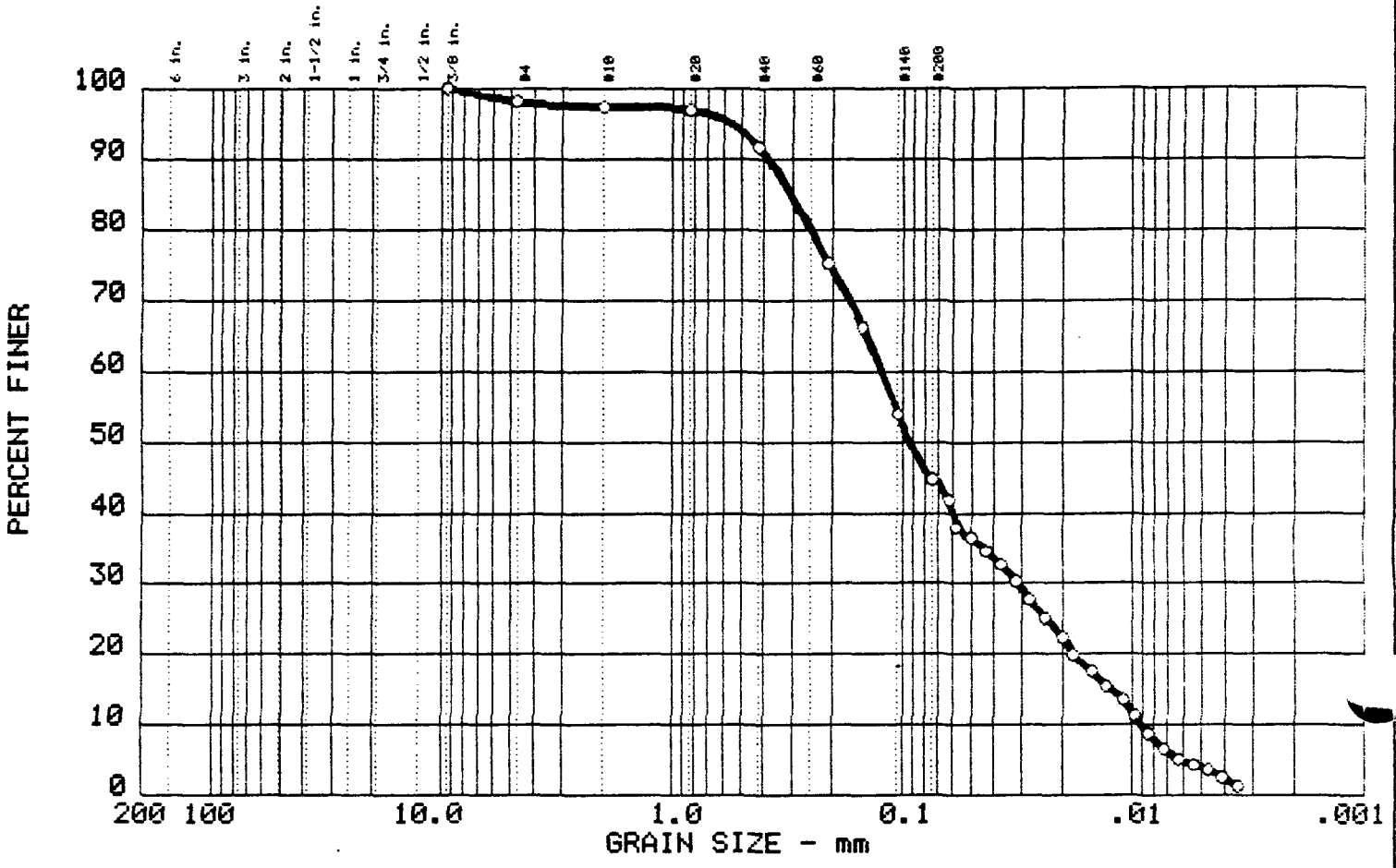
Project No.:
Project: New Bedford Pilot Study
Location: PD-10(24-48)

Date: 9-8-87

Remarks: Lab. Ser. No. 100-453-29

GRAIN SIZE DISTRIBUTION TEST REPORT

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	9	0.0	1.9	53.2	41.0	3.9

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.21	0.12	0.09	0.031	0.0236	0.0091	0.89	13.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
Location: PD-11(0-12)

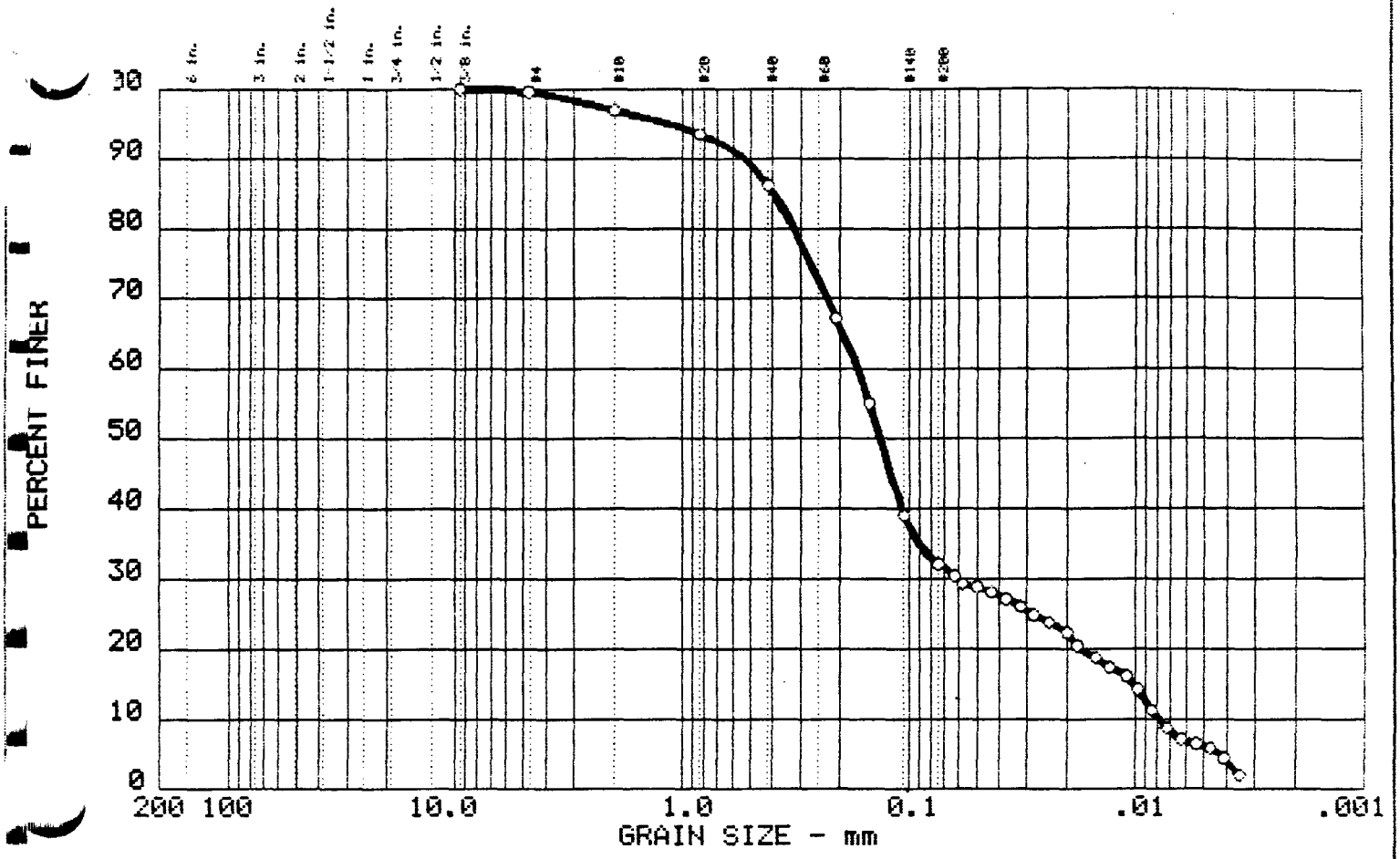
Date: 9-9-87

Remarks: Lab. Ser. No. 100-453-3

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 30

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
10	0.0	0.4	67.4	25.9	6.3

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.27	0.17	0.13	0.060	0.0285	0.0079	2.75	21.4

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-11(12-24)

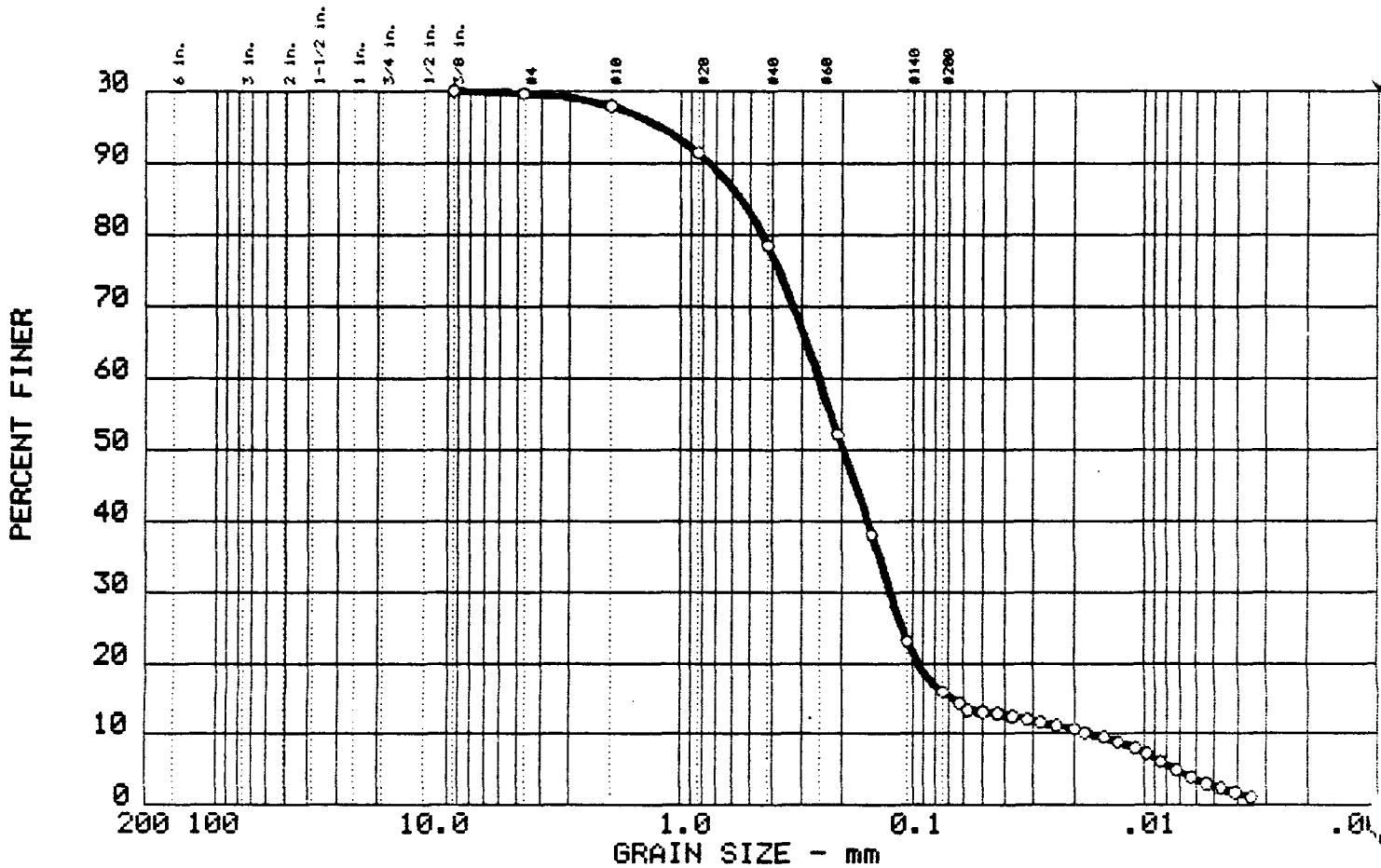
Date: 9-9-87

Remarks: Lab. Ser. No. 100-453-31

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 31

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	11	0.0	0.3	83.9	13.2	2.6

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.38	0.25	0.20	0.125	0.1105	0.0179	3.41	14.2

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-11(24-48)

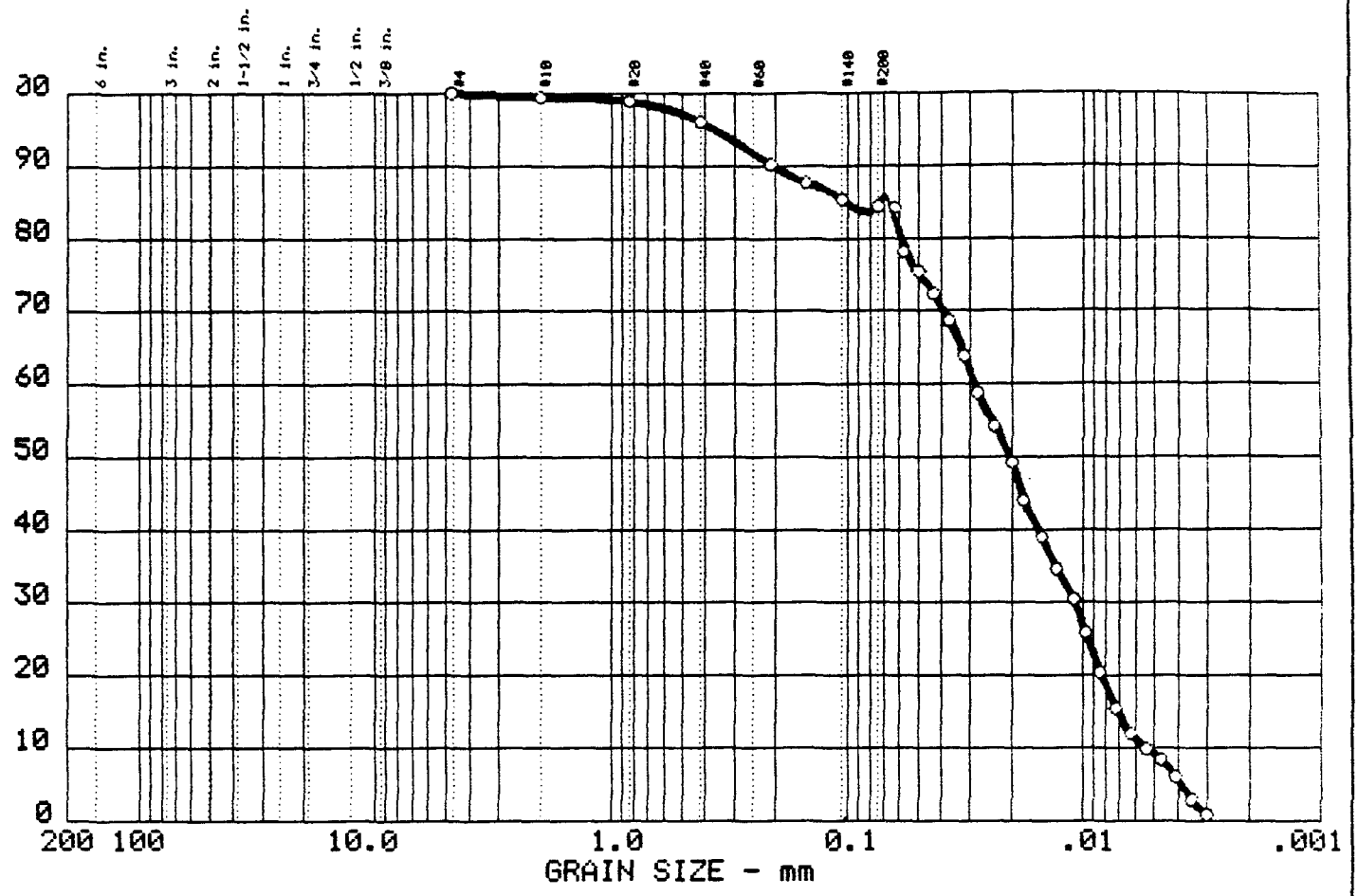
D-'-: 9-9-87

Remarks: Lab. Ser. No. 100-453-32

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 32

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
12	0.0	0.0	15.6	75.3	9.1

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.05	0.03	0.02	0.011	0.0096	0.0055	0.74	5.3

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-18(0-12)

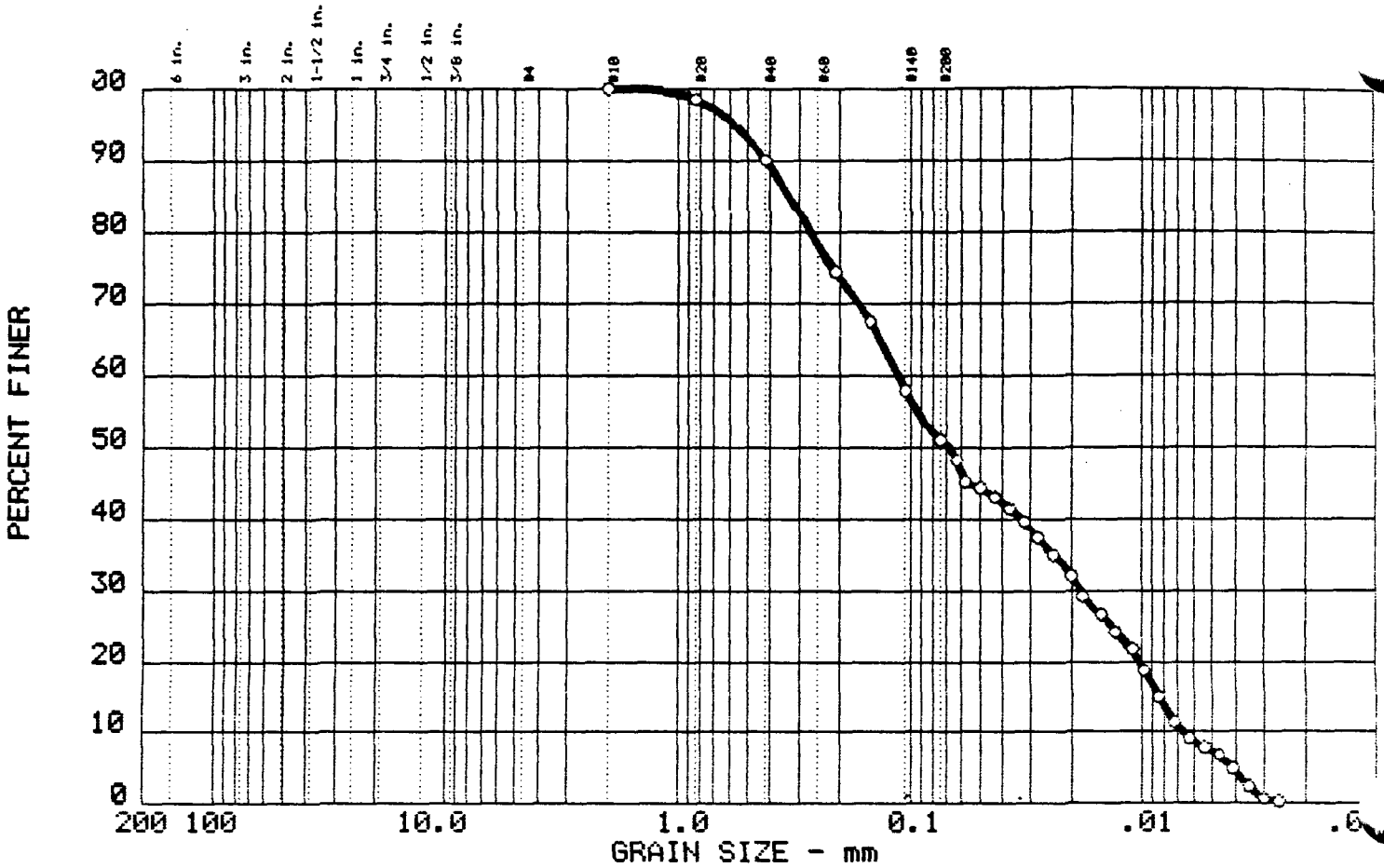
Date: 9-9-87

Remarks: Lab. Ser. No. 100-453-33

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 33

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	13	0.0	0.0	48.9	43.8	7.3

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.22	0.11	0.07	0.018	0.0135	0.0068	0.45	16.6

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-18(12-24)

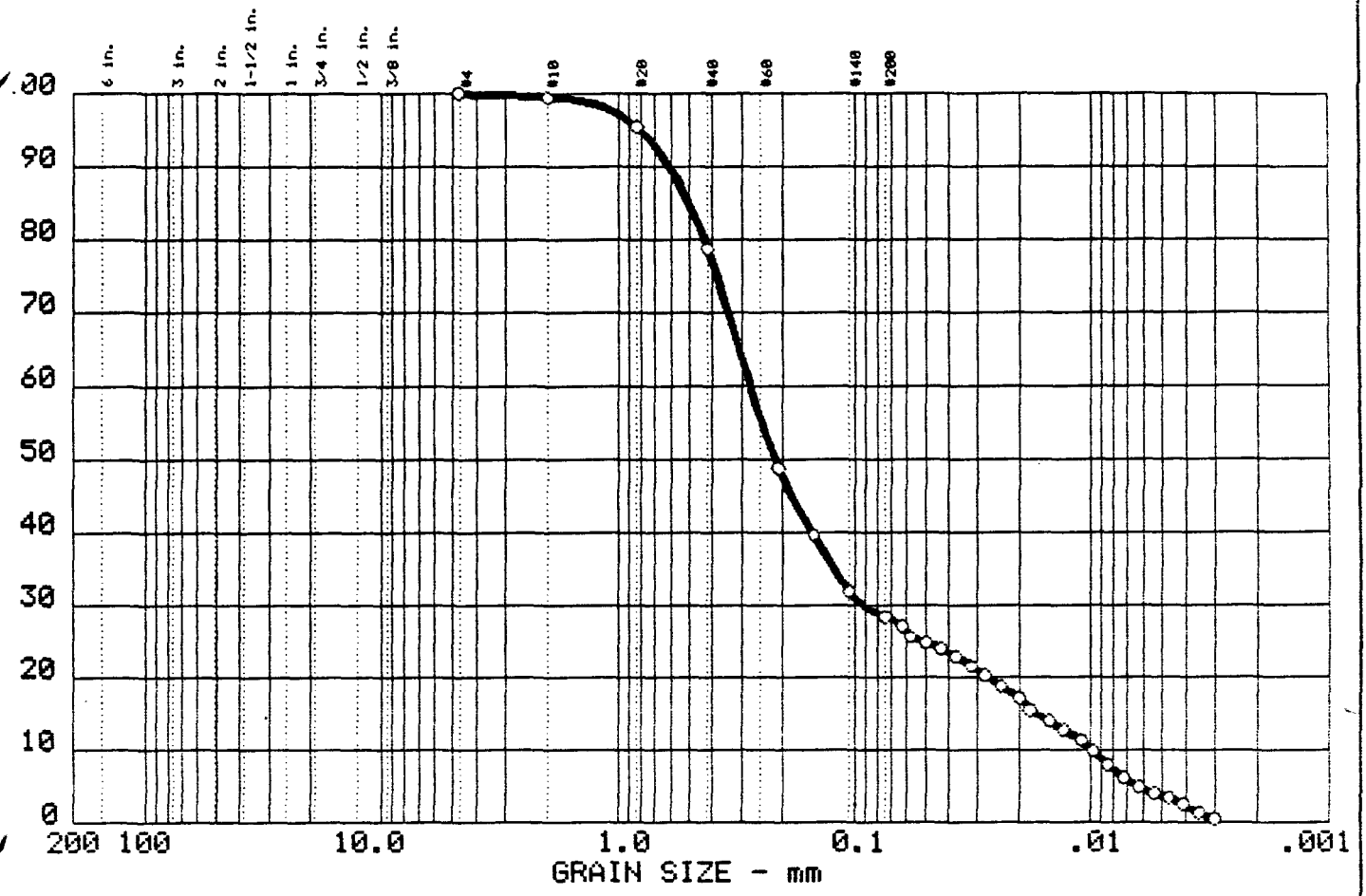
D : 9-9-87

Remarks: Lab. Ser. No. 100-453-34

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 34

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
14	0.0	0.0	71.6	24.7	3.7

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.38	0.28	0.22	0.092	0.0515	0.0098	3.09	28.2

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-18(24-48)

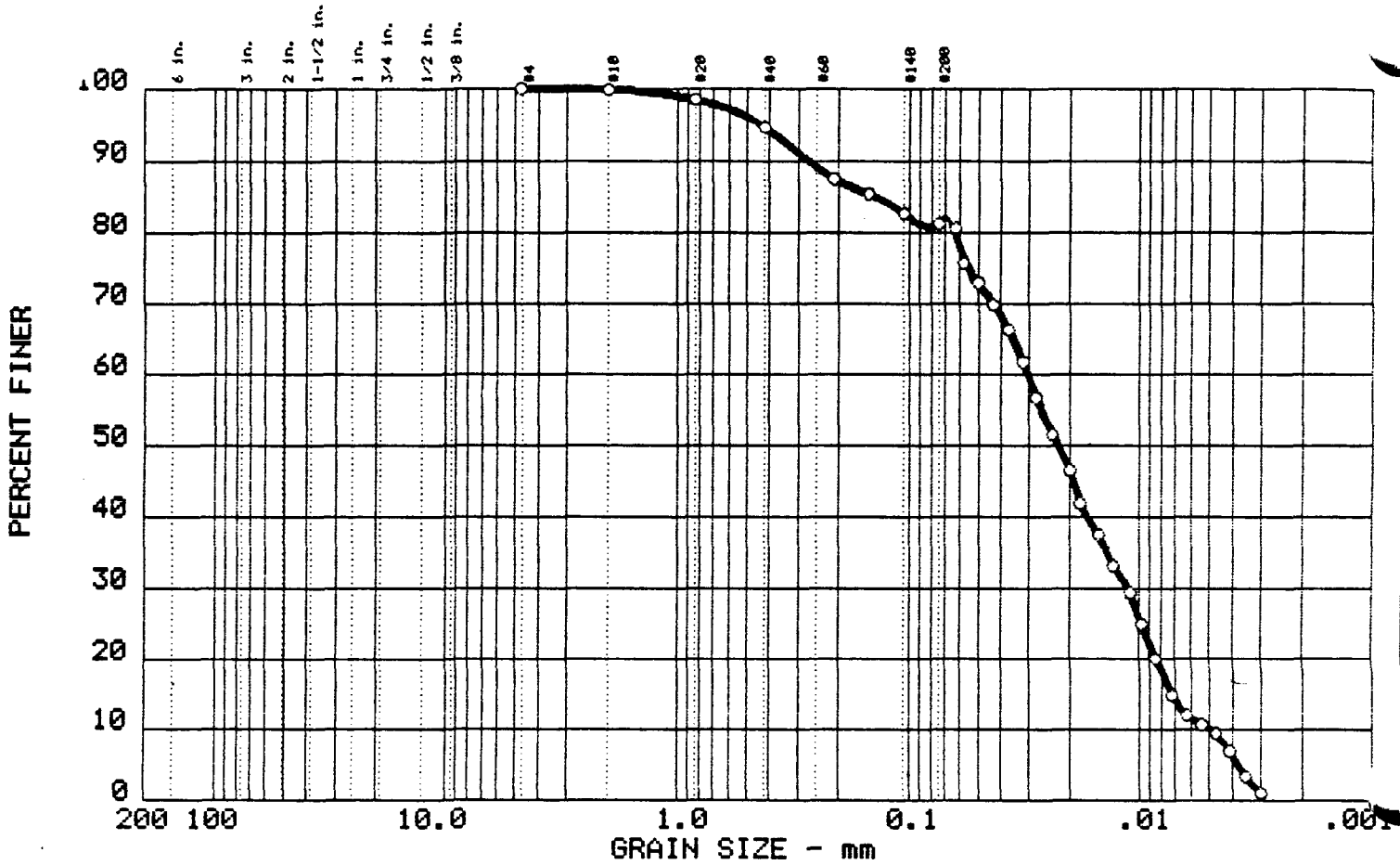
: 9-9-87

Remarks: Lab. Ser. No. 100-453-35

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 35

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	15	0.0	0.0	18.8	71.1	10.1

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.06	0.03	0.02	0.011	0.0098	0.0049	0.83	6.2

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: pd-19(0-12)

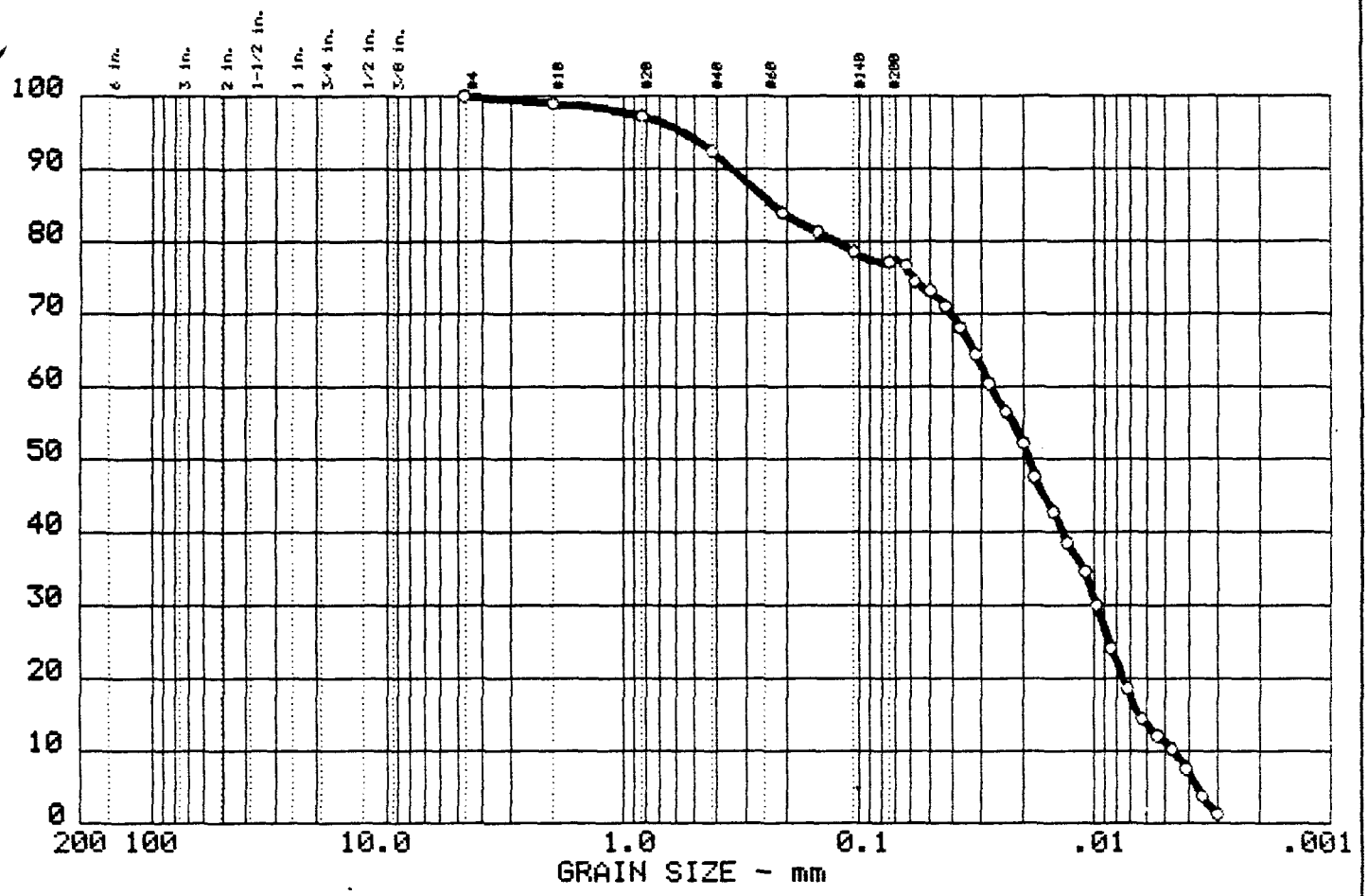
Remarks: Lab. Ser. No. 100-453-36

I : 9-9-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 36

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
16	0.0	0.0	22.8	66.0	11.2

LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
		0.06	0.03	0.02	0.010	0.0087	0.0046	0.75	6.0

MATERIAL DESCRIPTION	USCS	AASHTO

Project No.:
Project: New Bedford Pilot Study
Location: PD-19 (12-24)

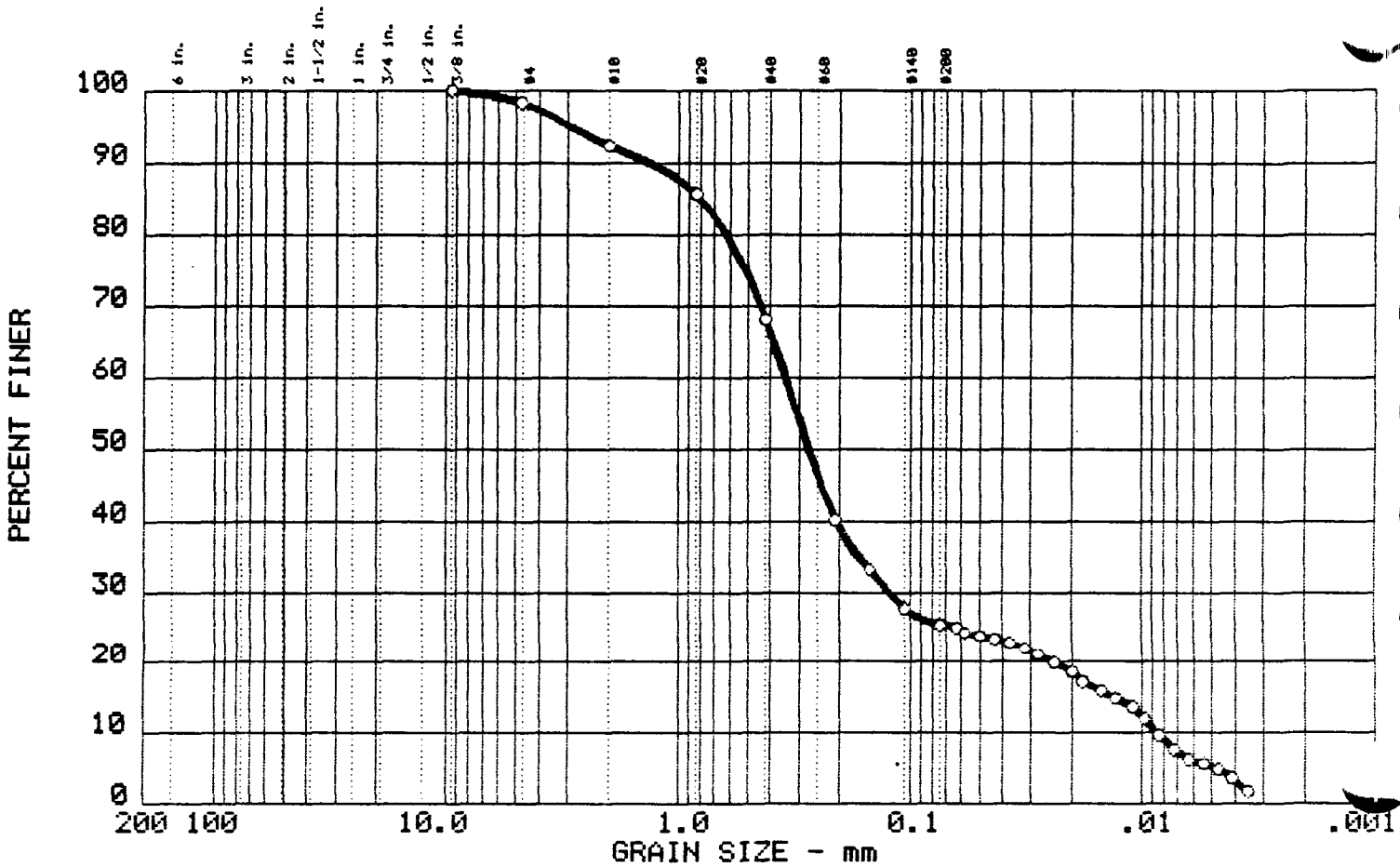
Remarks: Lab. Ser. No. 100-453-37

: 9-9-87

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 37

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	17	0.0	1.7	72.8	20.2	5.3

	LL	PI	D_{75}	D_{60}	D_{50}	D_{30}	D_{25}	D_{10}	C_c	C_u
○			0.51	0.34	0.27	0.122	0.0620	0.0087	5.01	39.8

MATERIAL DESCRIPTION	USCS	AASHTO
○		

Project No.:
Project: New Bedford Pilot Study
○ Location: PD-19(24-48)

: 9-9-87

Remarks: Lab. Ser. No. 100-453-38

GRAIN SIZE DISTRIBUTION TEST REPORT
CORPS OF ENGINEERS - NEW ENGLAND

Fig. No. 38

Law Environmental, Inc.

November 1987

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

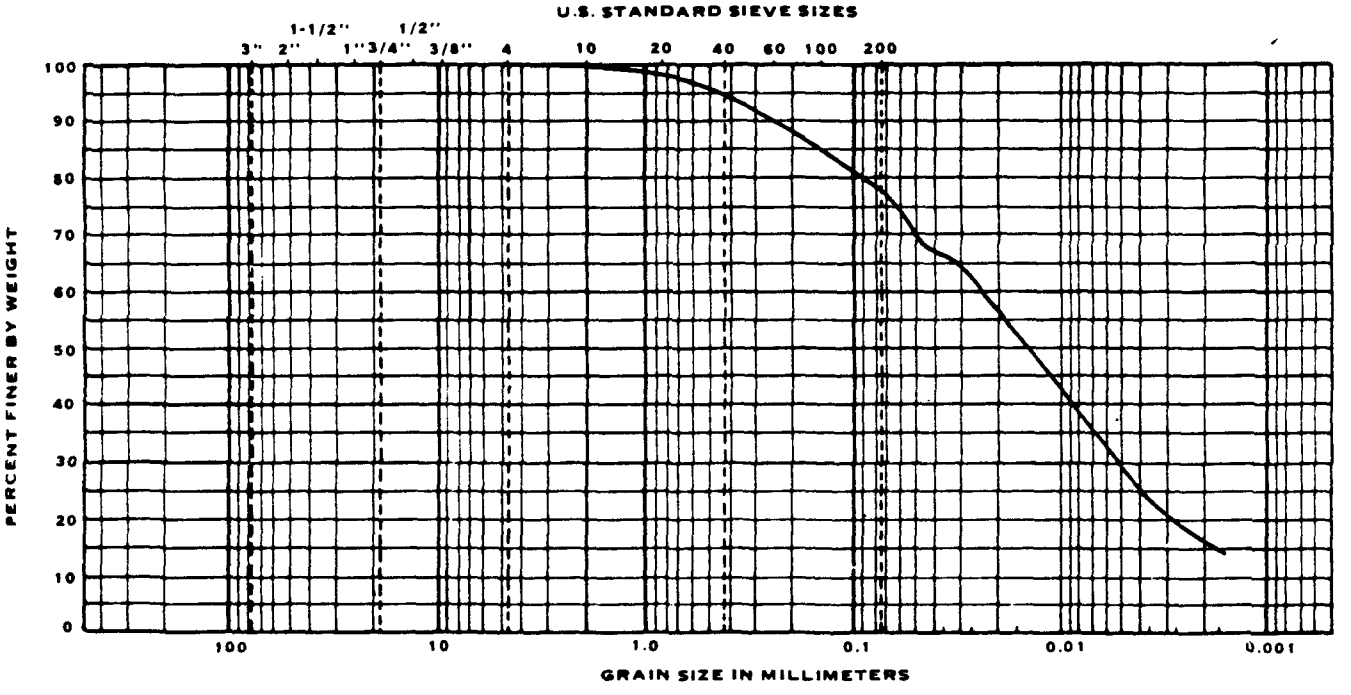
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW 33-88 -M-0034/LM-88-004

SAMPLE IDENTIFICATION IA : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.6
0.85	98.3
0.425	94.7
0.212	87.7
0.15	84.7
0.106	80.8
0.075	77.4
0.0452	67.3
0.0322	65.1
0.0234	59.0
0.0126	48.0
0.0092	41.1
0.0067	33.2
0.0048	28.6
0.0035	22.9
0.0015	14.3

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 124
PLASTIC LIMIT 70
PLASTICITY INDEX 54
CLASSIFICATION -
-
WATER CONTENT (%) 161.9
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.46
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

AF 49071B

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144 5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

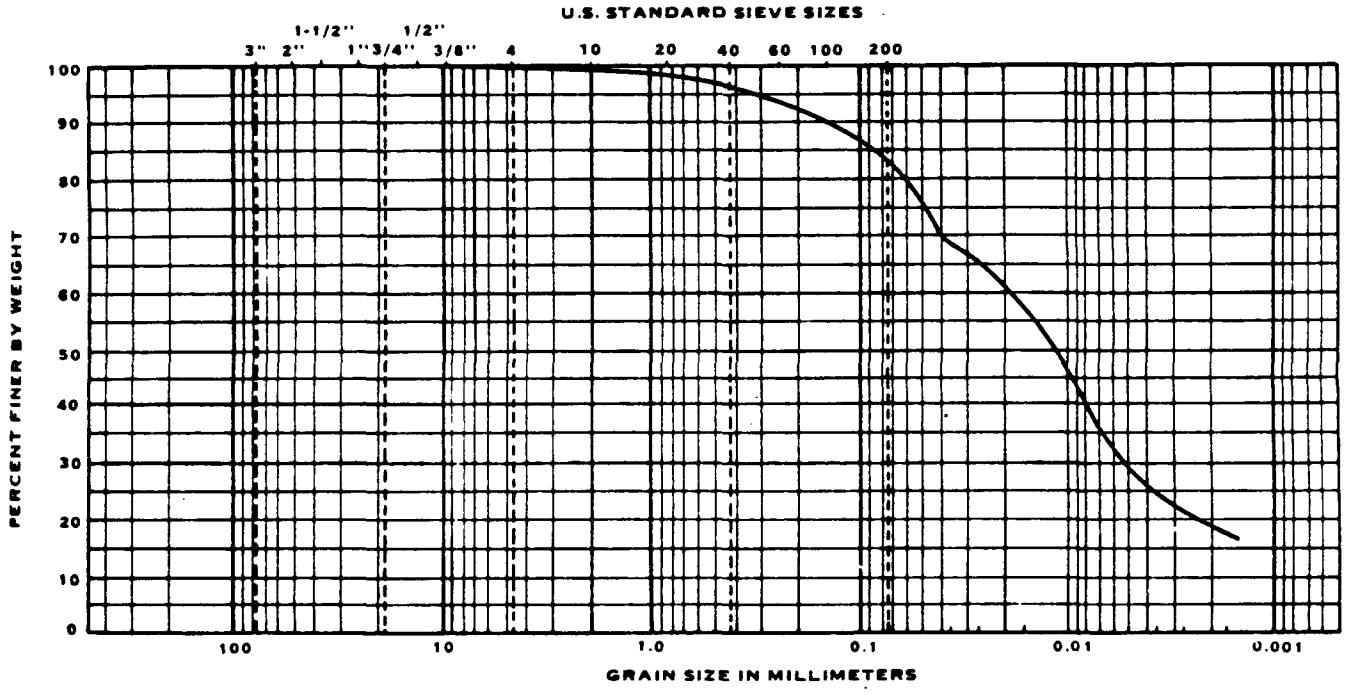
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IA :24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.7
2.00	99.1
0.85	98.7
0.425	96.7
0.212	92.1
0.15	89.5
0.106	86.4
0.075	83.4
0.0401	69.5
0.0290	66.2
0.0211	61.8
0.0117	49.2
0.0086	40.9
0.0063	33.5
0.0046	27.9
0.0033	24.2
0.0014	16.5

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 99
PLASTIC LIMIT 57
PLASTICITY INDEX 42
CLASSIFICATION -
-

WATER CONTENT (%) 111.3
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.54
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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M.A. O'Kelley

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404-421-3400

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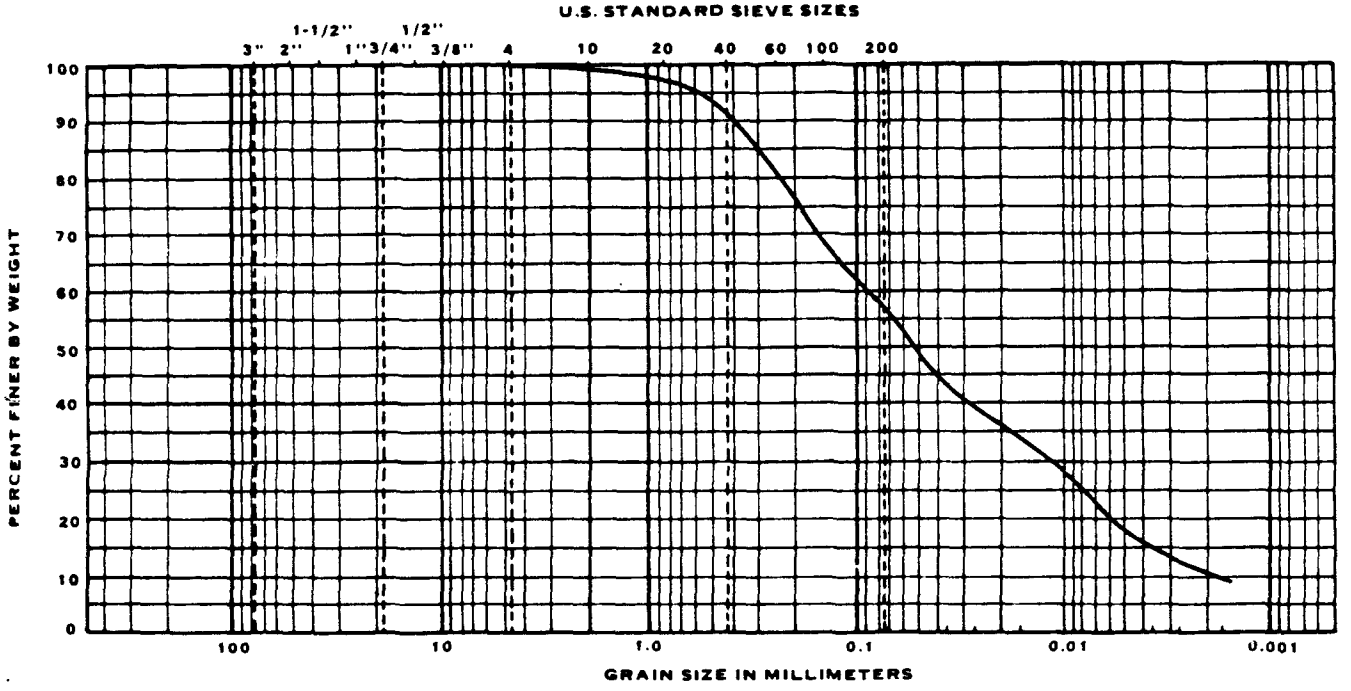
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IA : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.6
0.85	97.8
0.425	91.6
0.212	76.5
0.15	69.9
0.106	62.4
0.075	57.2
0.0462	45.7
0.0332	42.5
0.0239	39.0
0.0128	31.7
0.0093	26.2
0.0068	20.8
0.0049	17.0
0.0035	14.5
0.0014	9.3

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	92
PLASTIC LIMIT	58
PLASTICITY INDEX	34
CLASSIFICATION	-
	-
WATER CONTENT (%)	99.7
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.50
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

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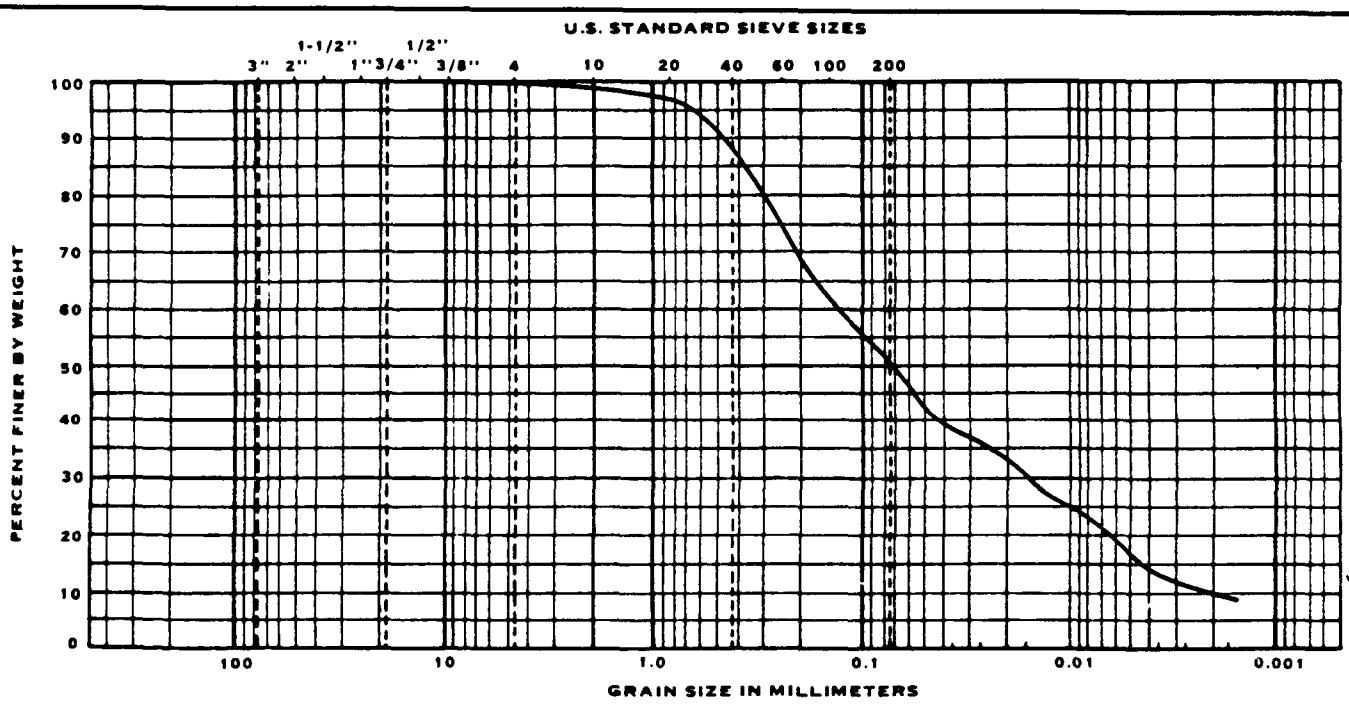
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IB : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.8
2.00	98.9
0.85	97.2
0.425	87.8
0.212	69.8
0.15	62.3
0.106	55.6
0.075	50.7
0.0463	40.6
0.0333	37.6
0.0238	35.2
0.0128	27.4
0.0092	24.6
0.0067	19.8
0.0048	15.7
0.0034	12.9
0.0014	8.7

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	72
PLASTIC LIMIT	37
PLASTICITY INDEX	35
CLASSIFICATION	-
	-
WATER CONTENT (%)	90.5
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.55
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

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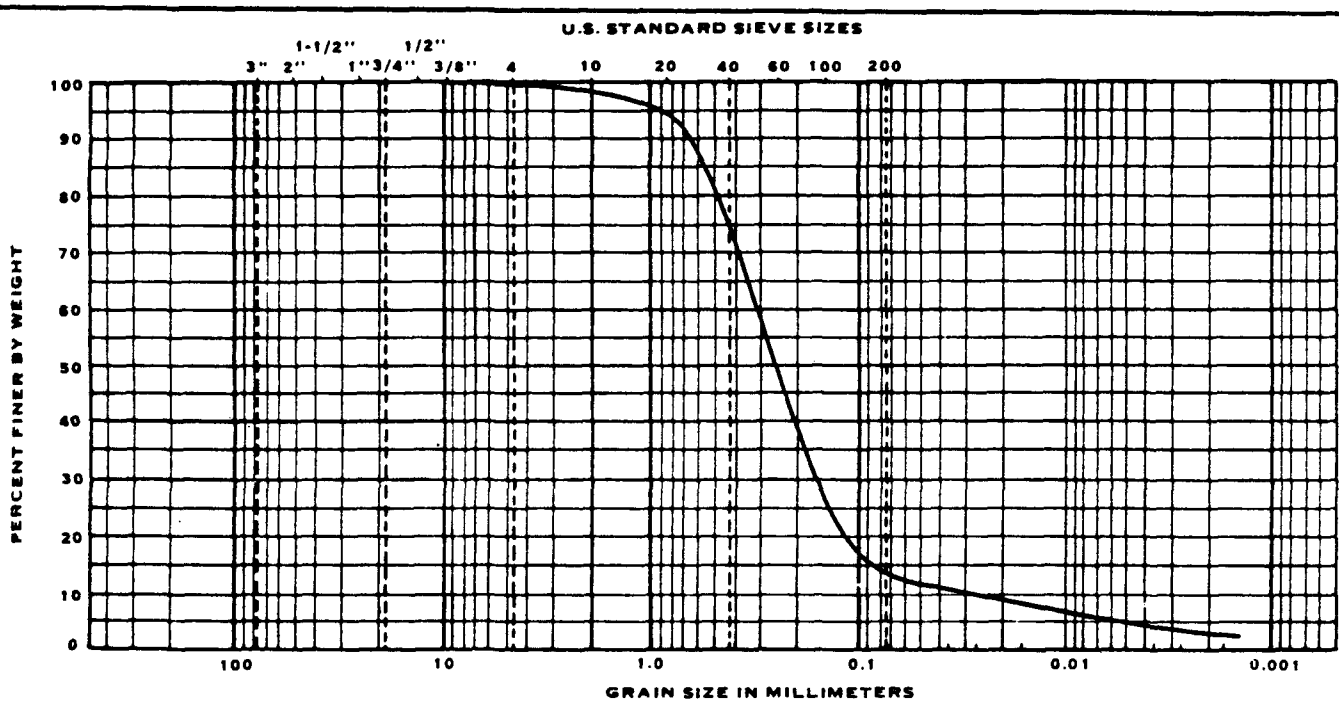
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IB : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.7
2.00	98.5
0.85	94.3
0.425	75.8
0.212	38.7
0.15	26.9
0.106	17.6
0.075	12.9
0.0480	12.2
0.0344	11.0
0.0246	10.1
0.0130	7.4
0.0093	6.4
0.0067	5.2
0.0048	4.2
0.0034	3.7
0.0014	2.0

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT -
PLASTIC LIMIT -
PLASTICITY INDEX non-plastic (visual)
CLASSIFICATION -
-

WATER CONTENT (%) 26.3
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.63
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

AF 49071B

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404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

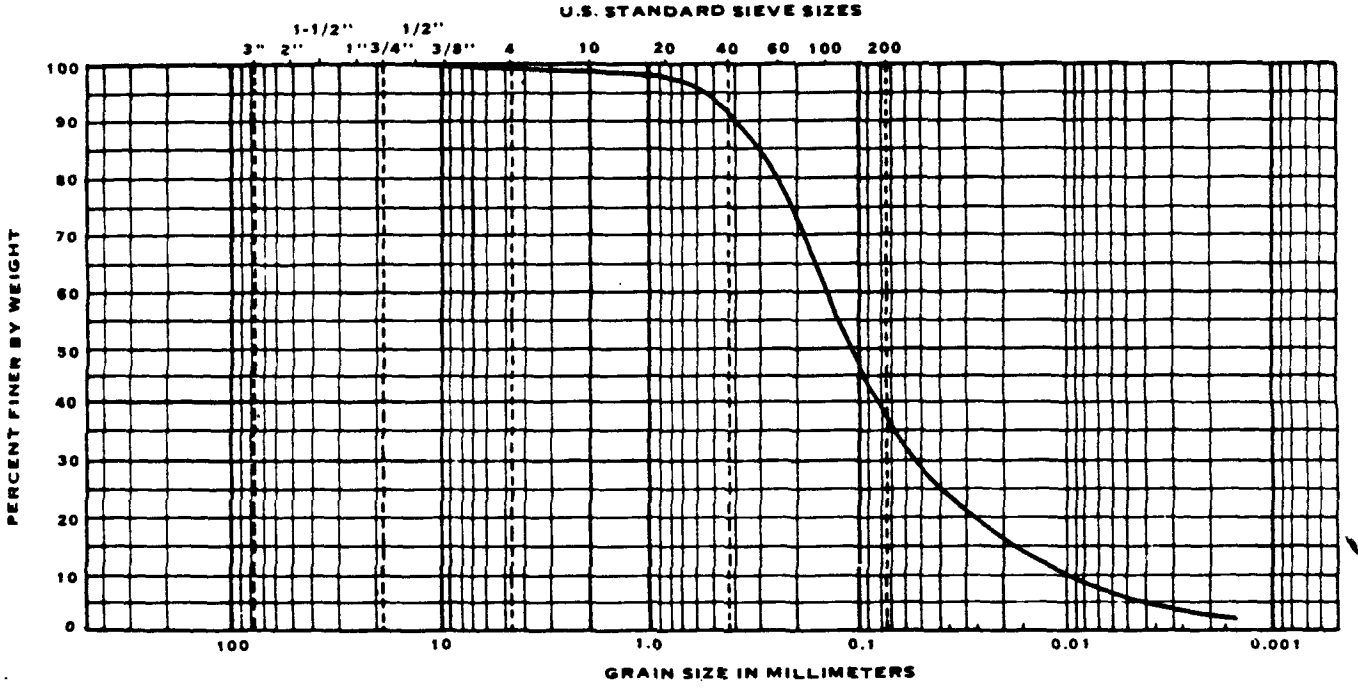
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IB : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
12.5	100.0
9.5	99.0
4.75	99.0
2.00	98.9
0.85	98.0
0.425	91.3
0.212	74.2
0.15	60.6
0.106	47.3
0.075	37.2
0.0415	25.2
0.0306	22.0
0.0228	17.7
0.0126	11.4
0.0092	8.5
0.0066	6.1
0.0048	4.3
0.0034	3.5
0.0014	1.6

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT -
PLASTIC LIMIT -
PLASTICITY INDEX non-plastic (visual)
CLASSIFICATION -
-

WATER CONTENT (%) 13.1
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.65
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

AF 49071B

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Dept. of the Army
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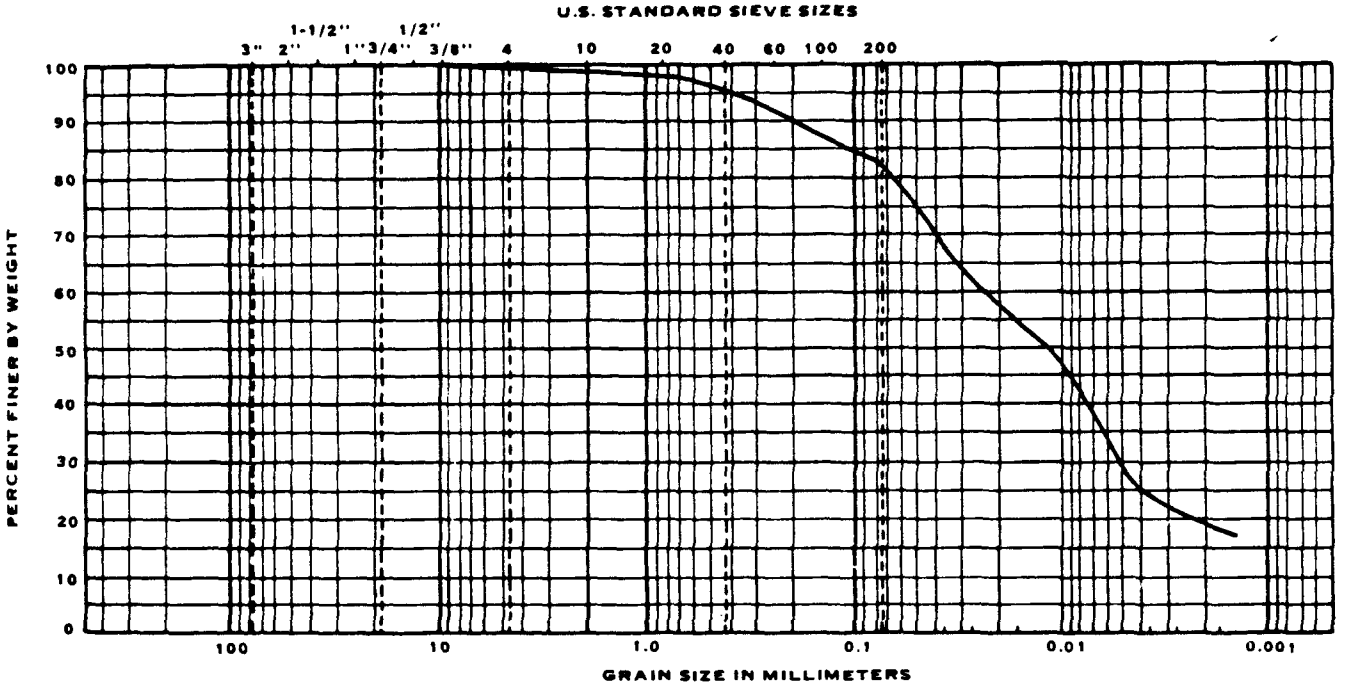
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IC : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.4
2.00	99.2
0.85	98.3
0.425	95.5
0.212	90.0
0.15	87.6
0.106	84.8
0.075	82.7
0.0424	70.8
0.0310	64.1
0.0225	59.4
0.0121	50.4
0.0088	44.0
0.0064	35.3
0.0047	27.4
0.0019	19.3
0.0014	17.1

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	131
PLASTIC LIMIT	76
PLASTICITY INDEX	55
CLASSIFICATION	-
	-
WATER CONTENT (%)	146.0
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.53
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

AF 49071B

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

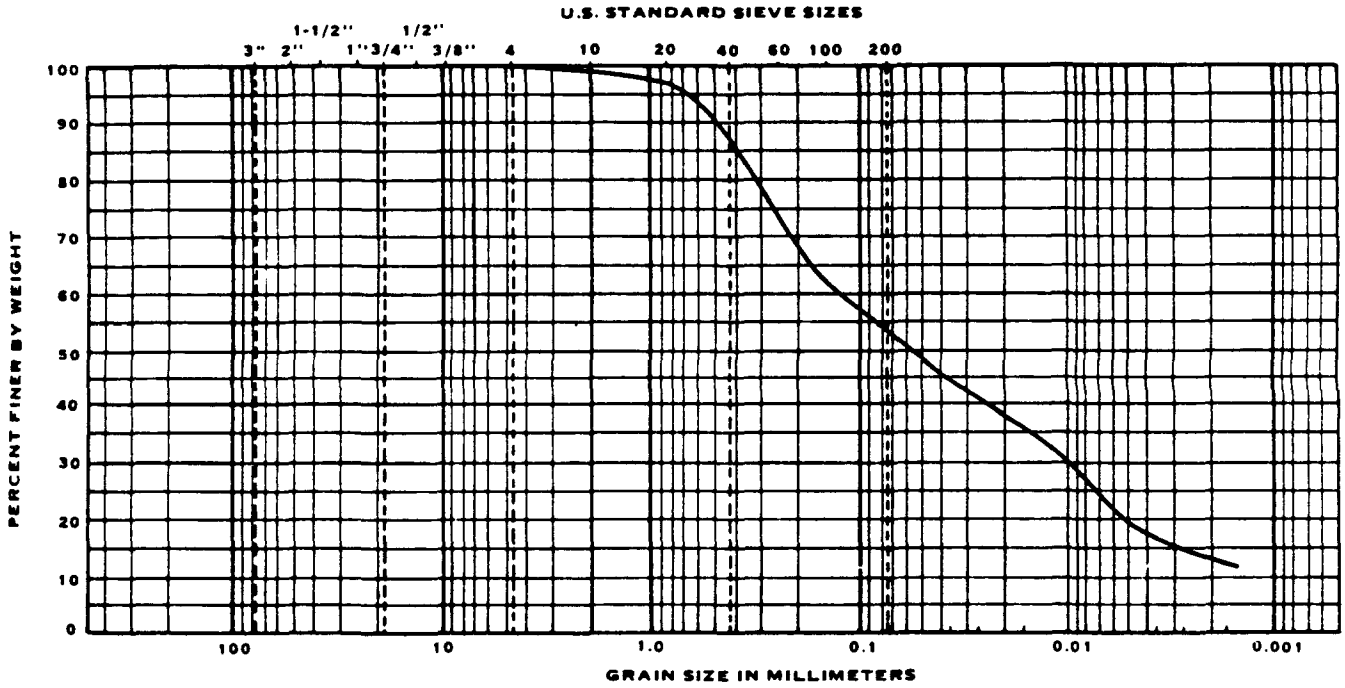
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IC : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.1
0.85	97.4
0.425	86.7
0.212	68.8
0.15	62.5
0.106	57.0
0.075	52.8
0.0415	45.1
0.0301	42.3
0.0218	39.3
0.0119	32.6
0.0087	27.5
0.0064	22.6
0.0046	19.3
0.0033	15.4
0.0014	11.3

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	60
PLASTIC LIMIT	39
PLASTICITY INDEX	21
CLASSIFICATION	-
	-
WATER CONTENT (%)	71.1
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.57
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelly

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

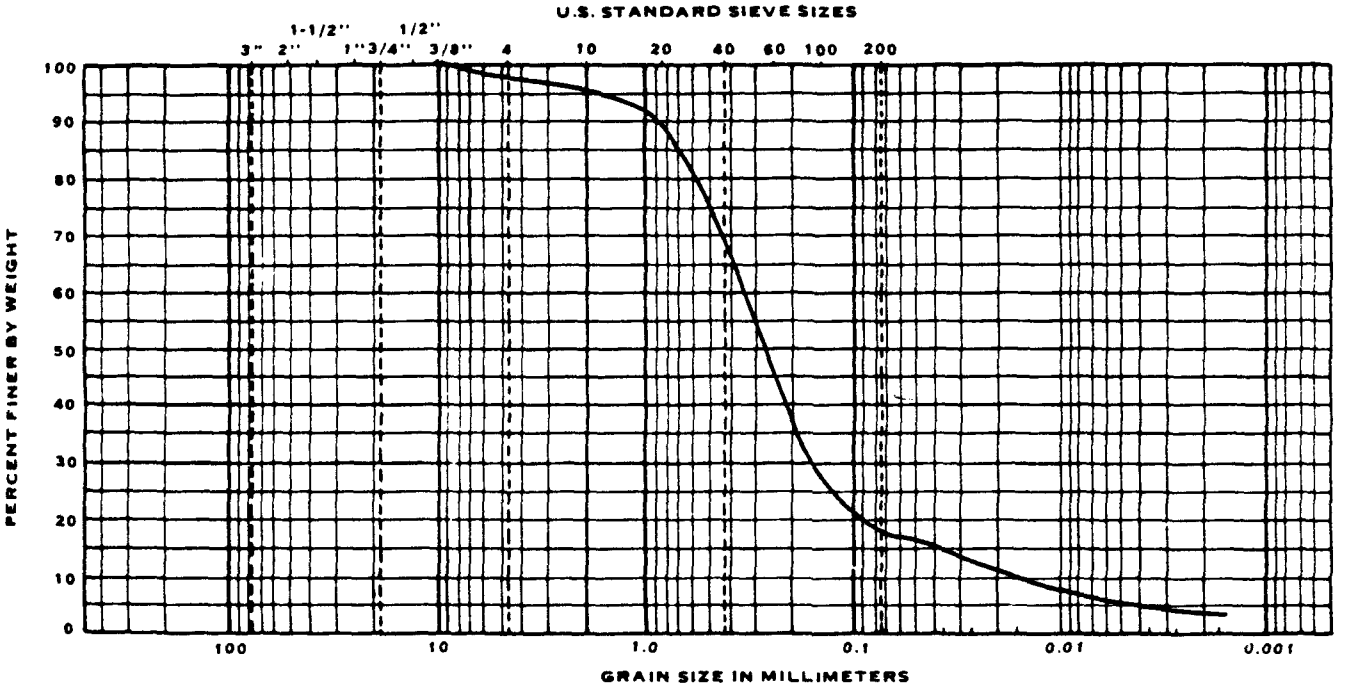
CLIENT Dept of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IC : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	97.5
2.00	95.1
0.85	89.7
0.425	69.0
0.212	38.1
0.15	28.7
0.106	21.4
0.075	17.4
0.0462	16.0
0.0334	14.0
0.0242	12.0
0.0130	8.7
0.0093	7.0
0.0067	5.7
0.0048	4.6
0.0034	3.9
0.0014	3.1

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT -
PLASTIC LIMIT -
PLASTICITY INDEX non-plastic (visual)
CLASSIFICATION -
-

WATER CONTENT (%) 21.7
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.65
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Dept of the Army
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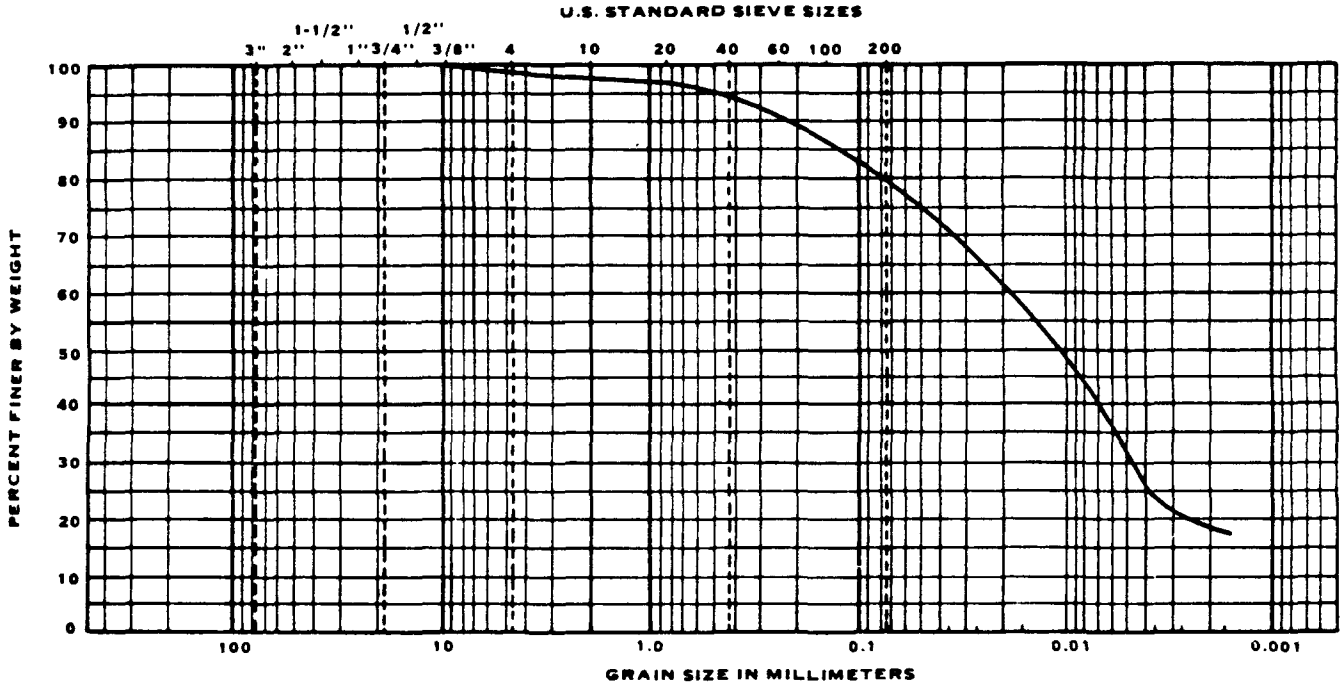
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION ID : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	98.6
2.00	97.7
0.85	96.9
0.425	94.2
0.212	89.0
0.15	86.1
0.106	82.8
0.075	79.9
0.0427	71.9
0.0308	68.4
0.0224	63.6
0.0122	53.1
0.0089	45.1
0.0066	37.4
0.0048	29.5
0.0035	23.7
0.0015	17.4

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	126
PLASTIC LIMIT	67
PLASTICITY INDEX	59
CLASSIFICATION	-
	-
WATER CONTENT (%)	136.3
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.45
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
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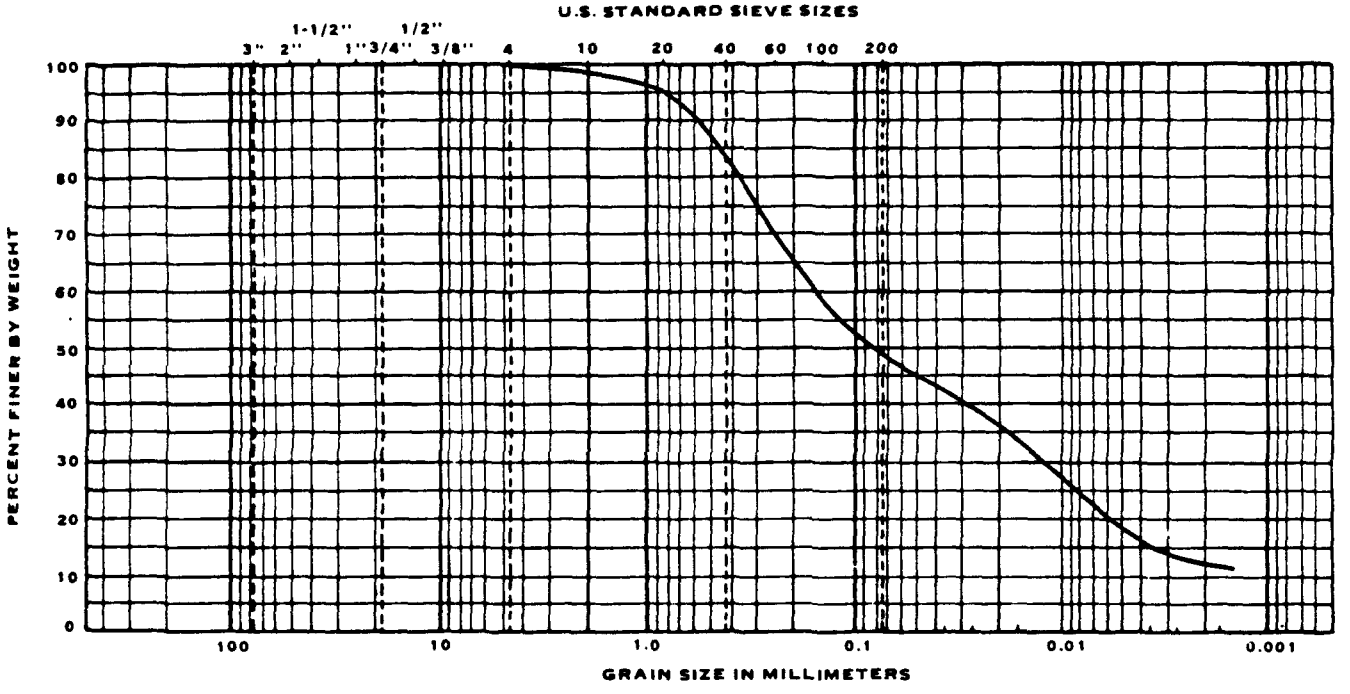
Corps of Engineers

PROJECT DACW33-88-M-0034/LM-88-004

DATE November 9, 1987

JOB NO. LL7000.63

SAMPLE IDENTIFICATION ID : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	98.5
0.85	95.4
0.425	83.8
0.212	65.0
0.15	59.0
0.106	53.1
0.075	49.3
0.0437	43.2
0.0314	41.1
0.0226	37.9
0.0123	29.2
0.0089	25.9
0.0064	22.1
0.0047	17.4
0.0034	15.0
0.0014	11.5

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	54
PLASTIC LIMIT	35
PLASTICITY INDEX	19
CLASSIFICATION	-
	-
WATER CONTENT (%)	69.9
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.59
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
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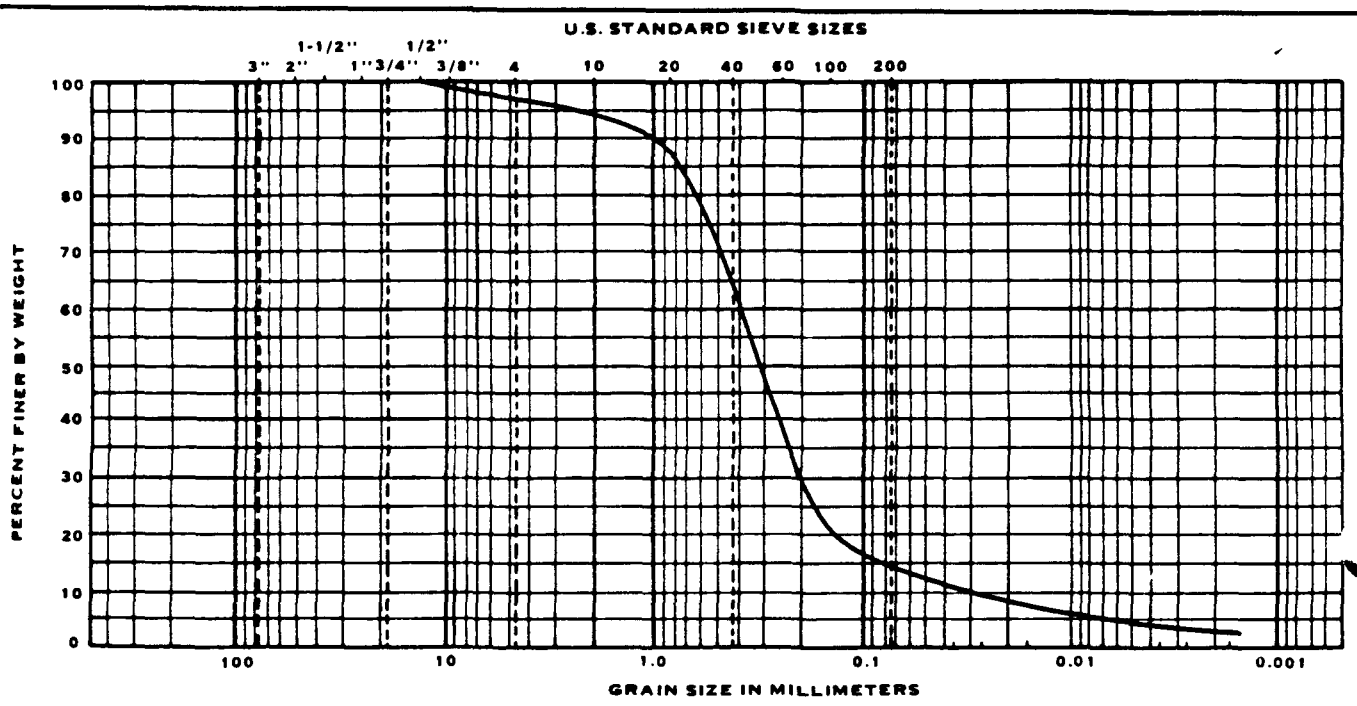
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION ID : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
12.5	100.0
9.5	98.7
4.75	97.0
2.00	94.2
0.85	88.2
0.425	63.8
0.212	29.8
0.15	21.3
0.106	16.3
0.075	13.4
0.0489	11.9
0.0349	11.0
0.0251	9.4
0.0133	6.3
0.0095	5.3
0.0068	4.4
0.0048	3.6
0.0034	3.1
0.0014	2.3

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT -
PLASTIC LIMIT -
PLASTICITY INDEX non-plastic (visual)
CLASSIFICATION -
-

WATER CONTENT (%) 18.8
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.65
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
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112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

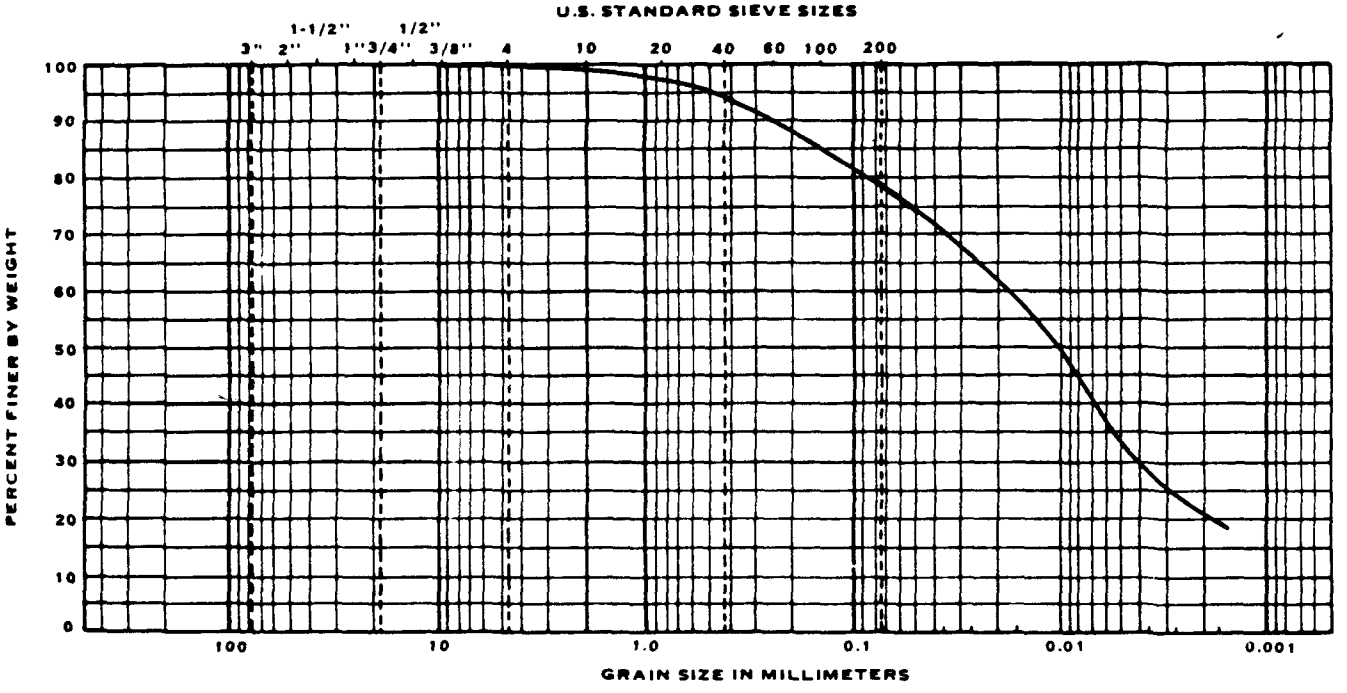
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IE : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.3
2.00	98.5
0.85	97.5
0.425	94.8
0.212	88.2
0.15	84.9
0.106	81.1
0.075	78.3
0.0435	73.0
0.0316	67.9
0.0228	63.6
0.0123	54.1
0.0090	45.5
0.0066	38.7
0.0048	31.8
0.0034	26.1
0.0014	18.7

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	119
PLASTIC LIMIT	76
PLASTICITY INDEX	43
CLASSIFICATION	-
	-
WATER CONTENT (%)	146.6
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.47
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
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112 TOWNPARK DRIVE
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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Dept. of the Army
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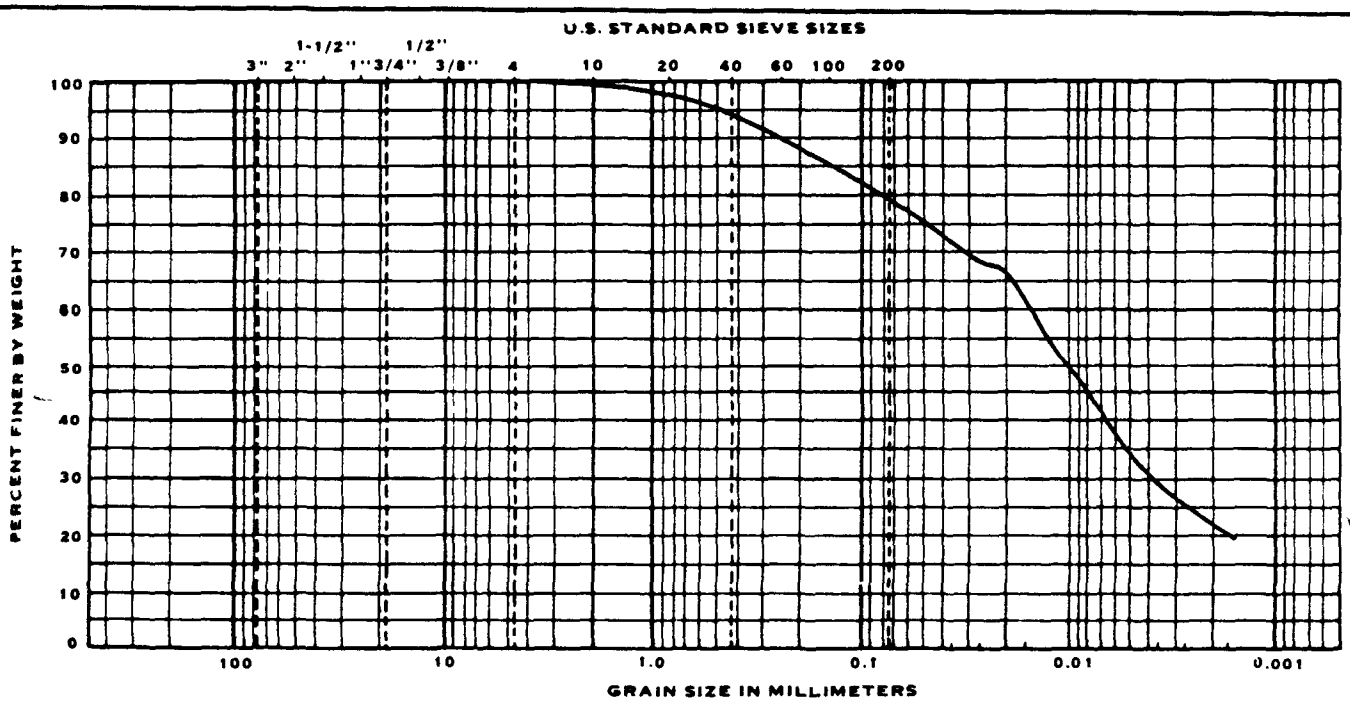
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IE : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.3
0.85	98.3
0.425	94.9
0.212	87.9
0.15	84.5
0.106	81.2
0.075	78.8
0.0392	71.2
0.0283	68.4
0.0202	67.0
0.0115	52.8
0.0084	46.1
0.0062	38.8
0.0045	32.1
0.0033	27.6
0.0014	19.4

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	100
PLASTIC LIMIT	50
PLASTICITY INDEX	50
CLASSIFICATION	-
	-
WATER CONTENT (%)	106.5
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.54
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

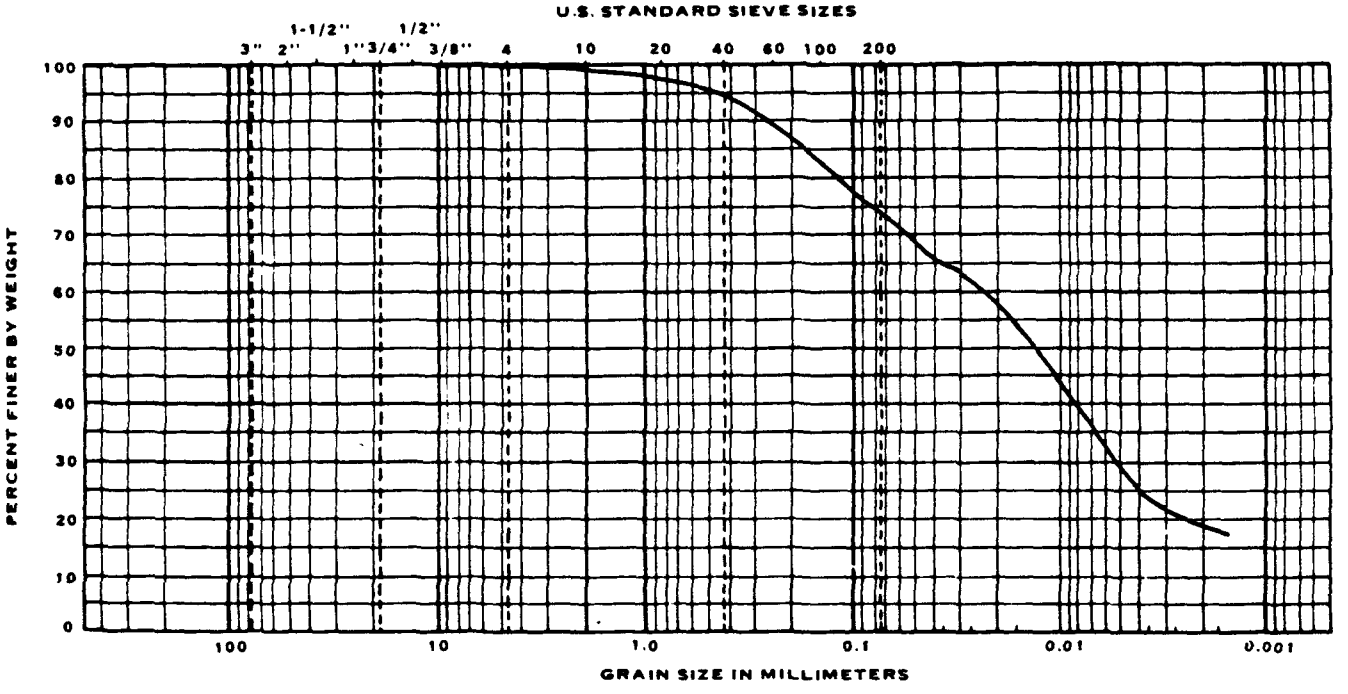
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IE : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.8
2.00	99.0
0.85	97.7
0.425	94.2
0.212	86.4
0.15	82.8
0.106	77.6
0.075	73.6
0.0410	65.4
0.0297	62.0
0.0215	58.6
0.0113	48.0
0.0087	40.9
0.0064	33.0
0.0047	27.9
0.0034	23.8
0.0014	16.5

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	100
PLASTIC LIMIT	51
PLASTICITY INDEX	49
CLASSIFICATION	-
	-
WATER CONTENT (%)	104.1
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.50
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

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LAW ENVIRONMENTAL, INC.
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KENNESAW, GEORGIA 30144-5599
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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

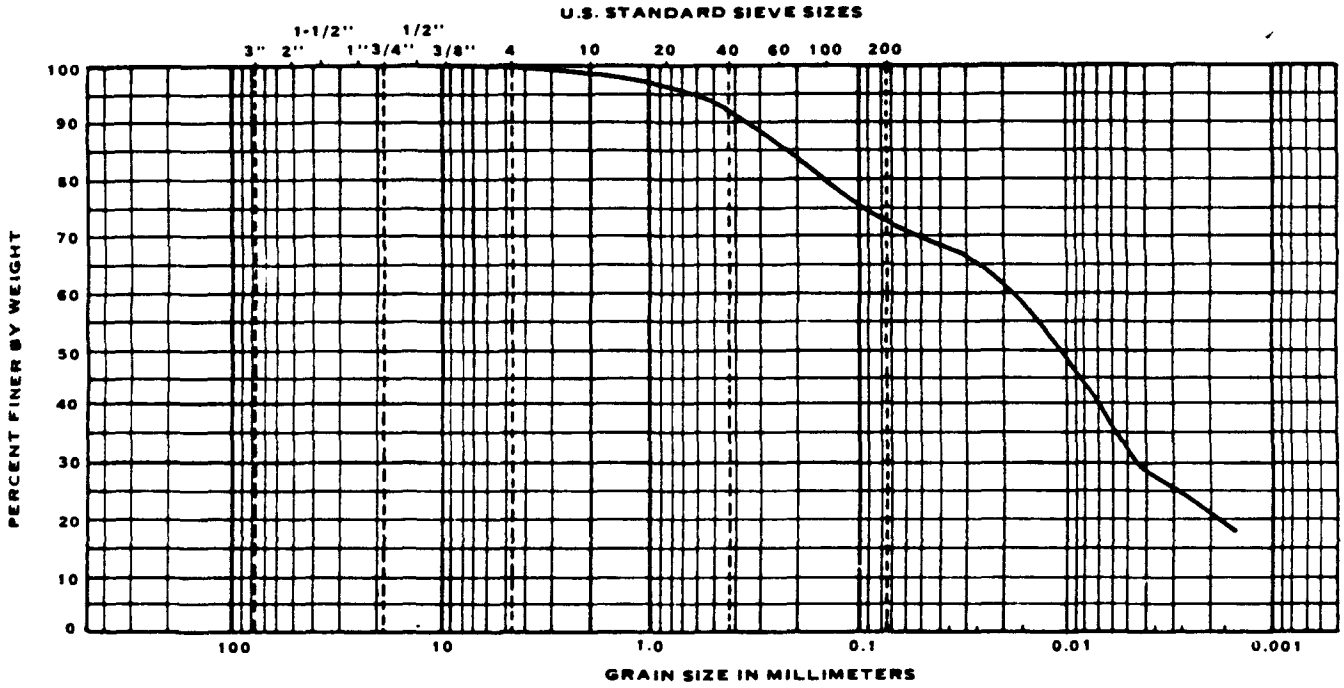
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IF : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.3
2.00	98.5
0.85	96.6
0.425	91.5
0.212	83.2
0.15	79.5
0.106	75.7
0.075	73.1
0.0432	68.9
0.0310	66.5
0.0223	63.2
0.0121	52.2
0.0089	44.1
0.0065	37.0
0.0047	30.8
0.0034	26.3
0.0014	18.0

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 128
PLASTIC LIMIT 47
PLASTICITY INDEX 81
CLASSIFICATION -
-
WATER CONTENT (%) 131.9
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.49
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelly

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112 TOWNPARK DRIVE
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CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

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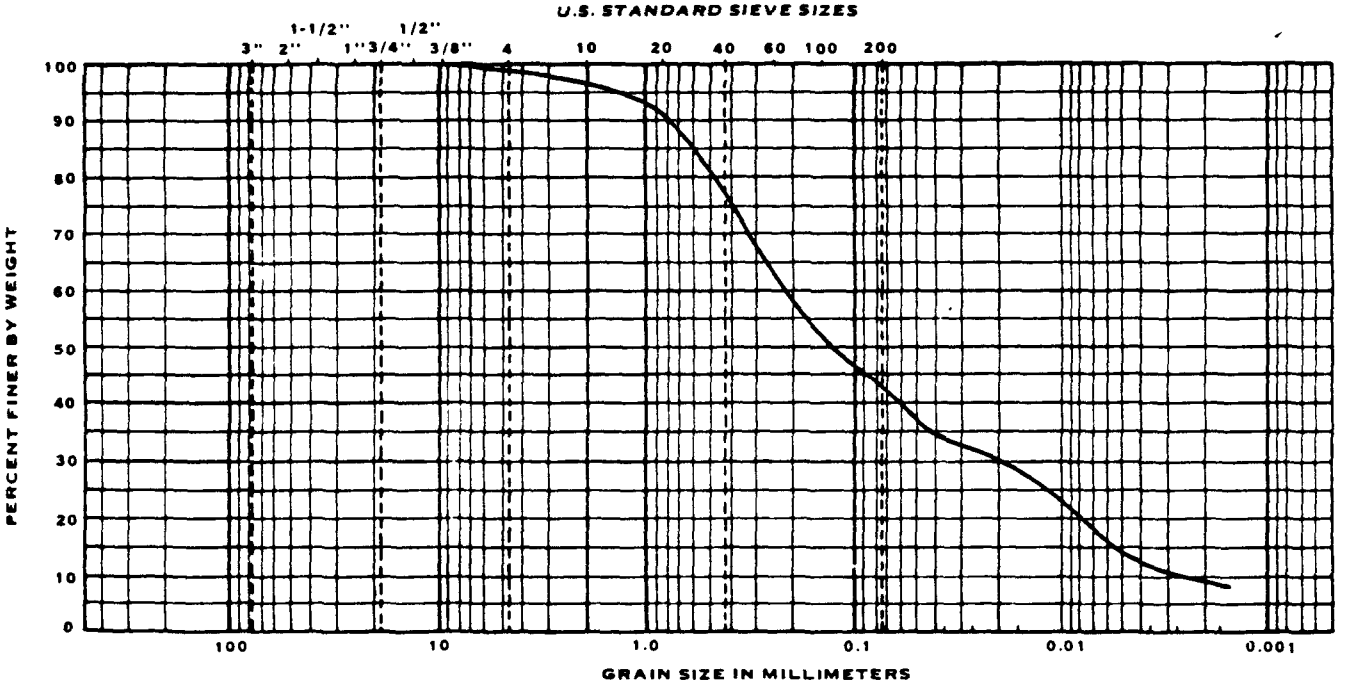
PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IF : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.3
2.00	95.6
0.85	91.6
0.425	77.7
0.212	58.3
0.15	52.1
0.106	47.1
0.075	44.2
0.0445	35.6
0.0319	33.8
0.0229	31.5
0.0123	25.4
0.0090	21.0
0.0065	17.4
0.0047	14.3
0.0034	11.5
0.0014	8.9

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	51
PLASTIC LIMIT	27
PLASTICITY INDEX	24
CLASSIFICATION	-
	-
WATER CONTENT (%)	60.1
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.60
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelly

AF 49071B

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

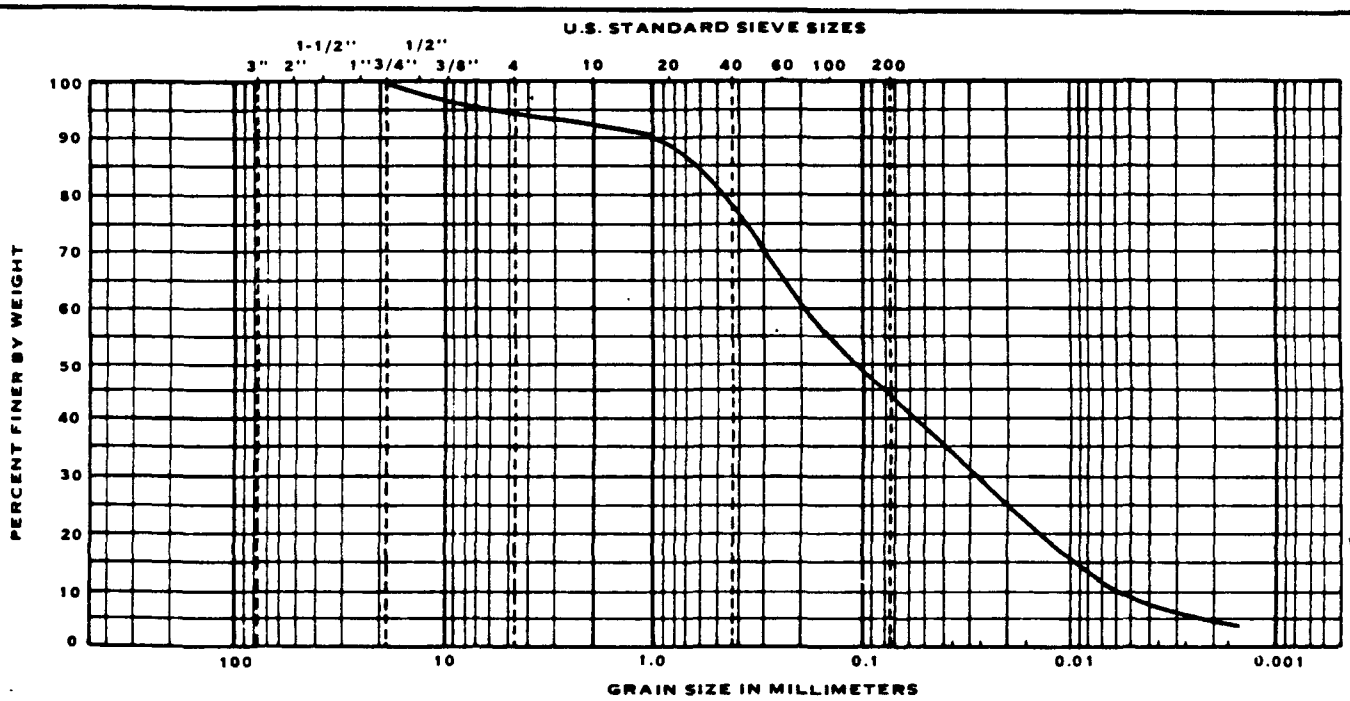
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IF : 48-72"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
19.0	100.0
12.5	97.8
9.5	96.1
4.75	94.4
2.00	92.6
0.85	89.1
0.425	77.9
0.212	60.9
0.15	55.3
0.106	49.7
0.075	44.0
0.0389	34.6
0.0293	29.7
0.0218	25.3
0.0121	17.9
0.0089	13.7
0.0065	10.1
0.0047	7.9
0.0034	6.1
0.0014	4.2

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	20
PLASTIC LIMIT	13
PLASTICITY INDEX	7
CLASSIFICATION	-
	-
WATER CONTENT (%)	21.8
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.65
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

AF 49071B

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

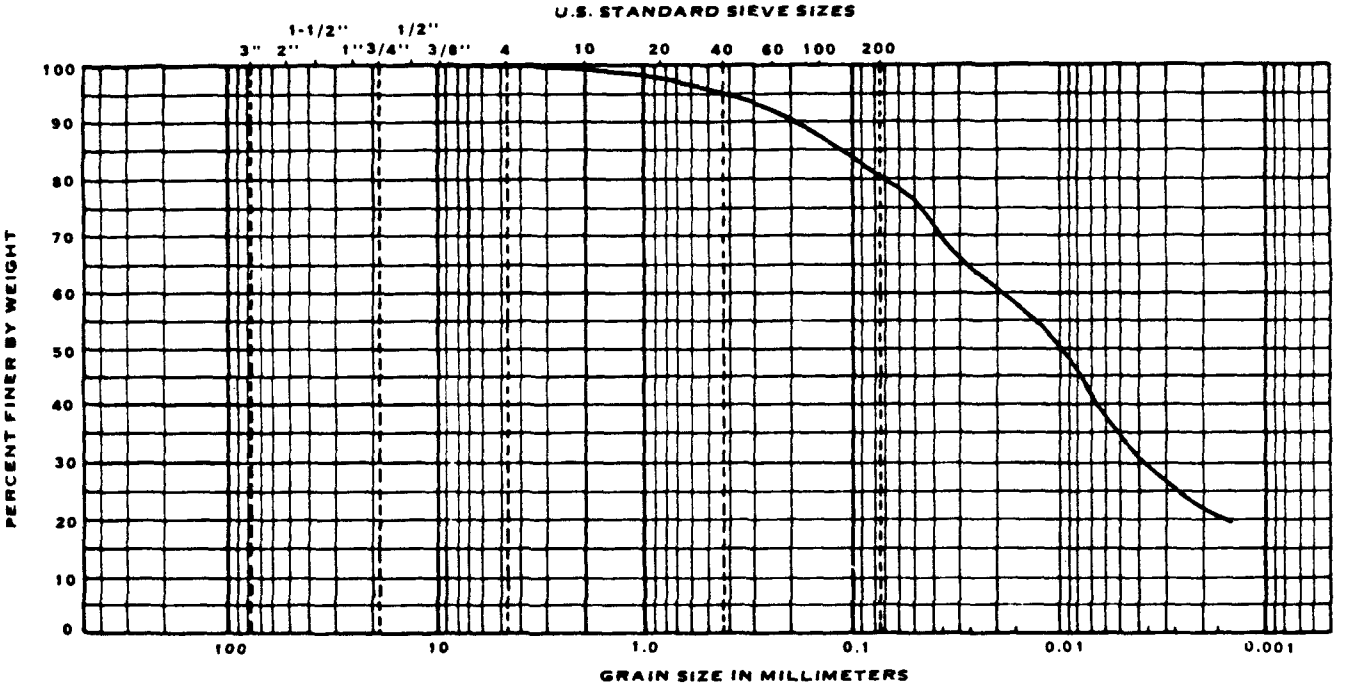
CLIENT Dept of the Army
New England Division
Corps of Engineers

DATE Nkovember 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION II A : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.8
2.00	99.6
0.85	98.5
0.425	95.8
0.212	90.1
0.15	87.1
0.106	83.4
0.075	80.2
0.0444	75.5
0.0325	67.5
0.0234	63.4
0.0125	54.0
0.0091	48.1
0.0066	39.5
0.0048	33.5
0.0034	28.3
0.0014	19.9

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 119
PLASTIC LIMIT 76
PLASTICITY INDEX 43
CLASSIFICATION -
-

WATER CONTENT (%) 161.7
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.47
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

AF 49071B

LAW ENVIRONMENTAL, INC.
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KENNESAW, GEORGIA 30144-5599
404-421-3400

GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

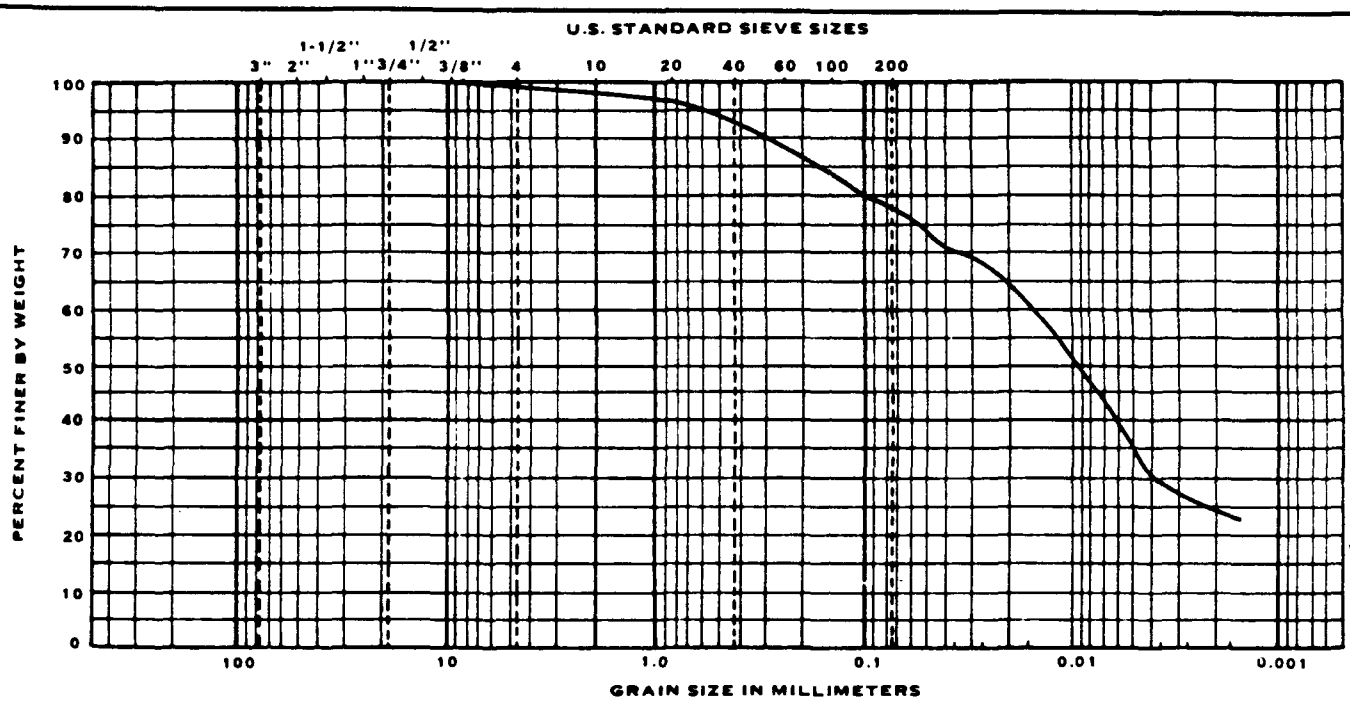
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION II A : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	98.9
2.00	98.5
0.85	97.0
0.425	92.9
0.212	86.3
0.15	83.5
0.106	80.6
0.075	78.3
0.0396	70.5
0.0283	68.8
0.0206	64.9
0.0114	53.4
0.0084	47.0
0.0062	40.0
0.0045	33.0
0.0033	28.8
0.0014	22.5

VOLATILE SOLIDS (%)	-
EFFECTIVE SIZE (mm)	-
COEFFICIENT OF UNIFORMITY	-
COEFFICIENT OF CURVATURE	-
LIQUID LIMIT	99
PLASTIC LIMIT	45
PLASTICITY INDEX	54
CLASSIFICATION	-
	-
WATER CONTENT (%)	108.9
DRY DENSITY (PCF)	-
SPECIFIC GRAVITY	2.53
POROSITY (%)	-
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C)	-
TEST PROCEDURE	ASTM D4318, D422, D854

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CLIENT Dept. of the Army
New England Division
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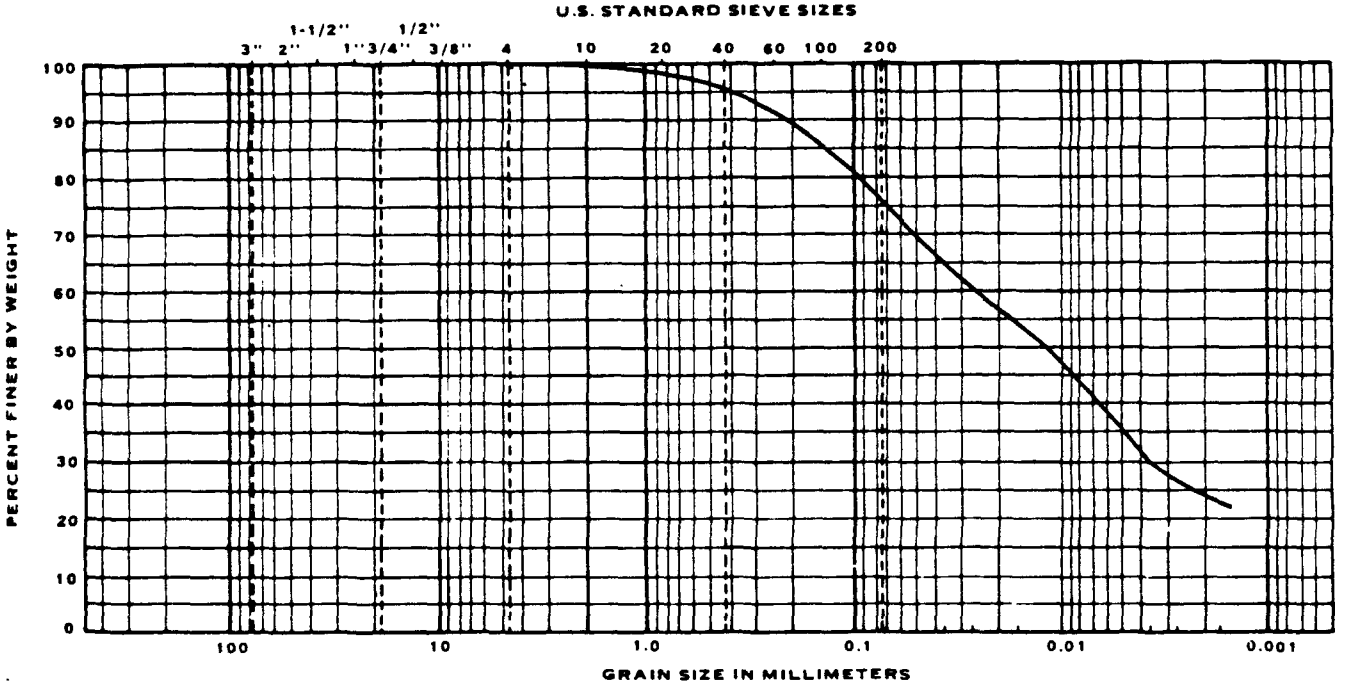
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-8-004

SAMPLE IDENTIFICATION IIB : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.8
0.85	98.8
0.425	95.2
0.212	88.7
0.15	85.1
0.106	80.4
0.075	76.0
0.0457	67.3
0.0329	63.4
0.0236	59.8
0.0126	51.3
0.0091	44.7
0.0066	39.4
0.0048	34.1
0.0034	29.3
0.0014	21.3

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 115
PLASTIC LIMIT 72
PLASTICITY INDEX 43
CLASSIFICATION -

WATER CONTENT (%) 148.5
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.46
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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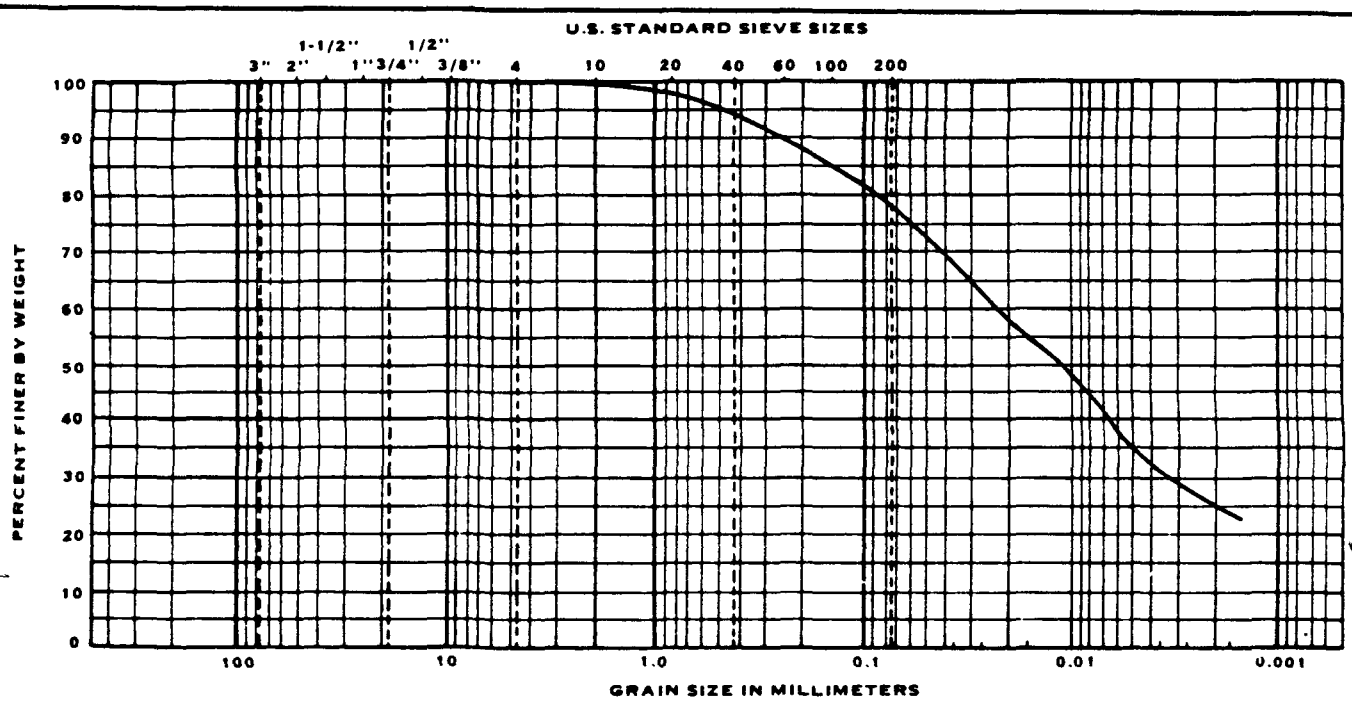
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIB : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.9
0.85	98.5
0.425	94.8
0.212	88.3
0.15	85.3
0.106	81.5
0.075	77.9
0.0408	70.2
0.0296	65.6
0.0214	62.1
0.0117	51.0
0.0085	44.8
0.0062	38.8
0.0045	34.2
0.0032	29.6
0.0014	23.1

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 101
PLASTIC LIMIT 54
PLASTICITY INDEX 47
CLASSIFICATION -
-
WATER CONTENT (%) 121.4
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.57
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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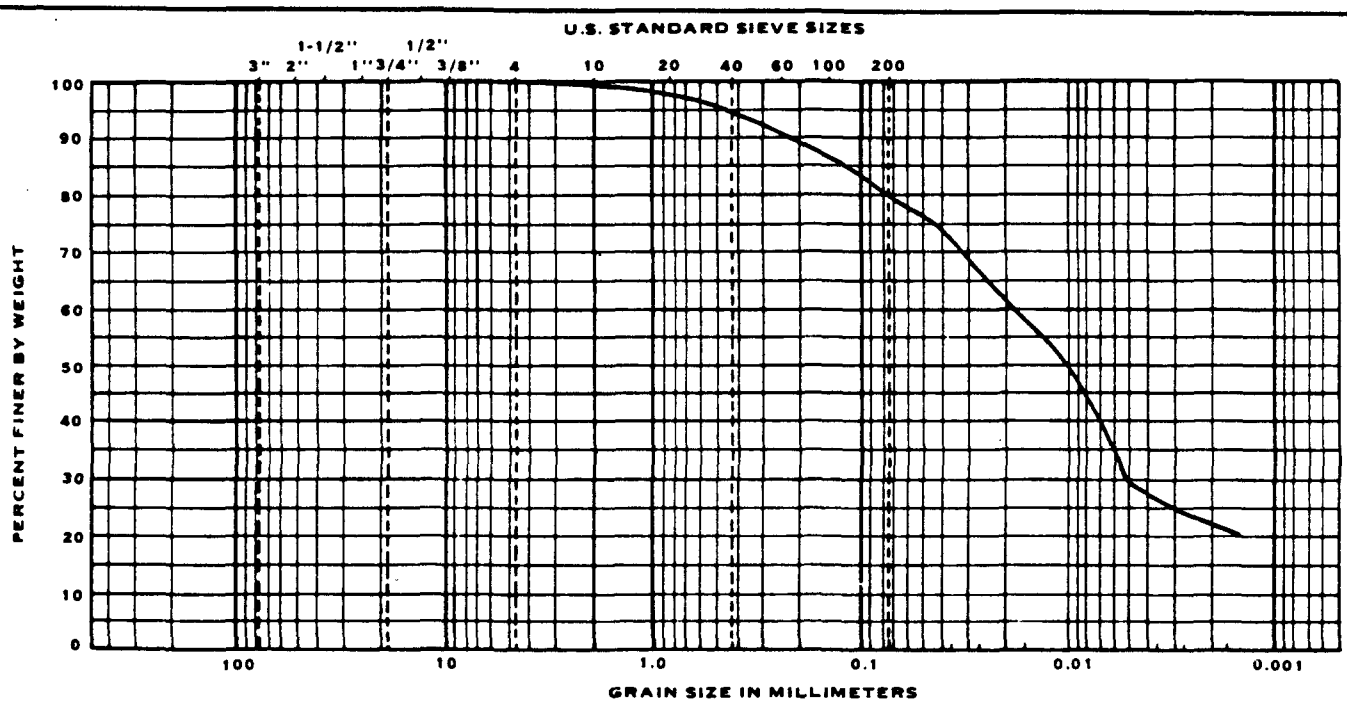
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIC : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.6
2.00	99.1
0.85	98.2
0.425	94.9
0.212	88.9
0.15	85.8
0.106	82.7
0.075	79.8
0.0421	75.0
0.0309	68.5
0.0224	63.6
0.0122	53.6
0.0088	46.4
0.0065	37.0
0.0048	28.4
0.0034	26.3
0.0014	20.3

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 114
PLASTIC LIMIT 76
PLASTICITY INDEX 38
CLASSIFICATION -
-
WATER CONTENT (%) 150.4
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.48
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Dept. of the Army
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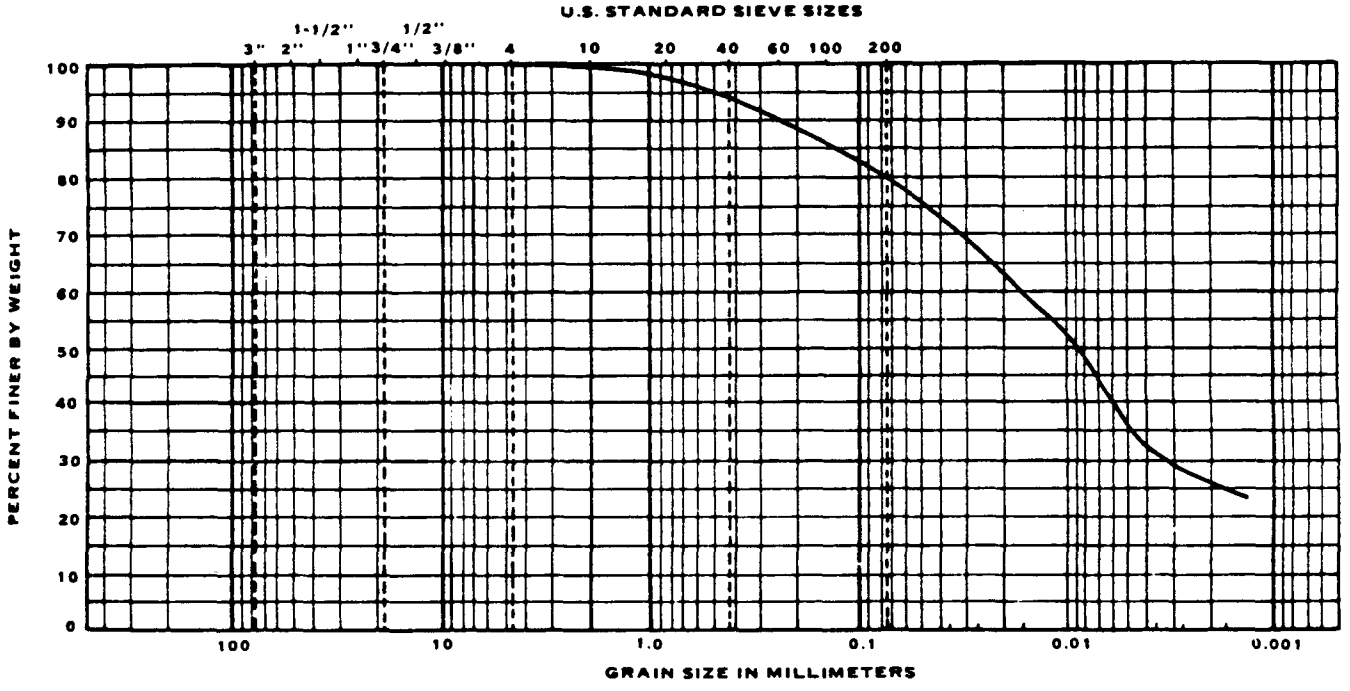
DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIC : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.0
0.85	97.7
0.425	94.2
0.212	87.8
0.15	85.1
0.106	82.3
0.075	80.3
0.0384	71.0
0.0277	68.2
0.0203	63.5
0.0112	53.3
0.0083	46.7
0.0061	40.2
0.0044	34.1
0.0032	30.2
0.0013	23.2

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 105
PLASTIC LIMIT 55
PLASTICITY INDEX 50
CLASSIFICATION -
-
WATER CONTENT (%) 109.7
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.55
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

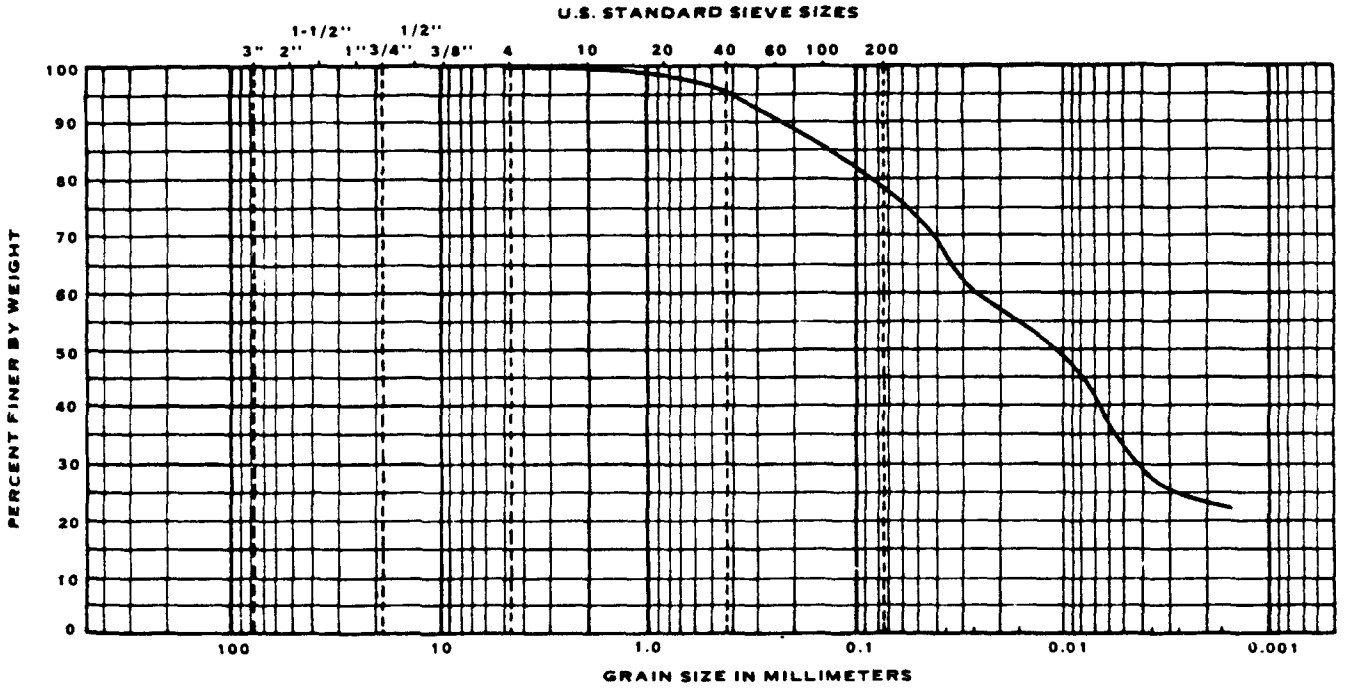
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IID : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
4.75	100.0
2.00	99.3
0.85	98.4
0.425	95.1
0.212	88.7
0.15	85.6
0.106	82.0
0.075	78.8
0.0447	71.8
0.0328	64.0
0.0236	59.9
0.0125	53.6
0.0091	48.1
0.0066	39.2
0.0048	31.2
0.0035	27.6
0.0014	21.4

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 148
PLASTIC LIMIT 96
PLASTICITY INDEX 52
CLASSIFICATION -
-
WATER CONTENT (%) 175.0
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.44
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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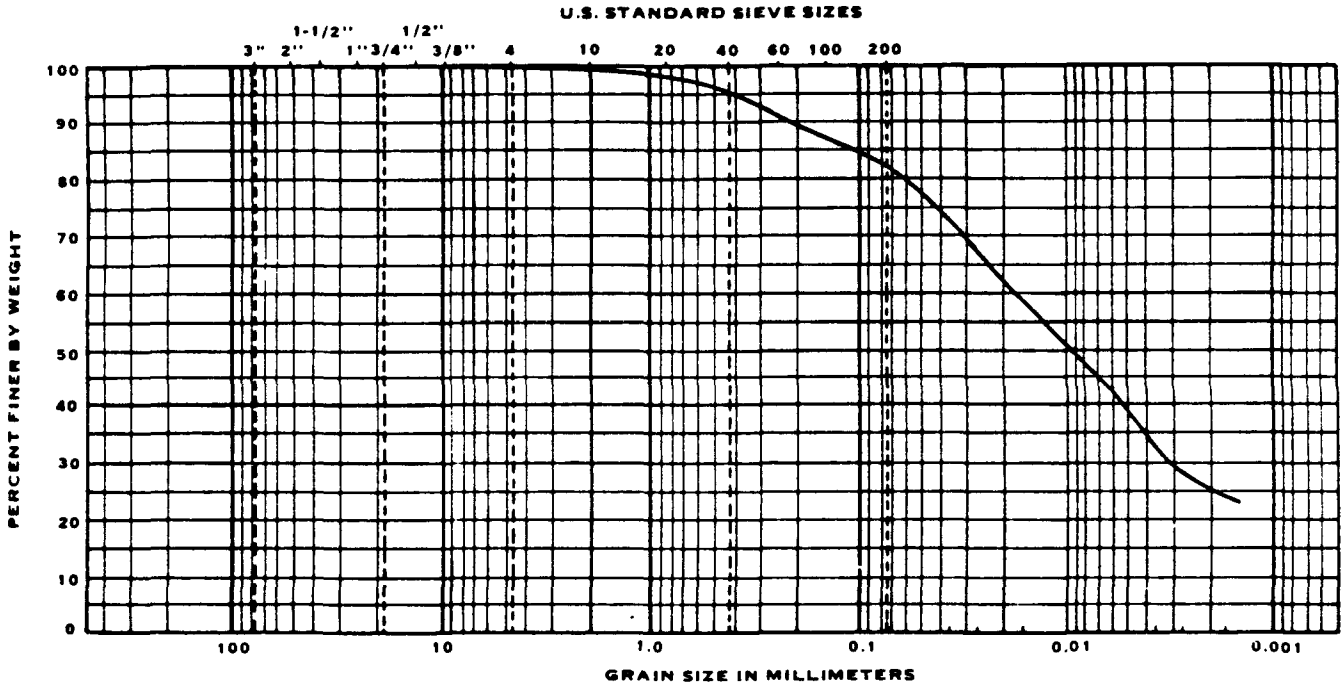
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IID : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.7
2.00	99.4
0.85	98.4
0.425	95.3
0.212	89.8
0.15	87.0
0.106	84.2
0.075	81.9
0.0413	73.9
0.0301	68.7
0.0219	63.5
0.0118	54.9
0.0086	48.2
0.0062	42.5
0.0046	36.1
0.0033	30.9
0.0014	22.6

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE
LIQUID LIMIT 134
PLASTIC LIMIT 72
PLASTICITY INDEX 62
CLASSIFICATION -
-
WATER CONTENT (%) 143.0
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.53
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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GRAIN SIZE DISTRIBUTION & PHYSICAL PROPERTIES

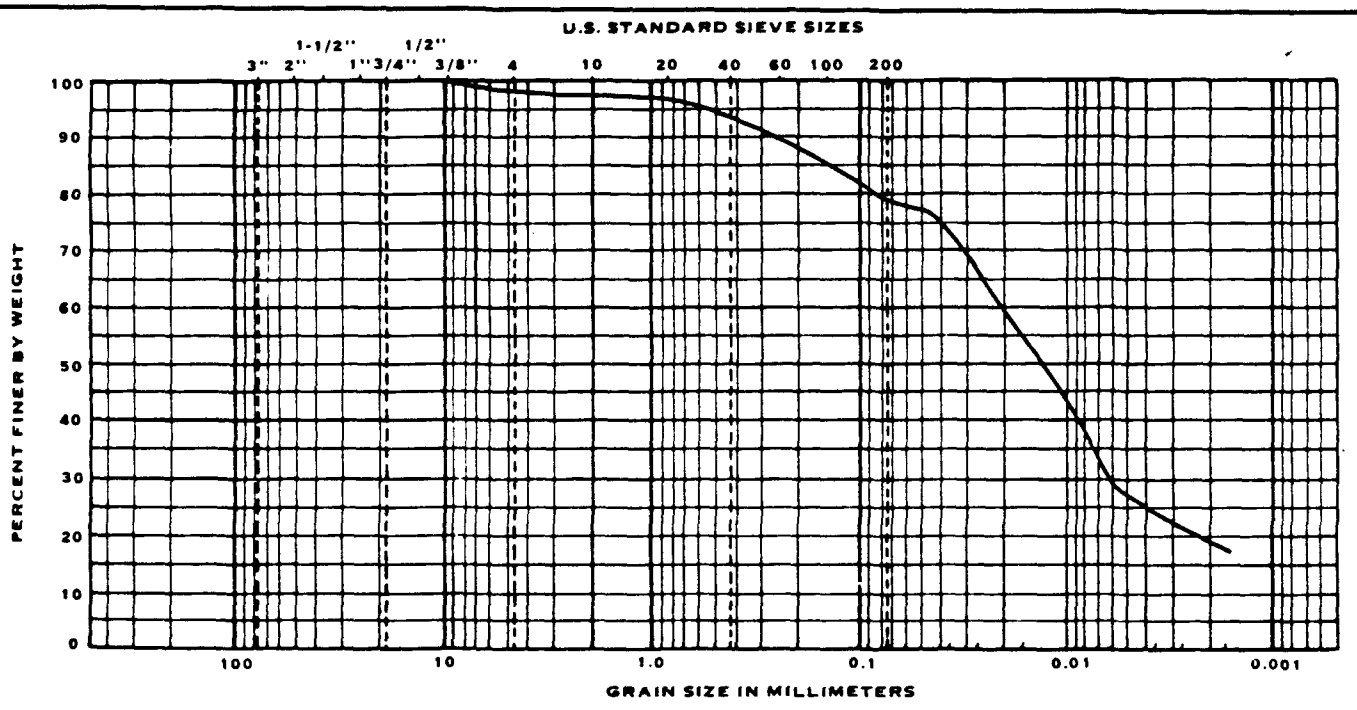
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIE : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	98.0
2.00	97.6
0.85	96.5
0.425	93.5
0.212	88.2
0.15	85.4
0.106	81.7
0.075	78.5
0.0431	76.6
0.0317	69.5
0.0232	62.7
0.0126	50.6
0.0093	40.4
0.0069	30.4
0.0049	26.2
0.0035	23.7
0.0015	17.1

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 132
PLASTIC LIMIT 74
PLASTICITY INDEX 58
CLASSIFICATION -
-
WATER CONTENT (%) 173.0
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.41
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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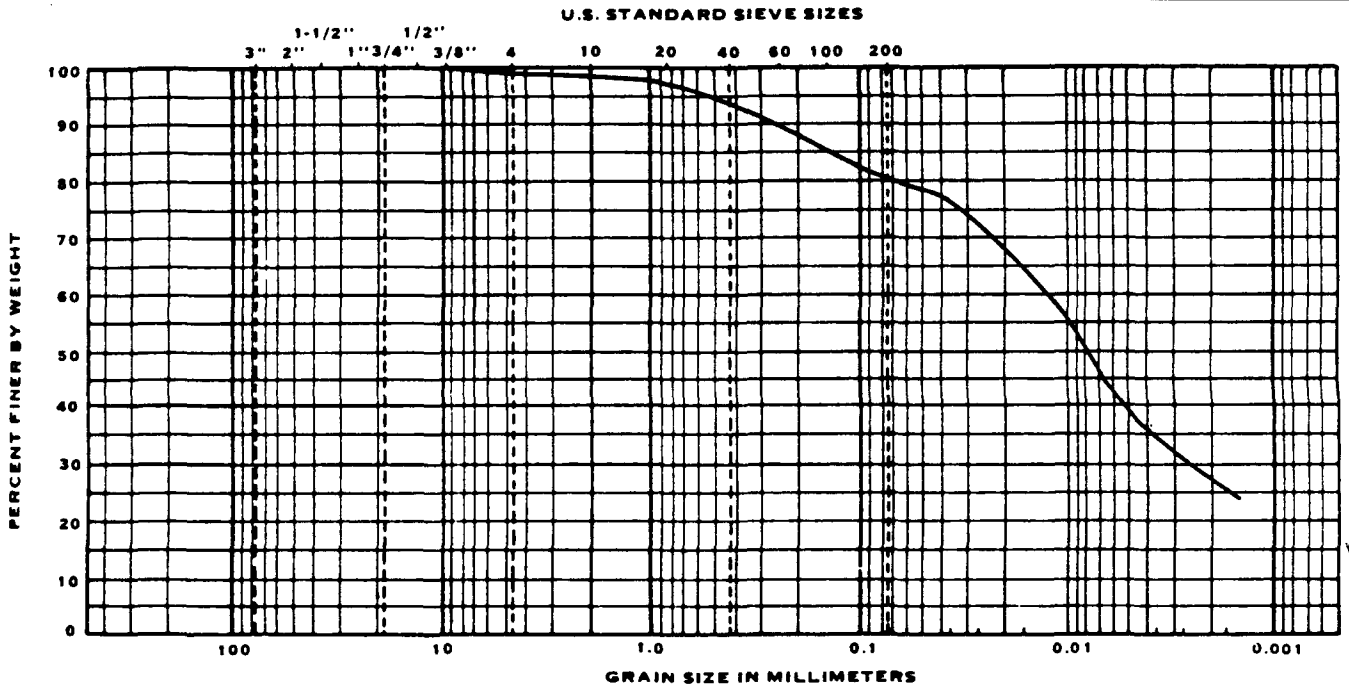
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIE : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	98.7
2.00	98.0
0.85	96.9
0.425	93.5
0.212	88.0
0.15	85.4
0.106	82.6
0.075	80.3
0.0377	77.4
0.0276	72.8
0.0202	67.7
0.0111	57.1
0.0081	51.0
0.0061	41.5
0.0044	36.6
0.0032	33.1
0.0013	24.1

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 112
PLASTIC LIMIT 52
PLASTICITY INDEX 60
CLASSIFICATION -
-
WATER CONTENT (%) 118.9
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.57
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE Astm D4318, D422, D854

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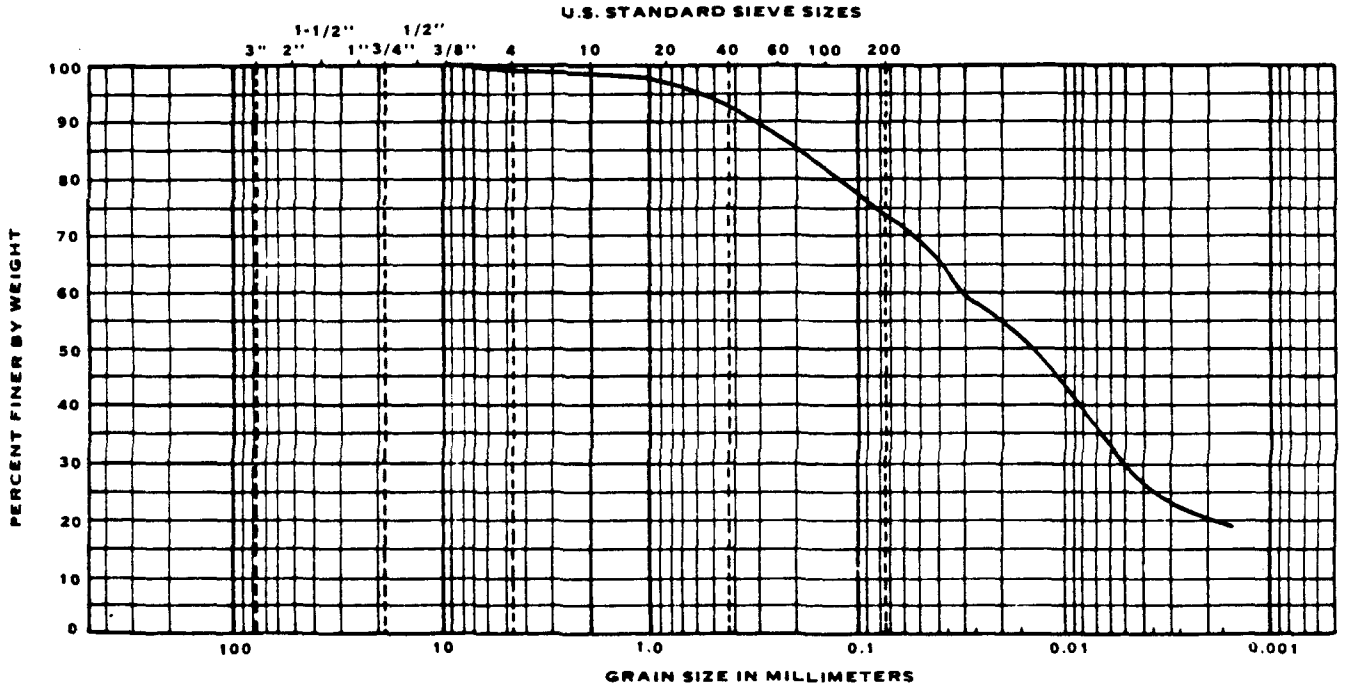
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-M-0034/LM-88-004

SAMPLE IDENTIFICATION IIF : 0-24"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	99.1
2.00	98.6
0.85	96.8
0.425	92.8
0.212	85.9
0.15	82.2
0.106	77.6
0.075	73.3
0.0439	67.5
0.0322	60.5
0.0231	57.2
0.0125	47.5
0.0090	42.0
0.0066	34.4
0.0048	28.4
0.0034	25.4
0.0014	18.9

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 109
PLASTIC LIMIT 68
PLASTICITY INDEX 41
CLASSIFICATION -
-
WATER CONTENT (%) 143.3
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.48
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

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M.A. O'Kelley

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404-421-3400

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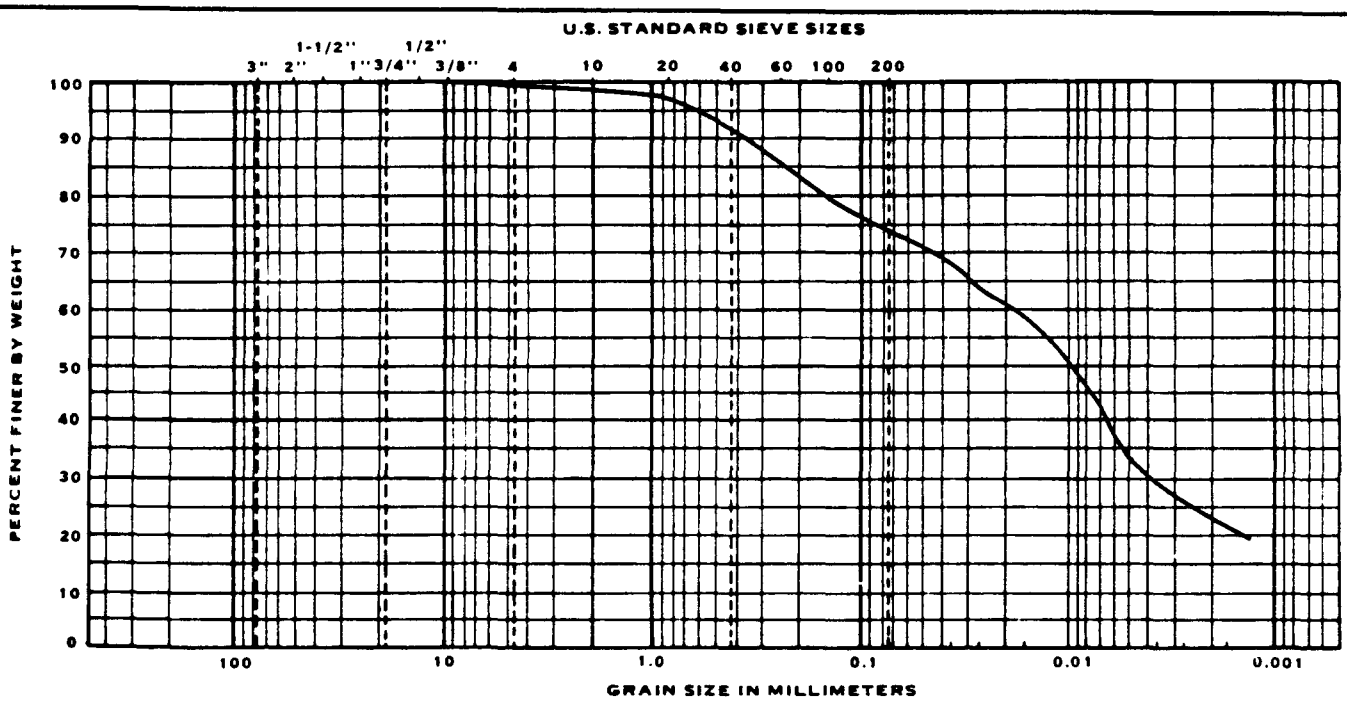
CLIENT Dept. of the Army
New England Division
Corps of Engineers

DATE November 9, 1987

JOB NO. LL7000.63

PROJECT DACW-33-88-0034/LM-88-004

SAMPLE IDENTIFICATION IIF : 24-48"



PARTICLE DIAMETER (IN MILLIMETERS)	PERCENT FINER
9.5	100.0
4.75	98.8
2.00	98.2
0.85	96.5
0.425	91.2
0.212	83.2
0.15	79.9
0.106	76.5
0.075	73.9
0.0358	68.4
0.0265	63.7
0.0193	60.4
0.0109	50.1
0.0079	45.8
0.0060	36.5
0.0044	31.8
0.0032	27.1
0.0013	19.5

VOLATILE SOLIDS (%) -
EFFECTIVE SIZE (mm) -
COEFFICIENT OF UNIFORMITY -
COEFFICIENT OF CURVATURE -
LIQUID LIMIT 89
PLASTIC LIMIT 52
PLASTICITY INDEX 37
CLASSIFICATION -
-
WATER CONTENT (%) 102.6
DRY DENSITY (PCF) -
SPECIFIC GRAVITY 2.56
POROSITY (%) -
HYDRAULIC CONDUCTIVITY (cm/sec @ 20° C) -
TEST PROCEDURE ASTM D4318, D422, D854

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

AF 49071B

Geotechnical Engineers, Inc.

October 1987 to November 1987

LIST OF SYMBOLS

CR - Virgin Compression Ratio = $\frac{\Delta\varepsilon_v}{\Delta\log\sigma_v}$ from virgin compression

LL - Liquid Limit

PL - Plastic Limit

PI - Plasticity Index = LL - PL

I_L - Liquidity Index = $\frac{W_n - PL}{LL - PL}$

e_o - Initial Void Ratio

W_o - Initial Water Content

W - Natural Water Content

S_o - Initial Degree of Saturation

G - Specific Gravity

$\bar{\sigma}_v$ - Effective Vertical Stress

ε_v - Vertical Strain, Percent

c_v - Coefficient of Consolidation

C_α - Coefficient of Secondary Compression = $\frac{\Delta\varepsilon_v}{\Delta\log t} \times 100\%$

q - Shear Stress = $\frac{\sigma_1 - \sigma_3}{2}$

$\bar{p}$ - Mean Effective Stress = $\frac{\bar{\sigma}_1 + \bar{\sigma}_3}{2}$

$\bar{\sigma}_3$ - Effective Minor Principal Stress

$\bar{\sigma}_1$ - Effective Major Principal Stress

U - Pore Pressure

D_c - Specimen Diameter after Consolidation

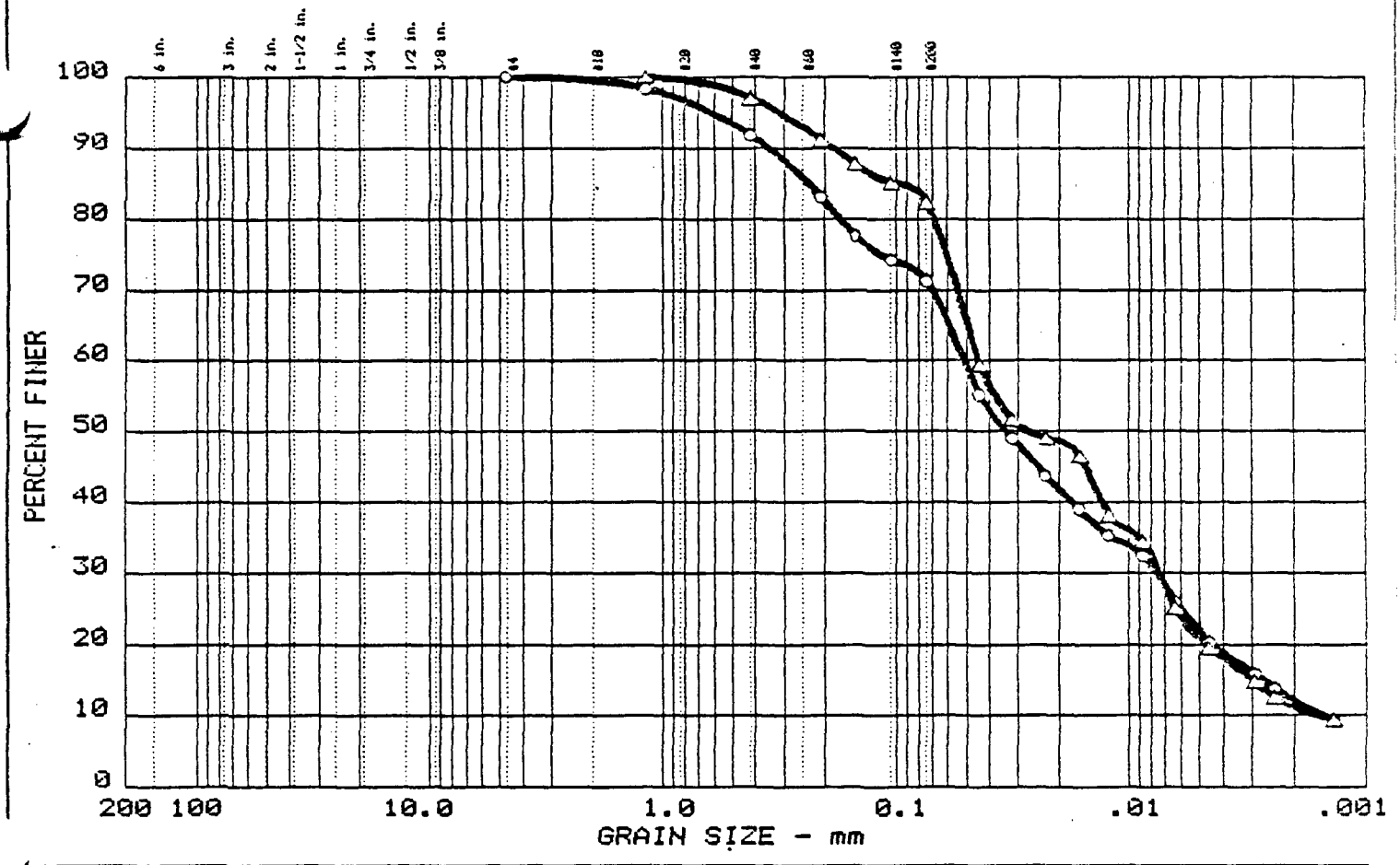
L_c - Specimen Length after Consolidation

B_c - B-value after consolidation

TABLE 5 SUMMARY OF LABORATORY TESTS
New Bedford Superfund Site

Boring	Sample	Depth ft.	Natural w %	LL	PL	PI	Classification	Specific Gravity	Grain Size Fig.	Consolidation Test Fig. No.	eo	wo %	CR	Q Test Fig. No.	Water Content %	Peak Deviator Stress psf	$\bar{R}$ Test Fig. No.	Effective Consolidation Stress psf	Water Content after Consolidation %	Peak Shear Stress psf
PD27	U01	5.5-7.5	128	122	35	87	OH							C4	128	120				
PD27	U02	8.0-10.0	103	104	33	71	OH							C7	103	233				
PD27	U04	13.0-15.0	120				OH													
PD29	U02	7.5-9.5	92	83	25	58	OH		4					C6	92	105	C9	614	66	298
PD34A	U01	4.0-6.0	120				OH													
PD34A	U02	6.5-8.5	99	116	35	81	OH	2.59		C1	3.048	118.0	0.464							
PD34	U3	10.0-12.0	91	106	33	73	OH	2.66									C8	1434	57	407
PD34	U5	15.0-17.0	88	103	36	67	OH	2.56	4	C2	2.321	90.0	0.243	C5	86	519				
TP3	S1	4.0					SM		5											
TP4	S1	3.5					SM		5											

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% FINES
○	0.0	0.0	28.8	71.2
△	0.0	0.0	17.6	82.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	83	58	0.23		0.03	0.008	0.0027	0.0015	0.74	33.9
△	105	67	0.09		0.03	0.007	0.0030	0.0016	0.76	27.5

MATERIAL DESCRIPTION	USCS	AASHTO
○ Organic clay	OH	
△ Organic clay	OH	

Project No.: 87311
Project: New Bedford Superfund
○ Location: PD-29, UO-2
△ Location: PD-34, U-5

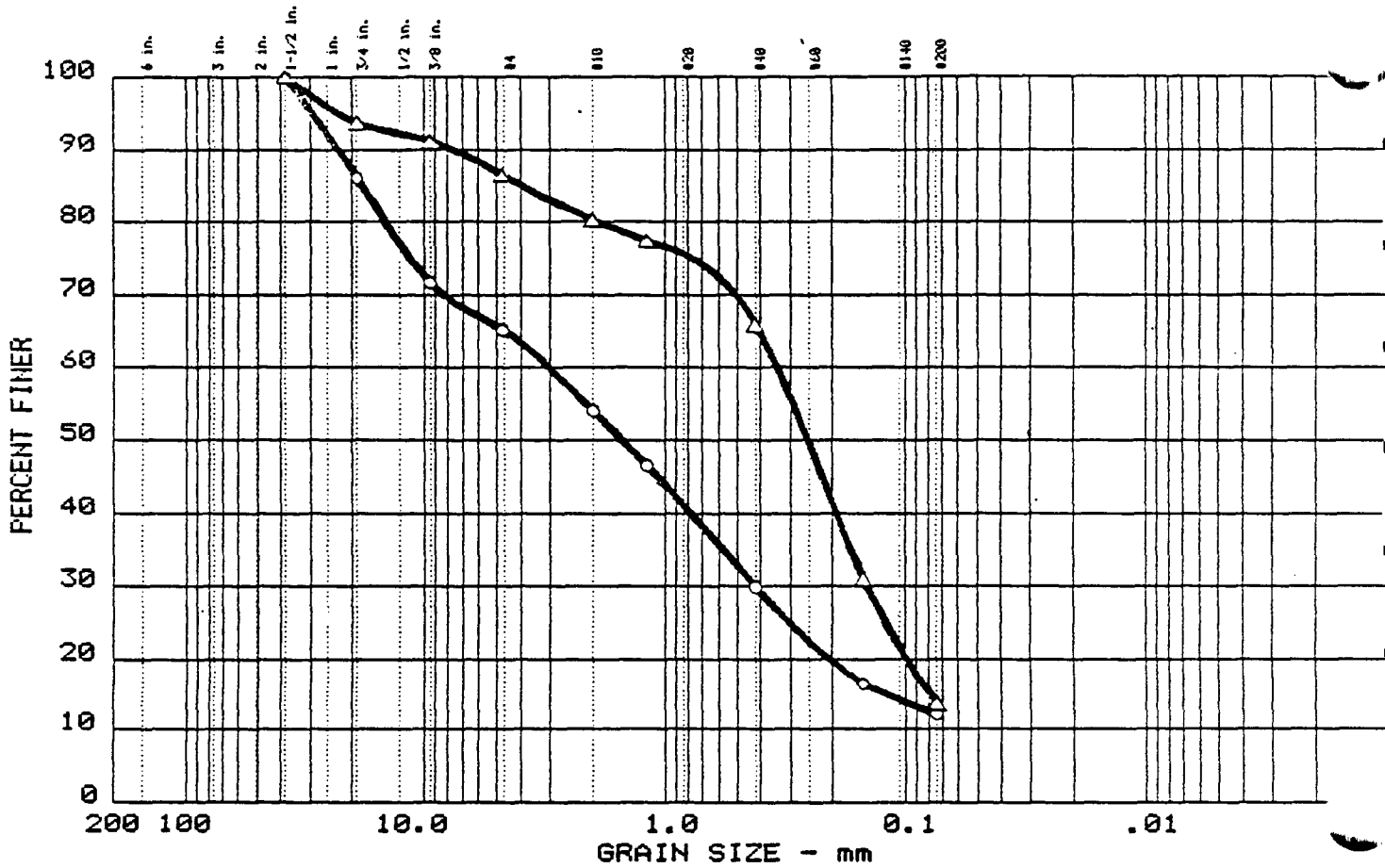
Date: November 13, 1987

GRAIN SIZE CURVES
ORGANIC CLAY

GRAIN SIZE DISTRIBUTION TEST REPORT
GEOTECHNICAL ENGINEERS, INC.

Fig. No. 4

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% FINES
○	0.0	34.8	53.0	12.2
△	0.0	13.5	72.8	13.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			18.20	3.02	1.50	0.422	0.1216			
△			3.89	0.34	0.25	0.144	0.0783			

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silty sand with gravel	SM	
△ Silty sand with gravel	SM	

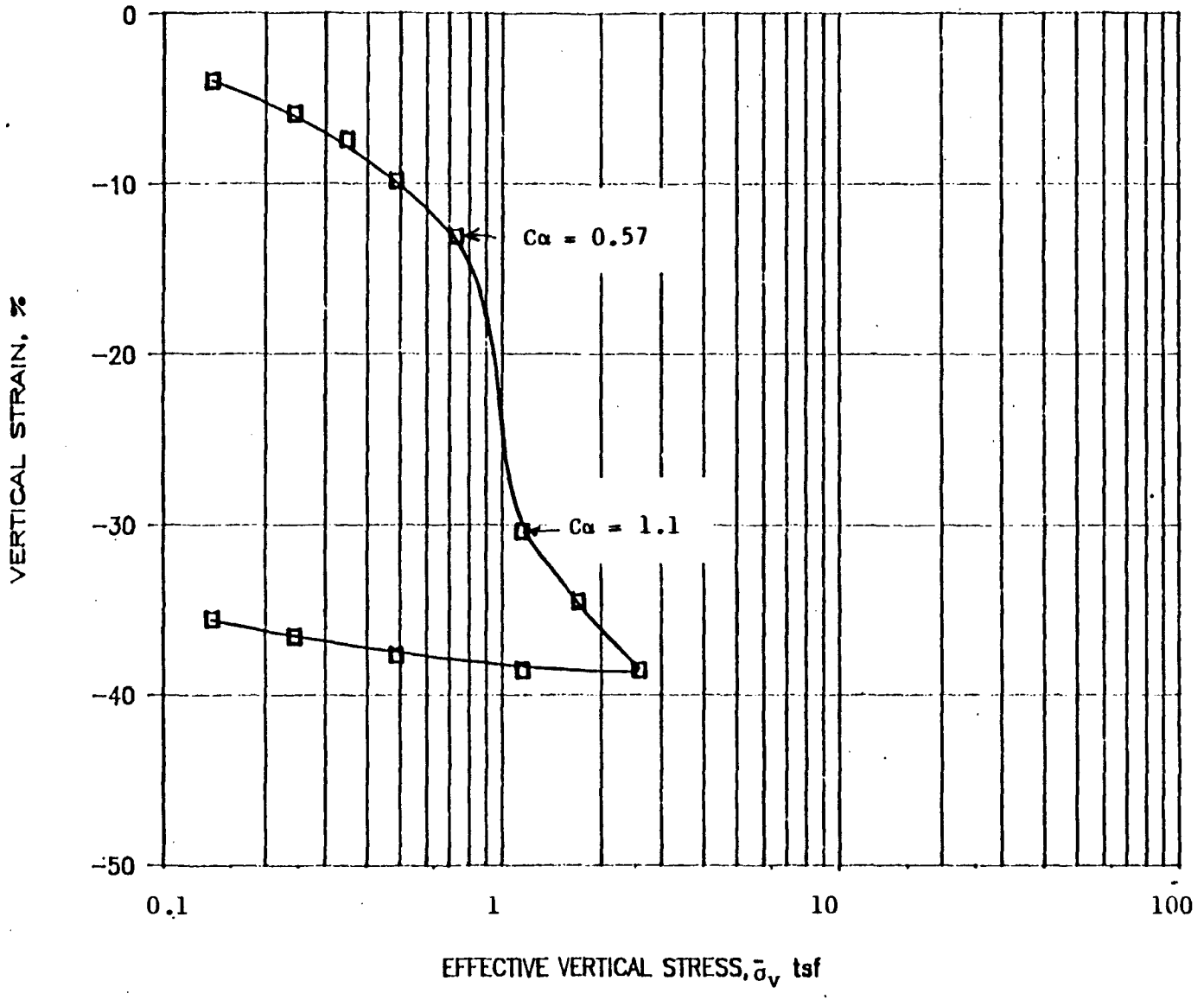
Project No.: 87311
Project: New Bedford Superfund
○ Location: TP-3
△ Location: TP-4

Date: November 13, 1987

GRAIN SIZE DISTRIBUTION TEST REPORT
GEOTECHNICAL ENGINEERS, INC.

GRAIN SIZE CURVES
ONSHORE FILL

Fig. No. 5



SOIL
PD34A,UO2/C
Organic Clay. (OH)
LL =116 PI =81

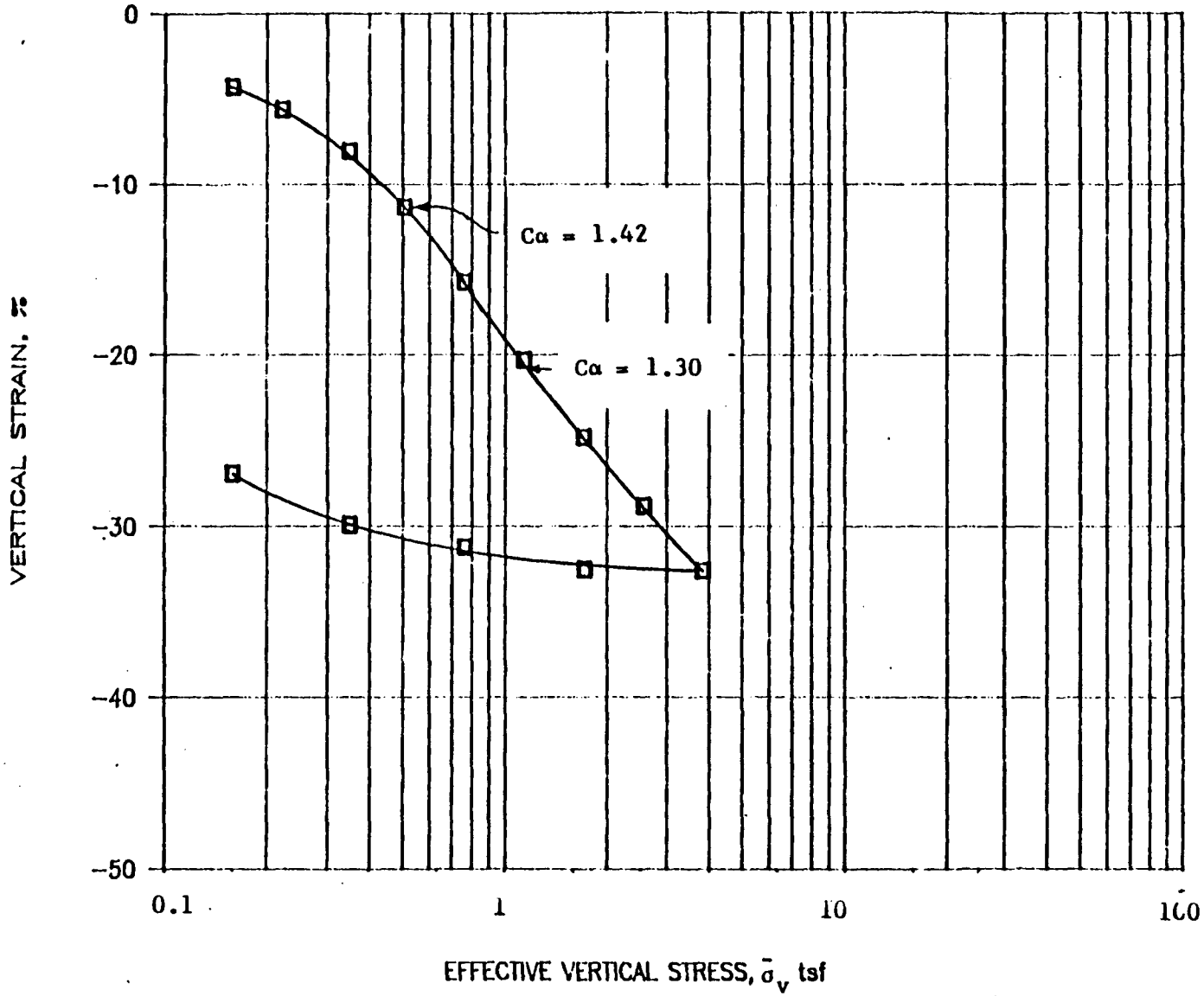
STRUCTURE
Undisturbed Osterberg Sample.

STATE
e_o = 3.048 w_o = 118 %
S_o = 100 %

LOADING
One-dimensional compression.

TEST DETAILS
Dia. = 2.5 in.
Ht. = 0.5 in.
Load incr. ratio = .5
Time of curve = 480 min.

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	COMPRESSION CURVE TEST C1
GEI Winchester,Massachusetts	Project 87311	Nov. 13, 1987 Fig.C1



SOIL
PD34 ,U 5/B
Organic Clay.(OH)
LL =103 PI =67

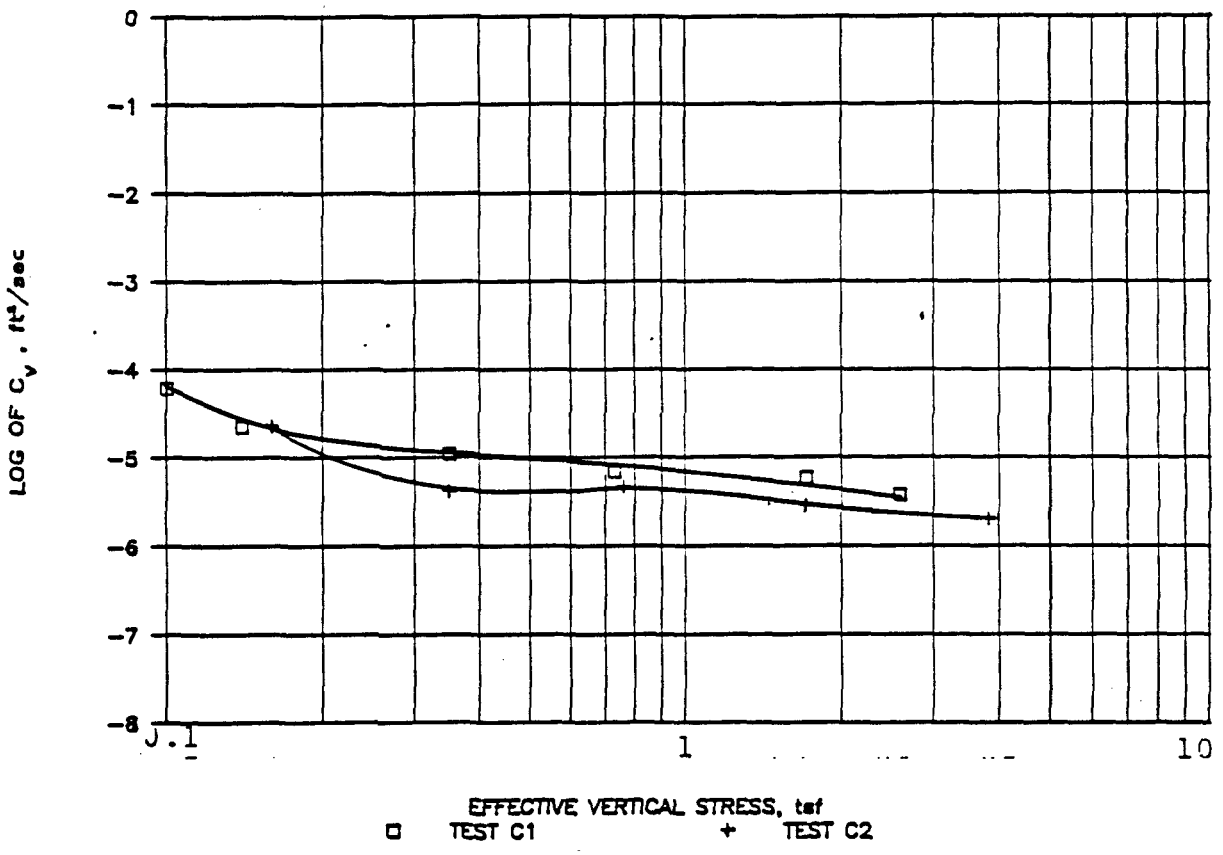
STRUCTURE
Undisturbed Osterberg Sample.

STATE
e_o = 2.321 w_o = 90 %
S_o = 99.4 %

LOADING
One-dimensional compression.

TEST DETAILS
Dia. = 2.5 in.
Ht. = 0.5 in.
Load incr. ratio = .5
Time of curve = 480 min.

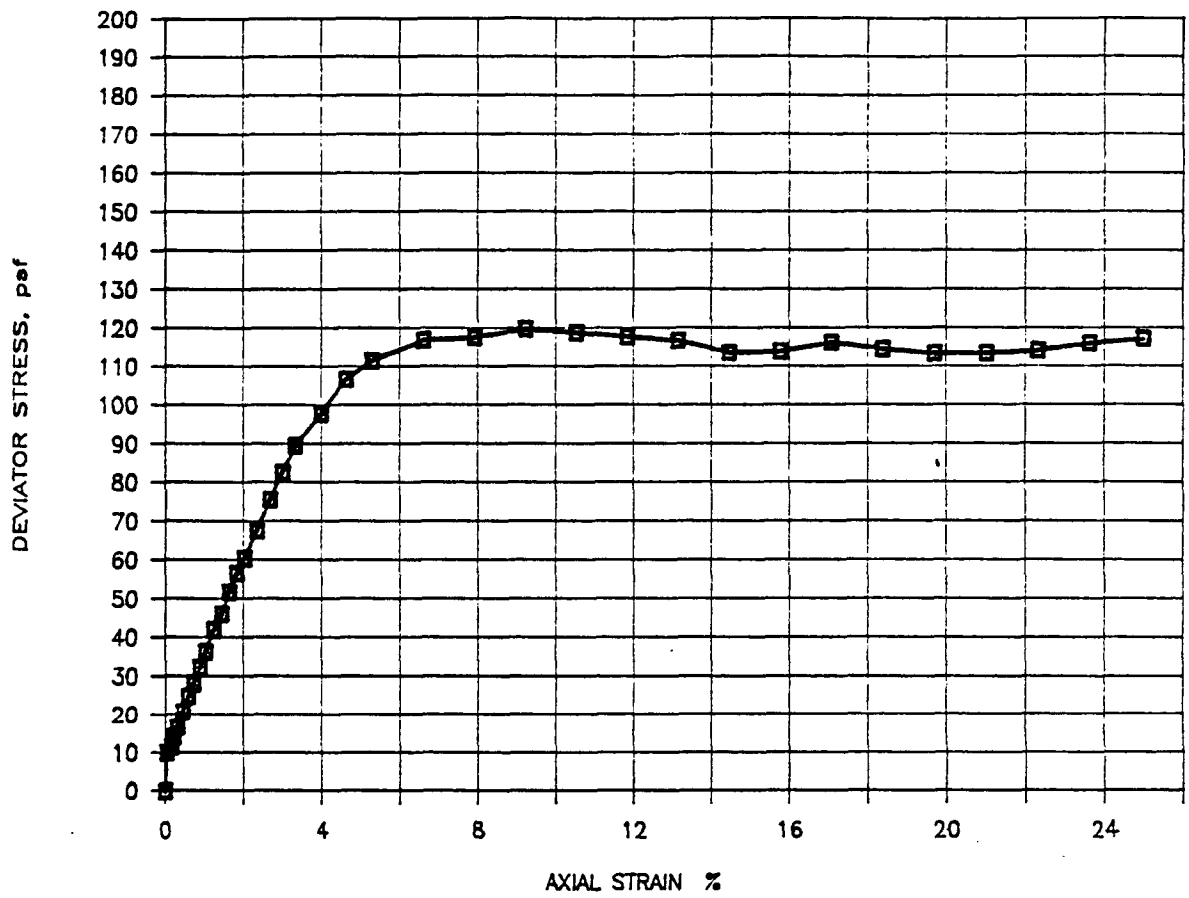
US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	COMPRESSION CURVE TEST C2
GEI Winchester,Massachuset	Project 87311	Nov. 13, 1987 1.C2



Notes:

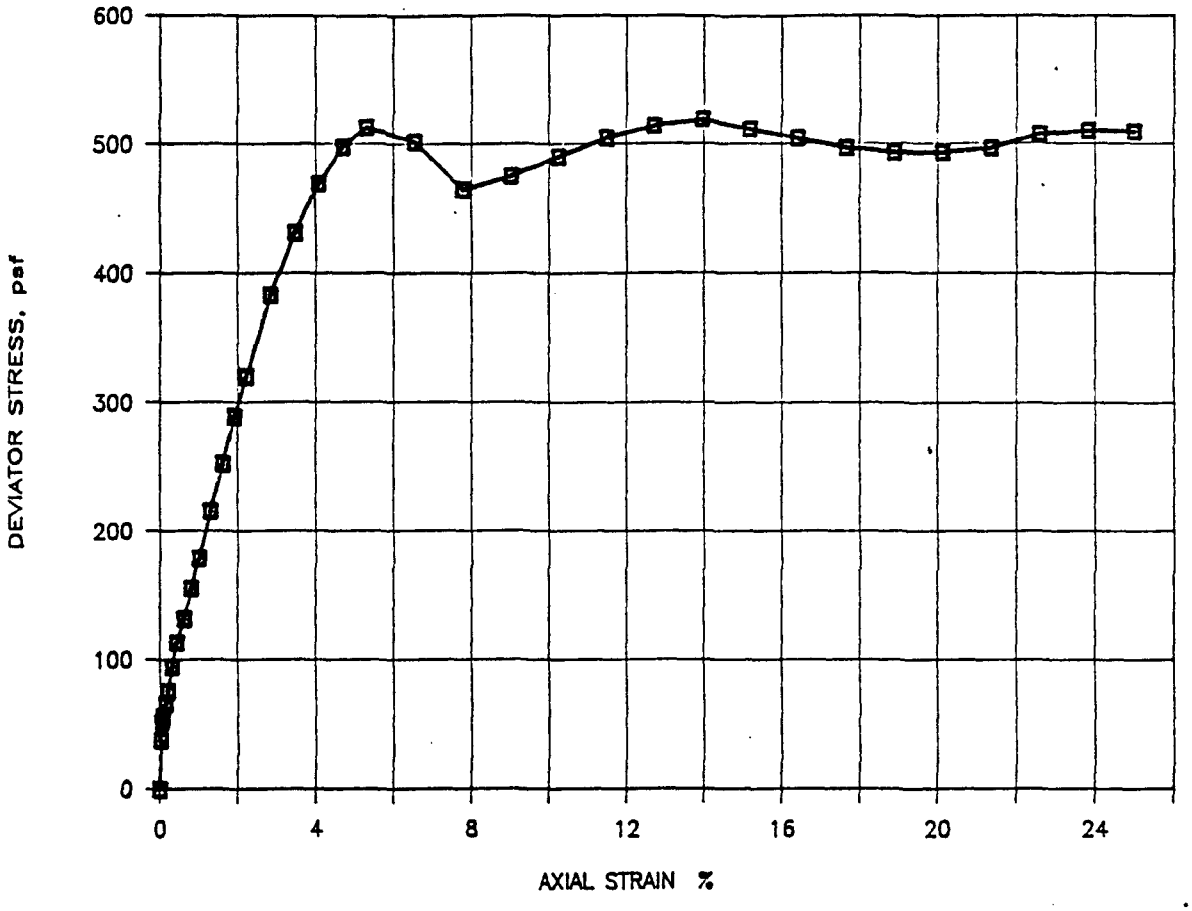
1) C_v based on t_{90} on square root of time consolidation curve.

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	COEFFICIENT OF CONSOLIDATION
GEI Winchester, Massachusetts	Project 87311	Nov. 13, 1987 Fig.C3



Soil:	Boring PD27 , Sample UO1 , Depth = 6.8 ft. Organic Clay.(OH) LL = 122 PI = 87
Structure:	Undisturbed 3 - inch dia. tube sample
State:	Cell Pressure = 410 psf Natural Moisture Content = 128 % Dry Unit Weight = 37.9 pcf
Loading:	Axial compression, unconsolidated, undrained. Strain rate = 0.50 %/min.
Nominal Size:	Height = 6.0 inches Diameter = 2.8 inches

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	UNCONSOLIDATED UNDRAINED TRIAXIAL TEST Q1
GEI Winchester,Massachusetts	Project 87311	Nov. 13, 1987 Fig.C4



Soil: Boring PD34 , Sample U5 , Depth = 16.6 ft.
Organic Clay.(OH)
LL = 103 PI = 67

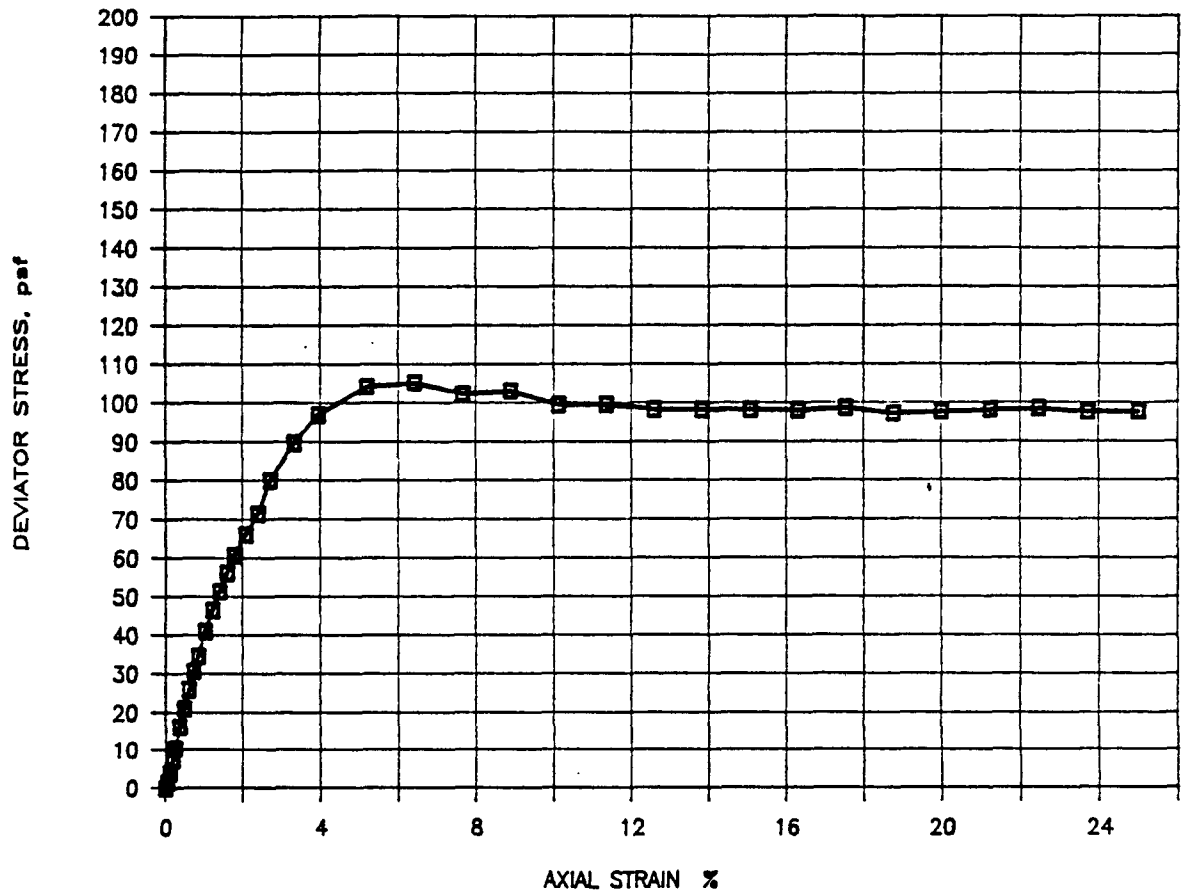
Structure: Undisturbed 3 - inch dia. tube sample

State: Cell Pressure = 410 psf
Natural Moisture Content = 86 %
Dry Unit Weight = 49.6 pcf

Loading: Axial compression, unconsolidated, undrained.
Strain rate = 0.50 %/min.

Nominal Size: Height = 6.4 inches
Diameter = 2.8 inches

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	UNCONSOLIDATED UNDRAINED TRIAXIAL TEST Q2
GEI Winchester,Massachusetts	Project 87311	Nov. 13, 1987 Fig.C5



Soil: Boring PD29 , Sample UO2 , Depth = 8.5 ft.
Organic Clay.(OH)
LL = 83 PI = 58

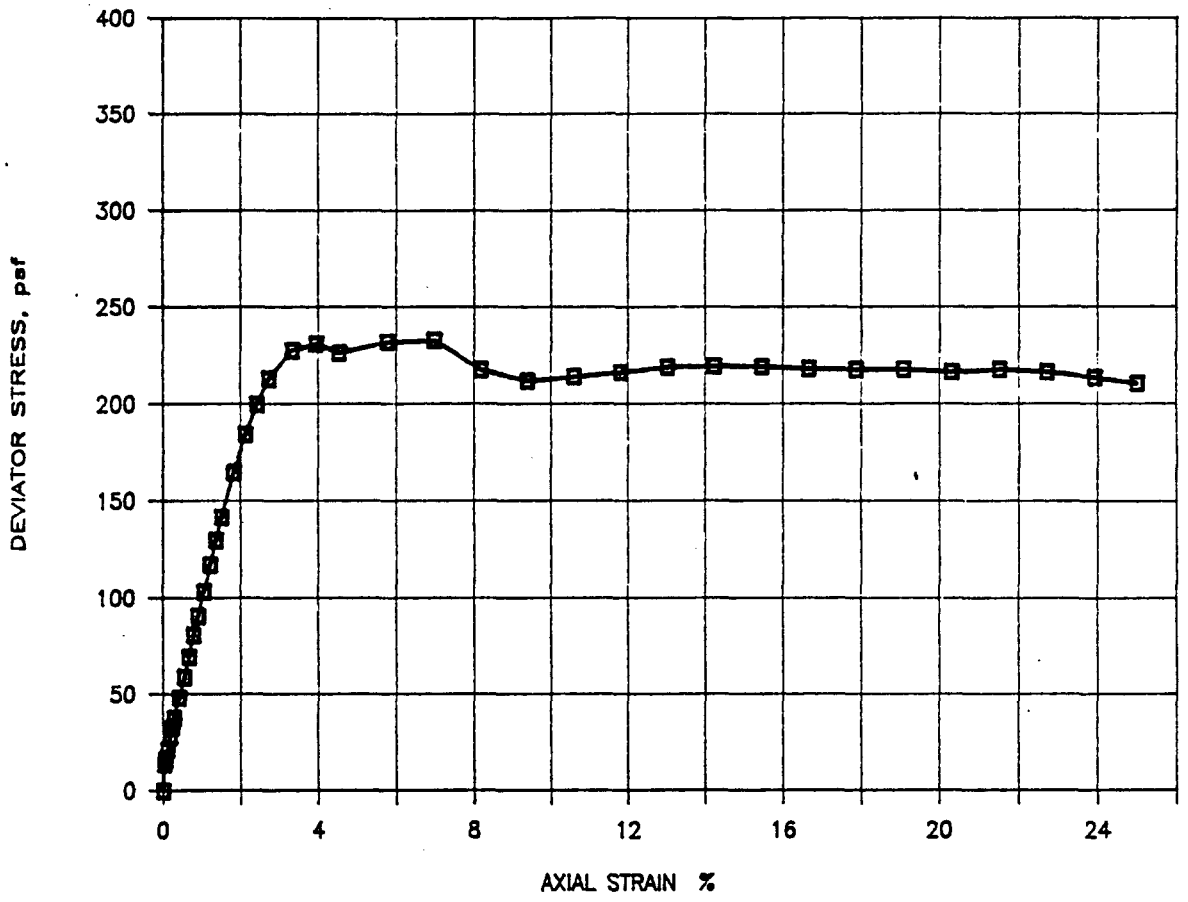
Structure: Undisturbed 3 - inch dia. tube sample

State: Cell Pressure = 410 psf
Natural Moisture Content = 92 %
Dry Unit Weight = 47.1 pcf

Loading: Axial compression, unconsolidated, undrained.
Strain rate = 0.50 %/min.

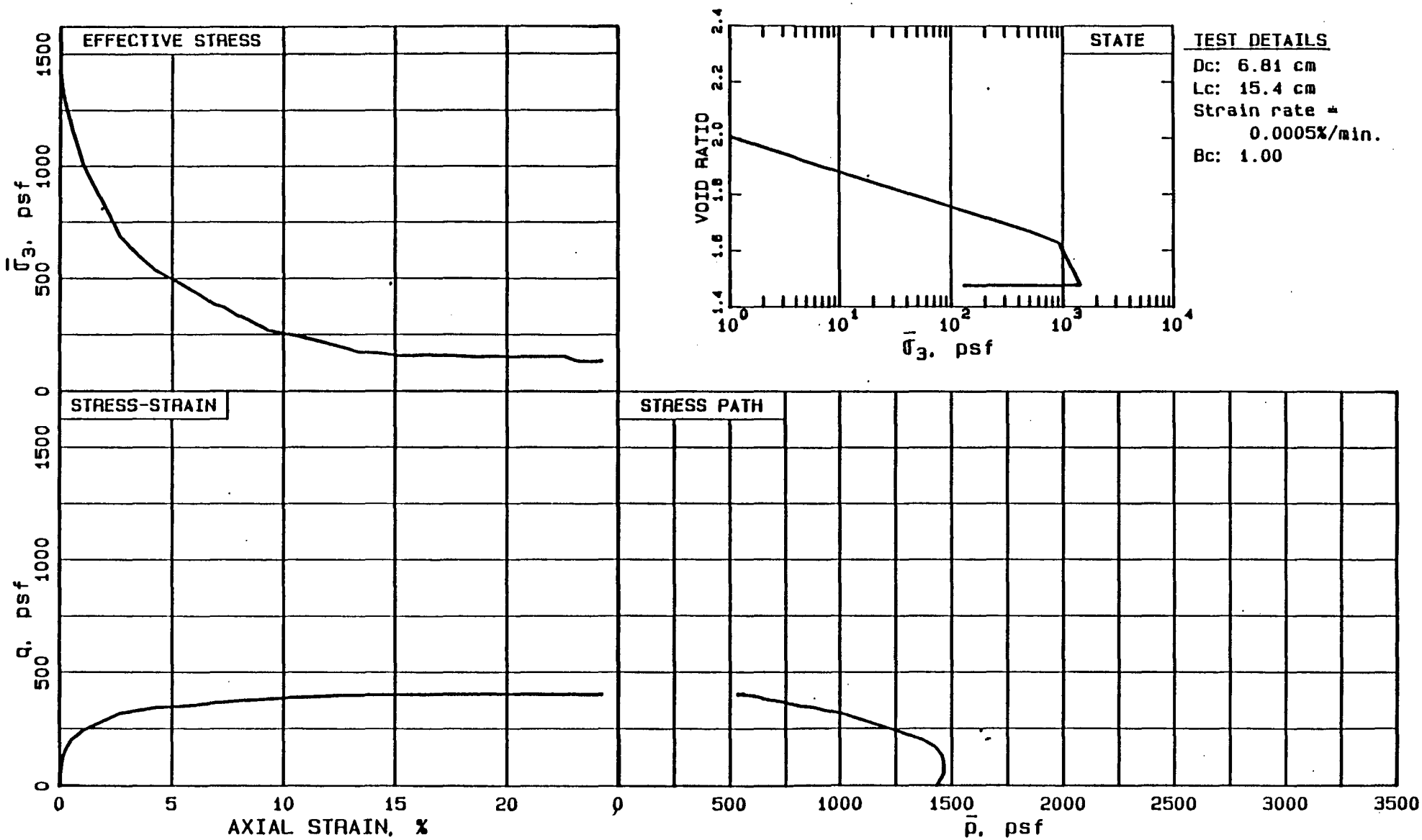
Nominal Size: Height = 6.4 inches
Diameter = 2.8 inches

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	UNCONSOLIDATED UNDRAINED TRIAXIAL TEST Q3
GEI Winchester,Massachusetts	Project 87311	Nov. 13, 1987 Fig.C6



Soil:	Boring PD27 , Sample UO2 , Depth = 9.5 ft. Organic Clay.(OH) LL = 104 PI = 71
Structure:	Undisturbed 3 - inch dia. tube sample
State:	Cell Pressure = 410 psf Natural Moisture Content = 103 % Dry Unit Weight = 44.3 pcf
Loading:	Axial compression, unconsolidated, undrained. Strain rate = 0.50 %/min.
Nominal Size:	Height = 6.5 inches Diameter = 2.8 inches

US Army Corps of Engineers - NED	Exploration Program New Bedford Superfund Site	UNCONSOLIDATED UNDRAINED TRIAXIAL TEST Q4
GEI Winchester,Massachusetts	Project 87311	Nov. 13, 1987 Fig.C7



TEST DETAILS

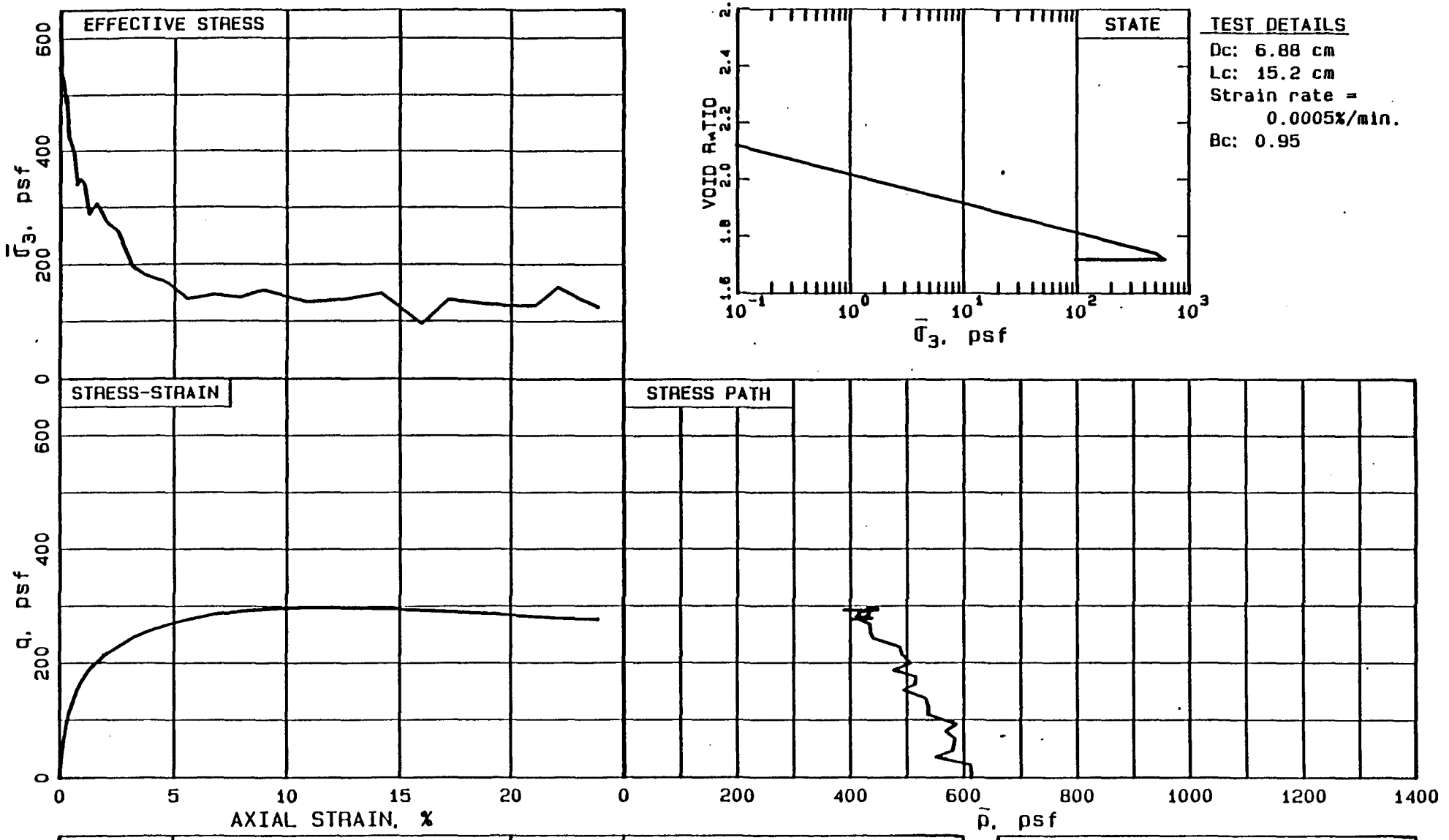
Dc: 6.81 cm
Lc: 15.4 cm
Strain rate = 0.0005%/min.
Bc: 1.00

SOIL	Boring PD-34, Sample U3/C Brown Organic Clay (OH)	STATE	$\bar{\sigma}_{3c}$ = 1434 psf e_c = 1.476 K_c = 1.00 γ_{dc} = 65.5 pcf
STRUCTURE	Undisturbed fixed-piston [illegible] sample.	LOADING	Undrained, monot[illegible]ic, axial compression

$\bar{R}$-1
NEW BEDFORD SUPERFUND SITE
PROJECT 87311 Nov. 13, 1987

GEOTECHNICAL ENGINEERS INC.
WINCHESTER - MASSACH[illegible]

Fig. C8



TEST DETAILS

Dc: 6.88 cm
Lc: 15.2 cm
Strain rate = 0.0005%/min.
Bc: 0.95

SOIL	Boring PD-29, Sample U02/C Brown Organic Clay (OH)	STATE	$\bar{\sigma}_{3c}$ = 614 psf e_c = 1.718 K_c = 1.00 γ_{dc} = 59.7 pcf
STRUCTURE	Undisturbed Osterberg tube sample.	LOADING	Undrained, monotonic, axial compression

$\bar{R}$-2
NEW BEDFORD SUPERFUND SITE
PROJECT 87311 Nov. 13, 1987

GEOTECHNICAL ENGINEERS INC.
WINCHESTER - MASSACHUSETTS

Fig. C9

APPENDIX 6-C

High-Strength Geotextile Laboratory Test Data

STS Consultants Ltd.

21 September 1988

STS Consultants Ltd.
Consulting Engineers
111 Pfingsten Road
Northbrook, Illinois 60062
(312) 272-6520

September 21, 1988

Mr. Gary Willibey
Nicolon Corp.
3150 Holcomb Bridge Road
Suite 300
Norcross, GA 30071

RE: Seam Strength Testing for the Confined Disposal Facility, New Bedford, MA -- STS Project No. 23769-AA

Dear Mr. Willibey:

Enclosed are results of seam strength tests performed on a white woven geotextile sample received from R. Zoppo Co., Inc. This fabric is from the Confined Disposal Facility (Contract No. DACW 33-88-C-0004) EPA Superfund Site at New Bedford, MA.

Wide width seam tensile strength tests were performed in general accordance with ASTM Standard D-4595. All specimens measured 8 in. wide with a 4 in. gage length, and were tested at a rate of 0.4 in./min. At the present time, we are unable to test the wide width strength of this fabric due to damage to our high strength tensile clamps.

If you have any questions regarding the data, or our test procedures, please do not hesitate to contact us.

Respectfully,

STS CONSULTANTS, LTD.

Wiley D. Bell

Wiley D. Bell, P.E.
Project Engineer

Andrew E. Haubert, P.E.
Principal Engineer

WDB/lm

encl.

STS Consultants Ltd.

Seam Tensile Strength Test

(ASTM D-4595)

STS Job No.: 23769-AA
Project: Nicolon
Geotextile: White woven
Specimen: Sample 1
7/15/88

SUMMARY OF TEST RESULTS

Seam Type	Specimen	Peak Load (lbs/in)
Butterfly	1	728
	2	750
	Ave.	739

Fabric failed in all samples

3 rows of stitching
6 stitches per inch
fabric in cross direction

STS Consultants Ltd.

Seam Tensile Strength Test

(ASTM D-4595)

STS Job No.: 23769-AA
Project: Nicolon
Geotextile: White wover
Specimen: Sample 2
9/14/88

SUMMARY OF TEST RESULTS

Seam Type	Specimen	Peak Load (lbs/in)
Butterfly	1	615
	2	725
	3	770
	Ave.	703

Fabric failed in all samples

2 rows of stitching
6 stitches per inch
fabric in cross direction

STS Consultants Ltd.

Seam Tensile Strength Test

(ASTM D-4595)

STS Job No.: 23769-AA
Project: Nicolon
Geotextile: White woven
Specimen: Sample 3
9/14/88

SUMMARY OF TEST RESULTS

Seam Type	Specimen	Peak Load (lbs/in)
Butterfly	1	712
	2	694
	3	656
	Ave.	687

Fabric failed in all samples

2 rows of stitching
6 stitches per inch
fabric in cross direction

Geosyntec, Inc.

20 October 1988

STANDARD USED IN TESTING

Wide Strip Tensile Strength - ASTM D4595, "Tensile Properties of Geotextiles by the Wide-Width Strip Method."

********** GEOSYNTEC, INC. TESTING RESULTS **********

GEOSYNTHETIC CONFORMANCE TESTING
USAE NEW BEDFORD HARBOR PROJECT

CLIENT:	NICOLON CORPORATION	MATERIAL TESTED:	WOVEN GEOTEXTILE	GEOSYNTEC JOB NUMBER:	G88-390
CONTACT:	MR. GARY WILLIBEY	CLIENT PANEL NUMBER:	#1	GEOSYNTEC SAMPLE NUMBER:	161
TELEPHONE:	404-447-6272	DATE RECEIVED:	22 SEPTEMBER 1988	DATE TESTED:	28 SEPTEMBER 1988

SUMMARY RESULTS

PROPERTY	UNITS	MEAN	STANDARD DEVIATION
5% SECANT MODULUS	lb/in.	30181.667	333.796
WIDE STRIP TENSILE STRENGTH	lb/in.	3994.667	144.163
STRAIN AT FAILURE	%	11.500	0.216

INDIVIDUAL SPECIMEN RESULTS

1	2	3	4	5	6	7	8	9	10
30545.000	30261.000	29739.000							
4159.000	4017.000	3808.000							
11.600	11.200	11.700							

COMMENTS:

RHS:07:G88-390A:ael

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********** GEOSYNTEC, INC. TESTING RESULTS **********

GEOSYNTHETIC CONFORMANCE TESTING
USAE NEW BEDFORD HARBOR PROJECT

CLIENT:	NICOLON CORPORATION	MATERIAL TESTED:	WOVEN GEOTEXTILE	GEOSYNTEC JOB NUMBER:	G88-390
CONTACT:	MR. GARY WILLIBEY	CLIENT PANEL NUMBER:	#3B	GEOSYNTEC SAMPLE NUMBER:	162
TELEPHONE:	404-447-6272	DATE RECEIVED:	22 SEPTEMBER 1988	DATE TESTED:	28 SEPTEMBER 1988

SUMMARY RESULTS

PROPERTY	UNITS	MEAN	STANDARD DEVIATION
5% SECANT MODULUS	lb/in.	29361.667	865.297
WIDE STRIP TENSILE STRENGTH	lb/in.	4008.667	19.754
STRAIN AT FAILURE	%	11.867	0.419

INDIVIDUAL SPECIMEN RESULTS

	1	2	3	4	5	6	7	8	9	10
5% SECANT MODULUS	30545.000	29040.000	28500.000							
WIDE STRIP TENSILE STRENGTH	4036.000	3990.000	4000.000							
STRAIN AT FAILURE	12.300	11.300	12.000							

COMMENTS:

RHS:07:G88-390B:mel

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********** GEOSYNTEC, INC. TESTING RESULTS **********

GEOSYNTHETIC CONFORMANCE TESTING
USAE NEW BEDFORD HARBOR PROJECT

CLIENT:	NICOLON CORPORATION	MATERIAL TESTED:	WOVEN GEOTEXTILE	GEOSYNTEC JOB NUMBER:	G88-390
CONTACT:	MR. GARY WILLIBEY	CLIENT PANEL NUMBER:	03C	GEOSYNTEC SAMPLE NUMBER:	163
TELEPHONE:	404-447-6272	DATE RECEIVED:	22 SEPTEMBER 1988	DATE TESTED:	28 SEPTEMBER 1988

SUMMARY RESULTS

PROPERTY	UNITS	MEAN	STANDARD DEVIATION
5% SECANT MODULUS	lb/in.	33904.667	1298.665
WIDE STRIP TENSILE STRENGTH	lb/in.	3663.333	206.711
STRAIN AT FAILURE	%	9.983	0.646

INDIVIDUAL SPECIMEN RESULTS

1	2	3	4	5	6	7	8	9	10
33273.000	35714.000	32727.000							
3491.000	3954.000	3545.000							
9.300	9.800	10.850							

COMMENTS:

RHS:07:G88-390C:mel

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Geosyntec, Inc.

23 November 1988

STANDARD USED IN TESTING

Wide Strip Tensile Strength - ASTM D4595, "Tensile Properties of Geotextiles by the Wide-Width Strip Method."

********** GEOSYNTEC, INC. TESTING RESULTS **********

GEOSYNTHETIC CONFORMANCE TESTING
USAE NEW BEDFORD HARBOR PROJECT

CLIENT:	NICOLON CORPORATION	MATERIAL TESTED:	WOVEN GEOTEXTILE	GEOSYNTEC JOB NUMBER:	G88-390
CONTACT:	MR. GARY WILLIBEY	CLIENT PANEL NUMBER:		GEOSYNTEC SAMPLE NUMBER:	772
TELEPHONE:	404-447-6272	DATE RECEIVED:	14 NOVEMBER 1988	DATE TESTED:	17 NOVEMBER 1988

SUMMARY RESULTS

PROPERTY	UNITS	MEAN	STANDARD DEVIATION
5% SECANT MODULUS	lb/in.	35580.333	968.299
WIDE STRIP TENSILE STRENGTH	lb/in.	4871.333	102.558
STRAIN AT FAILURE	%	14.742	0.927

INDIVIDUAL SPECIMEN RESULTS

1	2	3	4	5	6	7	8	9	10
35852.000	35072.000	34636.000	37434.000	34636.000	35852.000				
4692.000	4924.000	4996.000	4798.000	4862.000	4956.000				
14.000	16.150	15.800	13.700	14.700	14.100				

COMMENTS:

RMS:00:G88-390:psa

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University of Deleware

8 December 1988

December 8, 1988

Gary Willibey
Engineering Manager
Construction Products Division
Nicolon Corporation
3500 Parkway Lane, Suite 500
Norcross, GA 30092

Dear Gary,

Tensile tests in the warp direction were conducted on six geotextile specimens provided by NICOLON Corp. The tested geotextile is of the same type used by the Corps of Engineers/New England District in the New Bedford, MA Project. The tests were performed on 11/30/88 essentially following ASTM D 4595-86 recommended procedure with these modifications: (1) Roller grips were used; (2) Strain was measured using strain gage; (3) Rate of grip movement was 0.4 inch/min; and (4) Specimen's aspect ratio of about one was used.

The following table is a summary of test results:

Specimen #	Width [in.]	Length [in.]	Aspect Ratio	Tensile Force at 5% Strain [lb/in]	Ultimate Tensile Strength [lb/in]
N1	7.75	8.5	0.9	1936	4800
N2	7.75	7.0	1.1	1900	4957
N3	7.75	7.0	1.1	1997	4929
N4	7.75	7.5	1.0	1780	4881
N5	7.25	7.0	1.0	2004	4767
N6	7.25	7.0	1.0	2235	4821

The average ultimate tensile strength was 4860 lb/in.

The average tensile force at 5% strain was 1975 lb/in.

All specimens failed at strains greater than 10%.

The attached six figures show the full load-elongation curve measured in each test. The seventh attached figure superimposes all six measured curves.

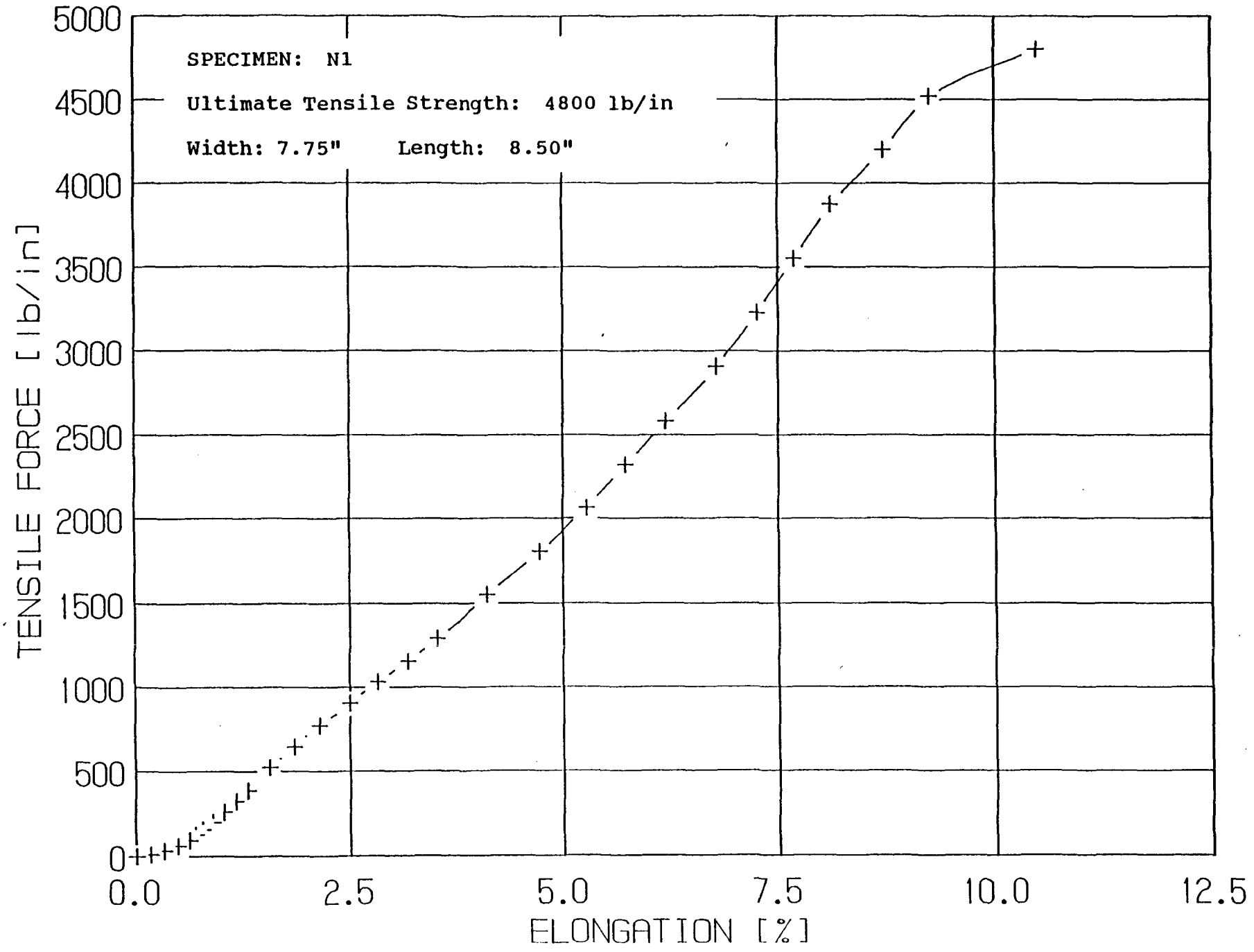
If more information is needed, please let me know.

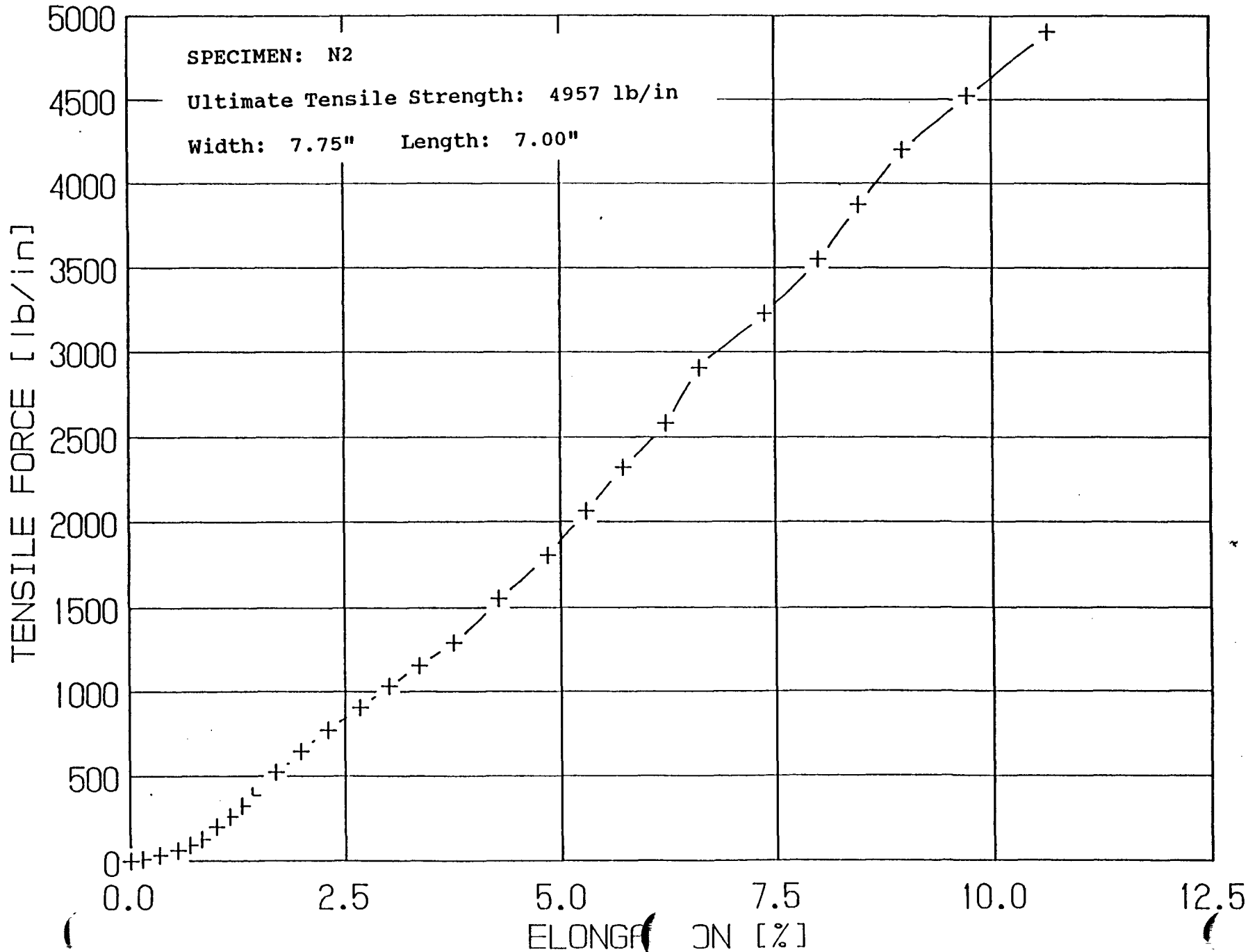
Sincerely,

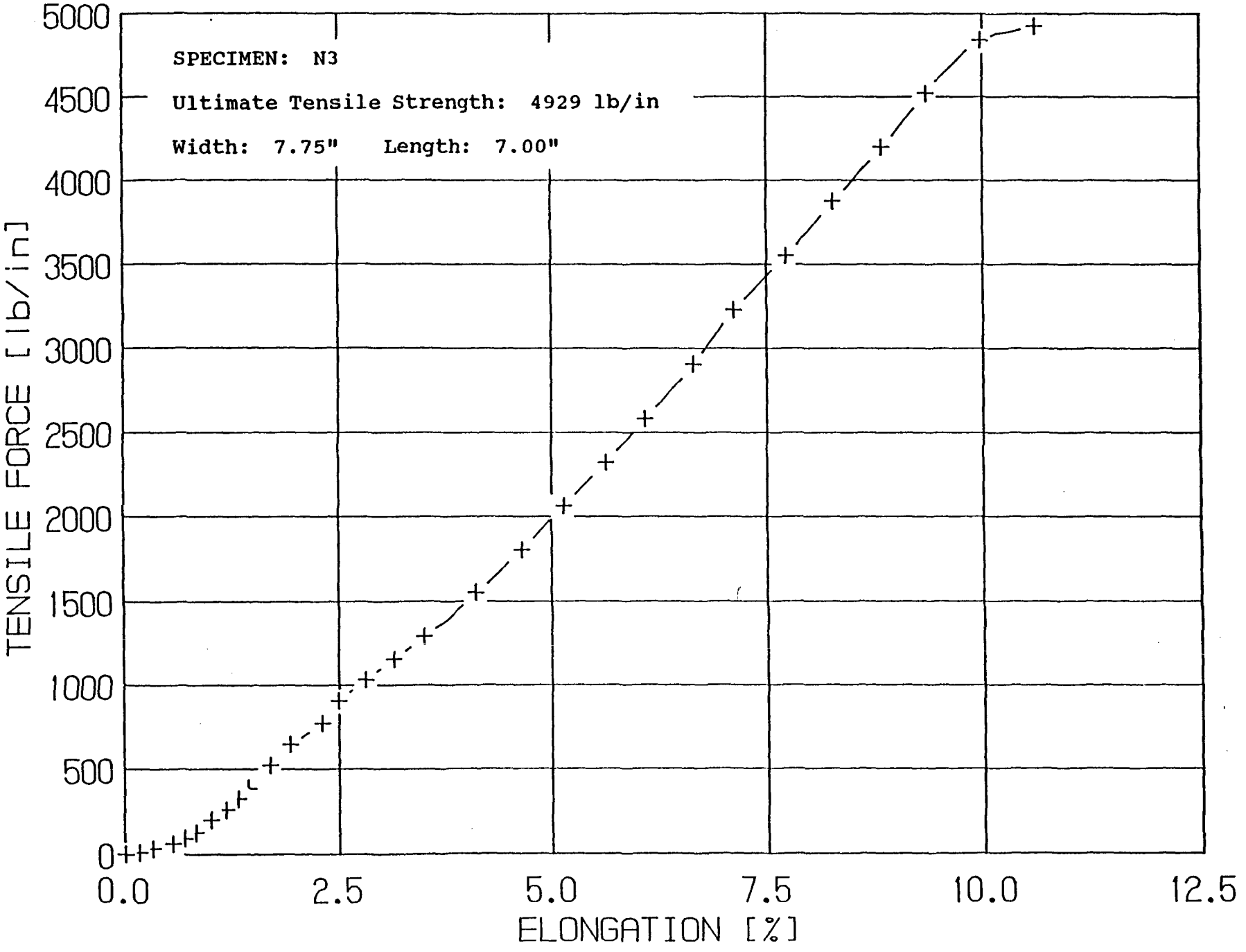
Dov Leshchinsky

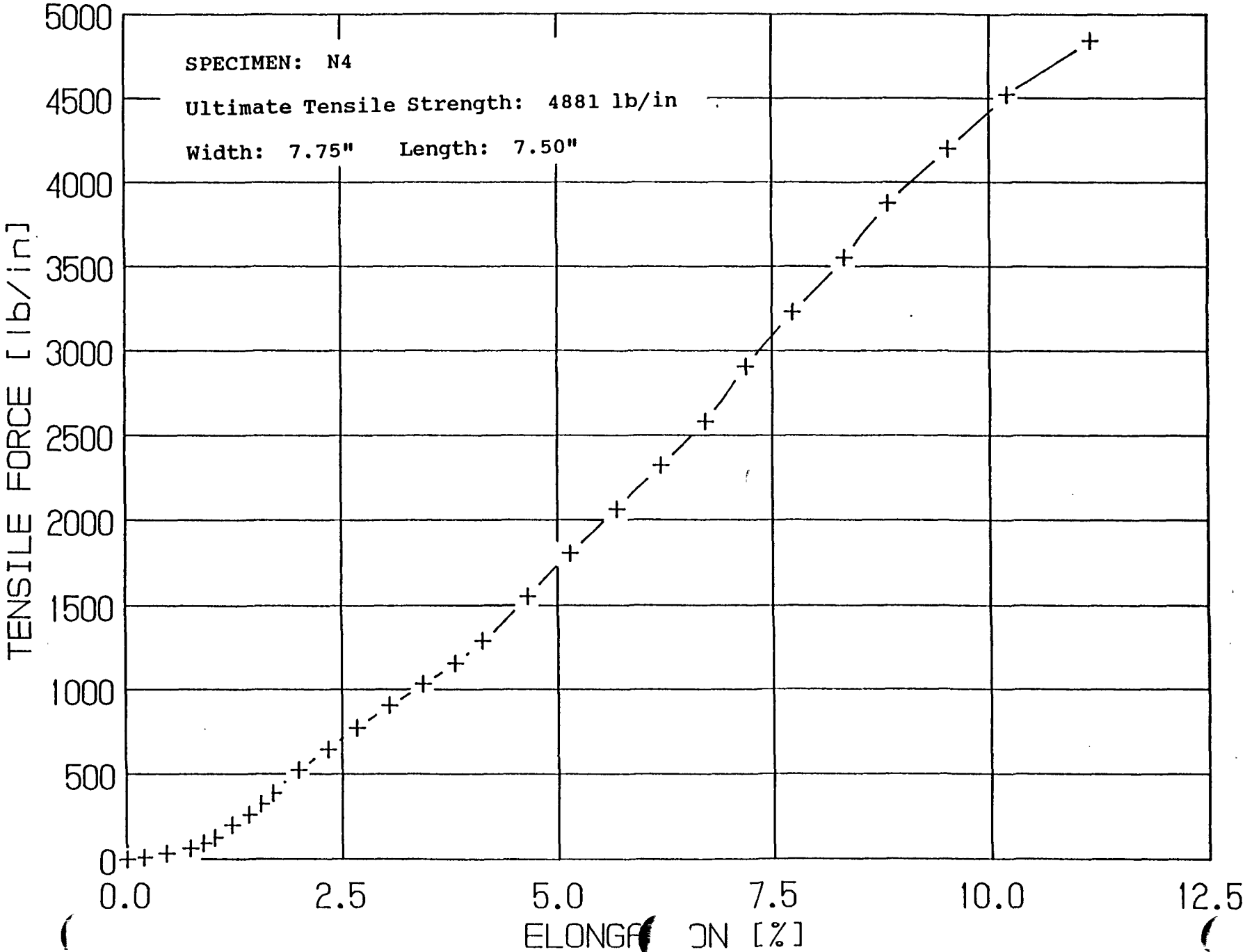
Dov Leshchinsky, Ph.D.
Associate Professor
Dept. of Civil Engineering
University of Delaware
Newark, DE 19716

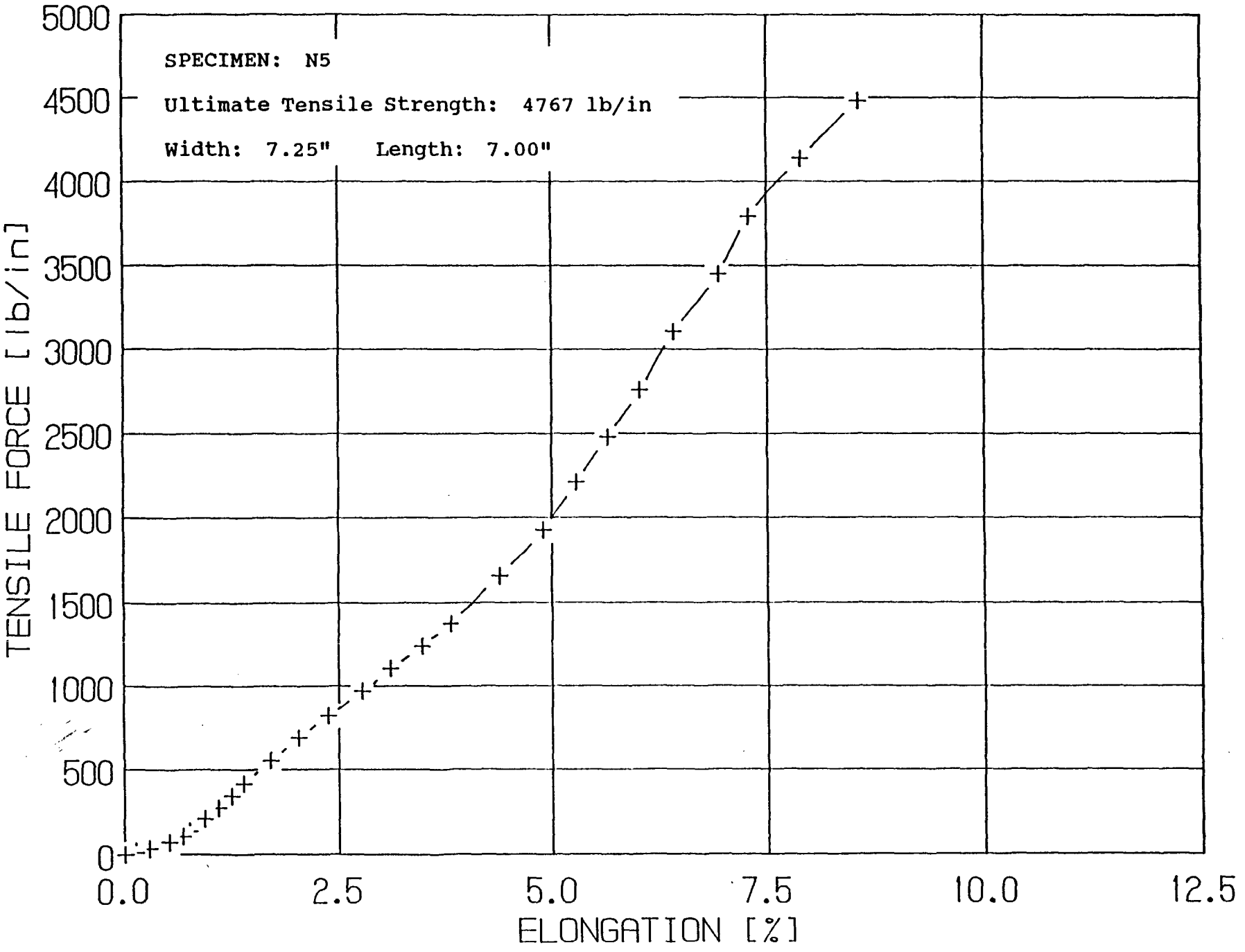
DL/rk
Enclosures

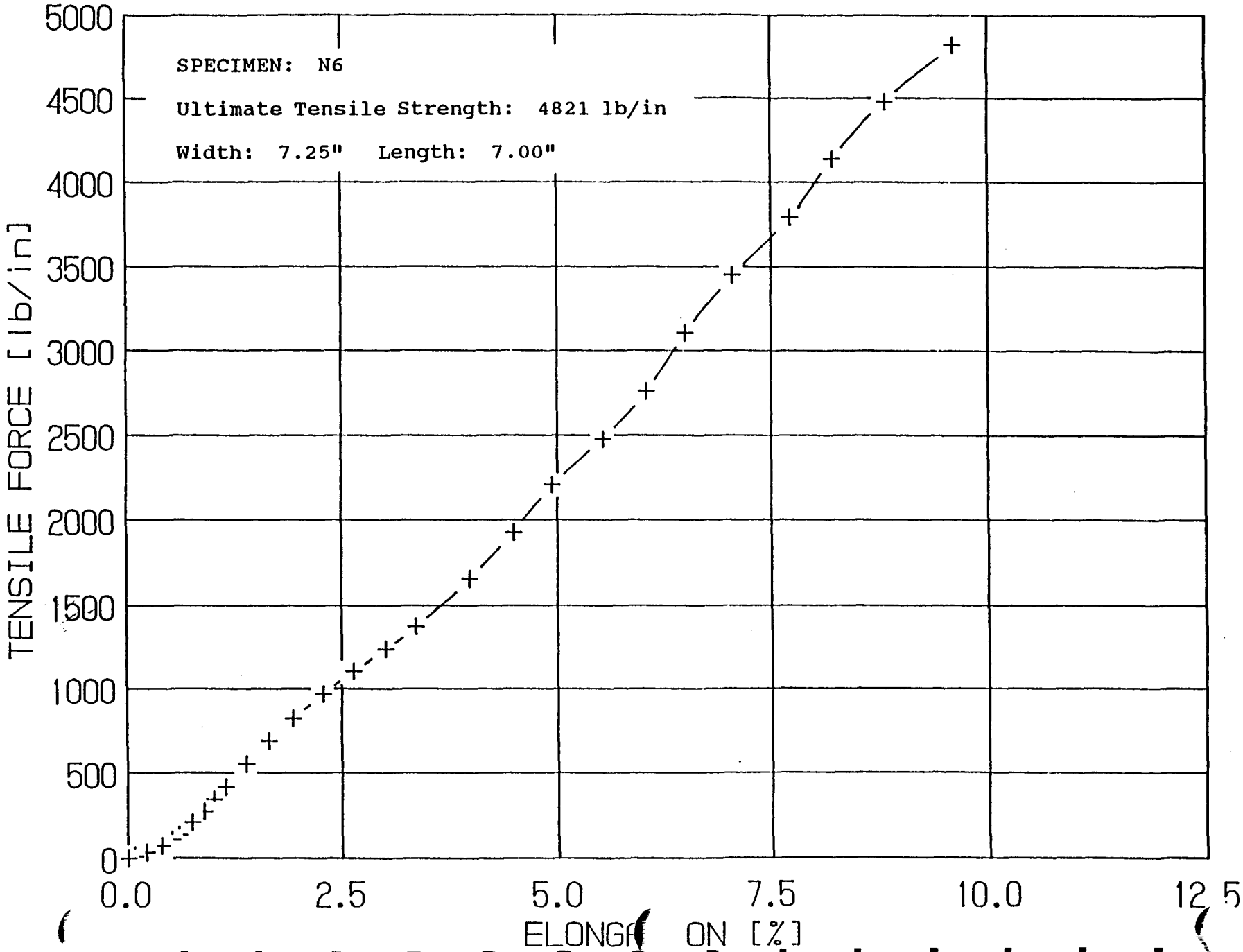

SPECIMEN: N1
Ultimate Tensile Strength: 4800 lb/in
Width: 7.75" Length: 8.50"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]

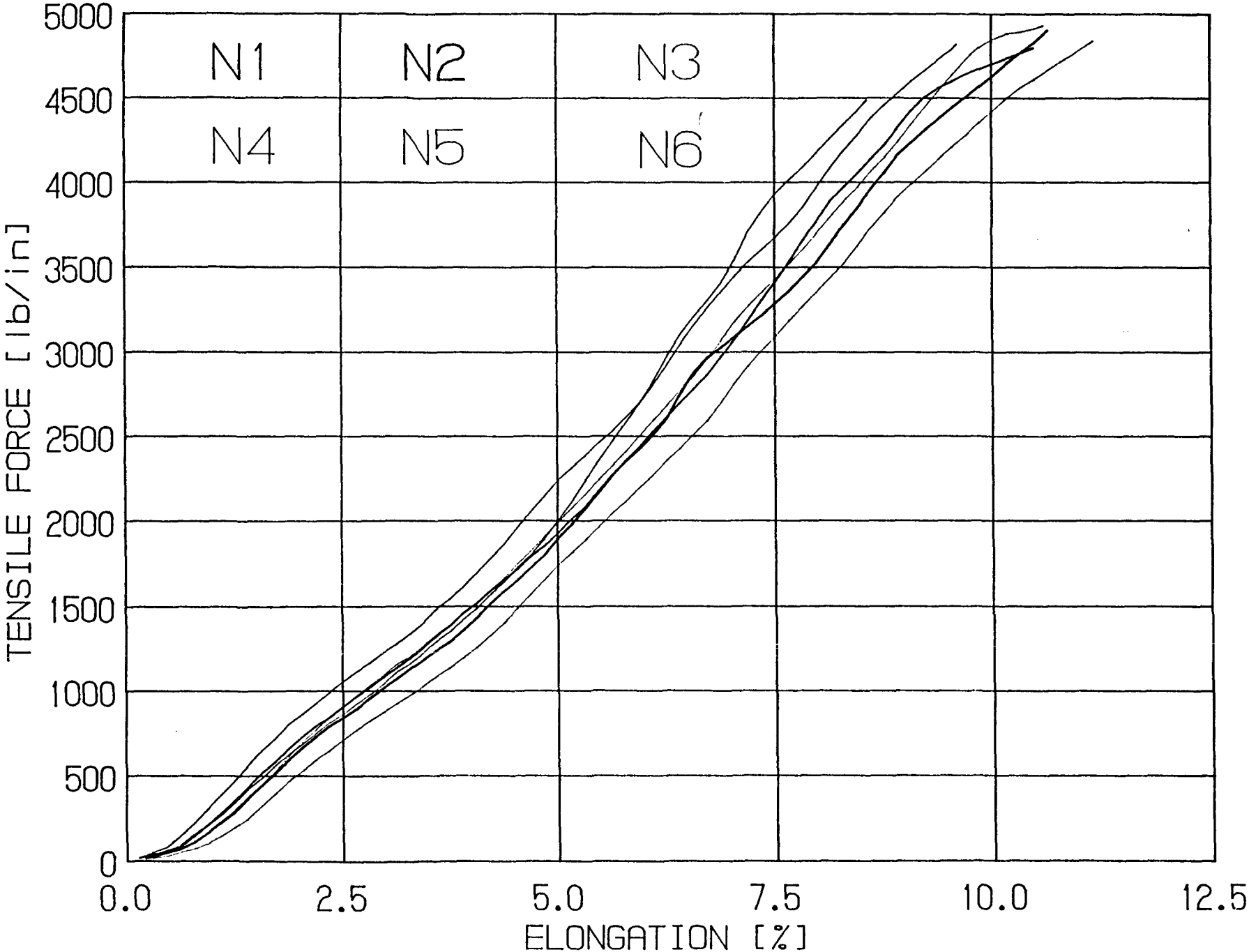

SPECIMEN: N2
Ultimate Tensile Strength: 4957 lb/in
Width: 7.75" Length: 7.00"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]


SPECIMEN: N3
Ultimate Tensile Strength: 4929 lb/in
Width: 7.75" Length: 7.00"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]


SPECIMEN: N4
Ultimate Tensile Strength: 4881 lb/in
Width: 7.75" Length: 7.50"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]


SPECIMEN: N5
Ultimate Tensile Strength: 4767 lb/in
Width: 7.25" Length: 7.00"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]


SPECIMEN: N6
Ultimate Tensile Strength: 4821 lb/in
Width: 7.25" Length: 7.00"
TENSILE FORCE [lb/in]
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]


N1
N2
N3
N4
N5
N6
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
TENSILE FORCE [lb/in]
0.0
2.5
5.0
7.5
10.0
12.5
ELONGATION [%]

Geosyntec, Inc.

23 December 1988

STANDARD USED IN TESTING

GEOTEXTILE

Wide Strip Tensile Strength - ASTM D4595, "Tensile Properties of Geotextiles by the Wide-Width Strip Method."

CLIENT: Nicolon Corporation
TYPE OF TESTING: Chemical Compatibility
MATERIAL TESTED: Woven Polyester Geotextile

SUMMARY RESULTS

MECHANICAL PROPERTIES WARP DIRECTION		IMMERSION PERIOD								
		30 day			60 day			120 day		
PROPERTY	UNIT	Value	Control Sample Value	% Change	Value	Control Sample Value	% Change	Value	Control Sample Value	% Change
SECANT MODULUS AT 5% STRAIN AT 23 DEG C	lb/in.	31657.667	37824.667	-16.304	36871.000	37824.667	-2.521	33975.000	37824.667	-10.17
ULTIMATE TENSILE TENSION AT 23 DEG C	lb/in.	3762.667	4652.000	-19.117	3955.667	4652.000	-14.968	3948.667	4652.000	-15.11
STRAIN AT FAILURE AT 23 DEG C	%	10.450	14.833	-29.551	9.483	14.833	-36.067	10.167	14.833	-31.461

NOTES: Control Sample = Sample tested prior to immersion.

LGT:44:352-001C:mel

CLIENT: Nicolon [illegible]ation
TYPE OF TESTING: Chemical Compatibility
MATERIAL TESTED: Woven Polyester Geotextile

INDIVIDUAL SPECIMEN RESULTS

MECHANICAL PROPERTIES WARP DIRECTION		IMMERSION PERIOD											
PROPERTY	UNIT	CONTROL SAMPLE							30 DAY SAMPLE						
		Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5	Mean	Standard Deviation	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5	Mean	Standard Deviation
SECANT MODULUS AT 5% STRAIN AT 23 DEG C	lb/in.	35000.000	36735.000	41739.000			37824.667	2857.045	31304.000	32348.000	31321.000			31657.667	488.189
ULTIMATE TENSILE TENSION AT 23 DEG C	lb/in.	4825.000	4592.000	4539.000			4652.000	124.228	3952.000	3626.000	3710.000			3762.667	138.201
STRAIN AT FAILURE AT 23 DEG C	%	15.600	14.700	14.200			14.833	0.579	11.750	9.400	10.200			10.450	0.976

NOTES: Control Sample = Sample tested prior to immersion.

LGT:44:352-001A:mel

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MECHANICAL PROPERTIES WARP DIRECTION		IMMERSION PERIOD											
PROPERTY	UNIT	60 DAY SAMPLE							120 DAY SAMPLE						
		Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5	Mean	Standard Deviation	Spec. 1	Spec. 2	Spec. 3	Spec. 4	Spec. 5	Mean	Standard Deviation
SECANT MODULUS AT 5% STRAIN AT 23 DEG C	lb/in.	36225.000	39388.000	35000.000			36871.000	1848.715	33272.000	32653.000	36000.000			33975.000	1454.019
ULTIMATE TENSILE TENSION AT 23 DEG C	lb/in.	4133.000	4209.000	3525.000			3955.667	306.104	3927.000	3928.000	3991.000			3948.667	29.937
STRAIN AT FAILURE AT 23 DEG C	%	10.000	9.350	9.100			9.483	0.379	9.900	9.900	10.700			10.167	0.377

NOTES: Control Sample = Sample tested prior to immersion.

LGT:44:352-001B:mel

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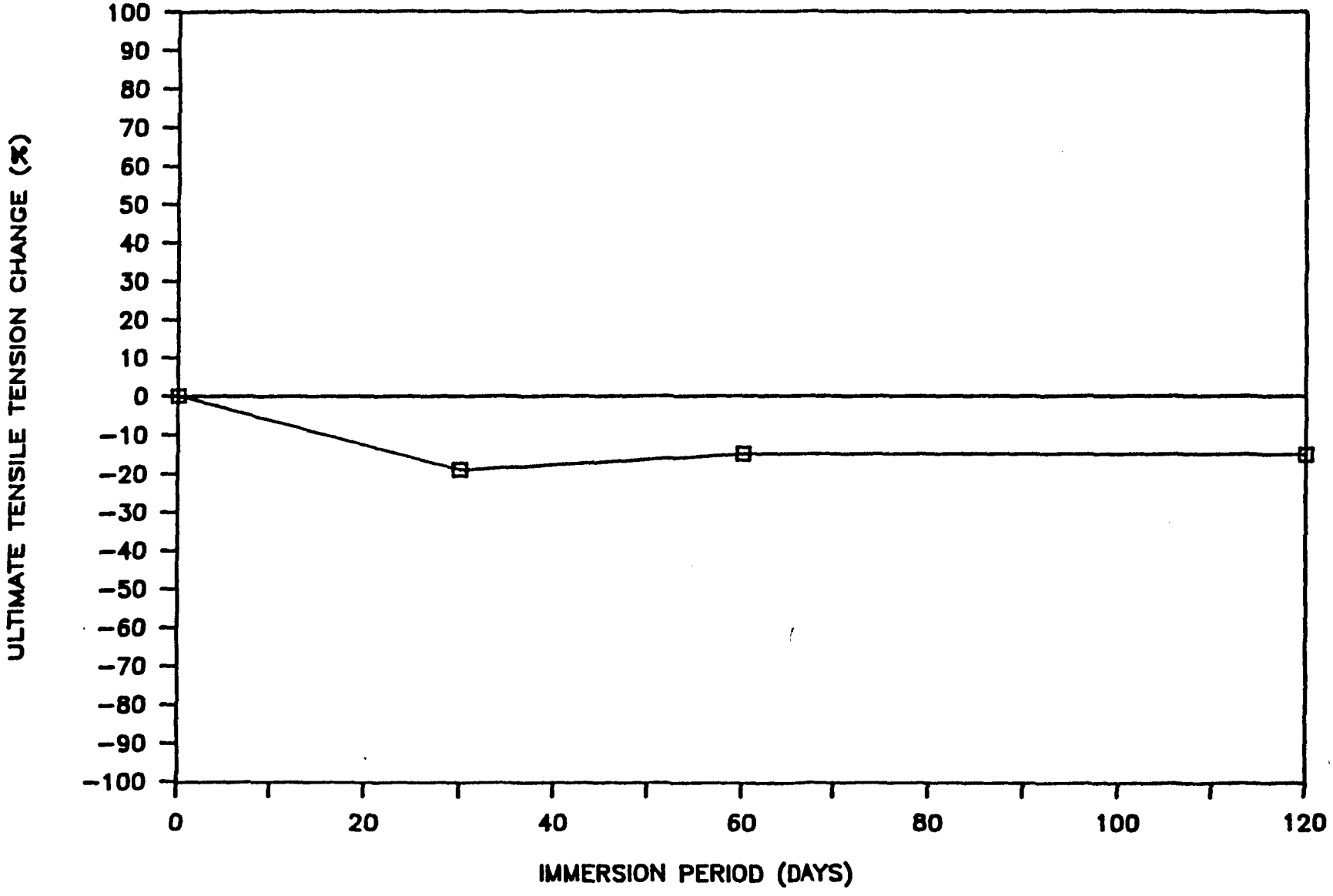
ULTIMATE TENSILE TENSION

WOVEN POLYESTER GEOTEXTILE



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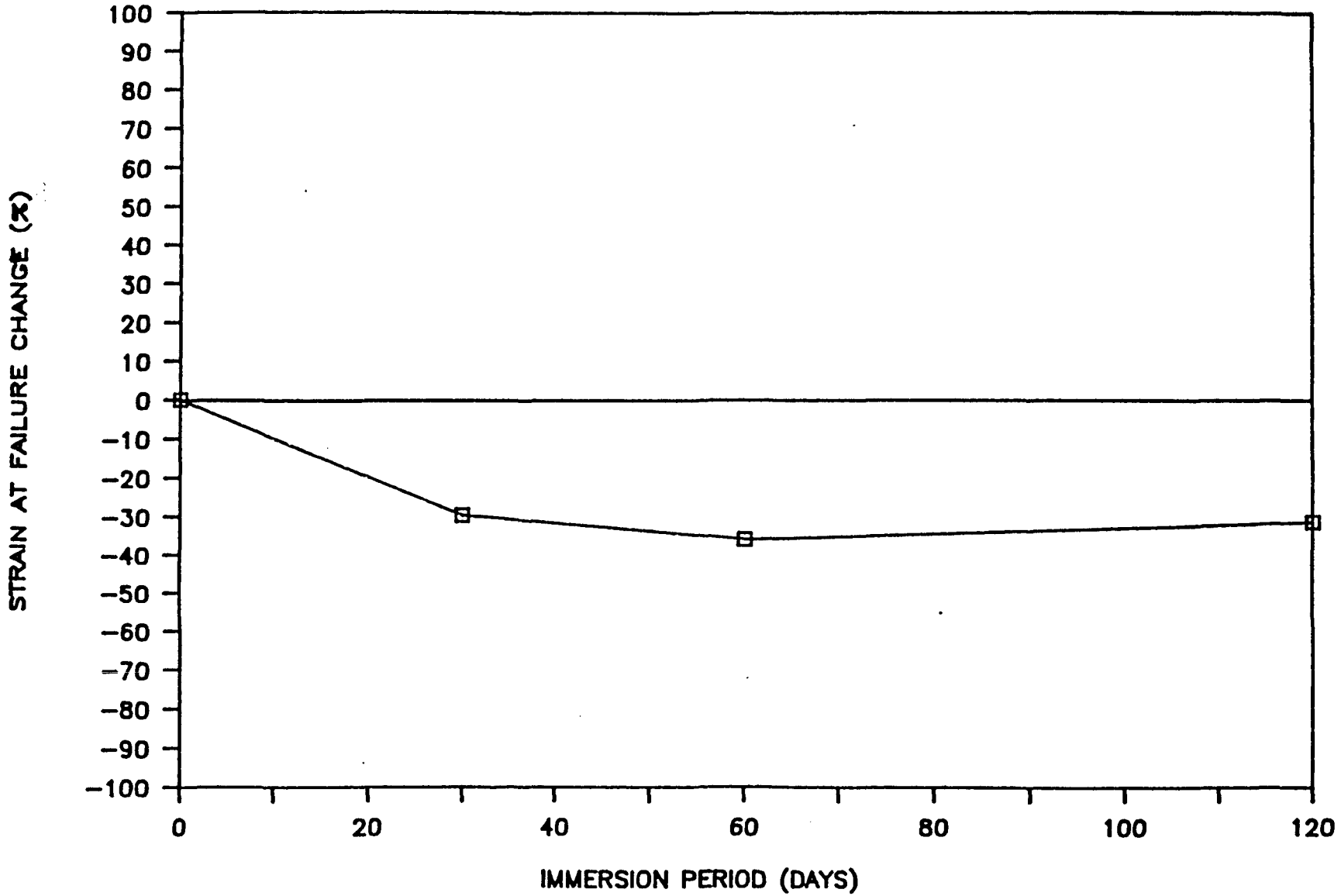
STRAIN AT FAILURE

WOVEN POLYESTER GEOTEXTILE



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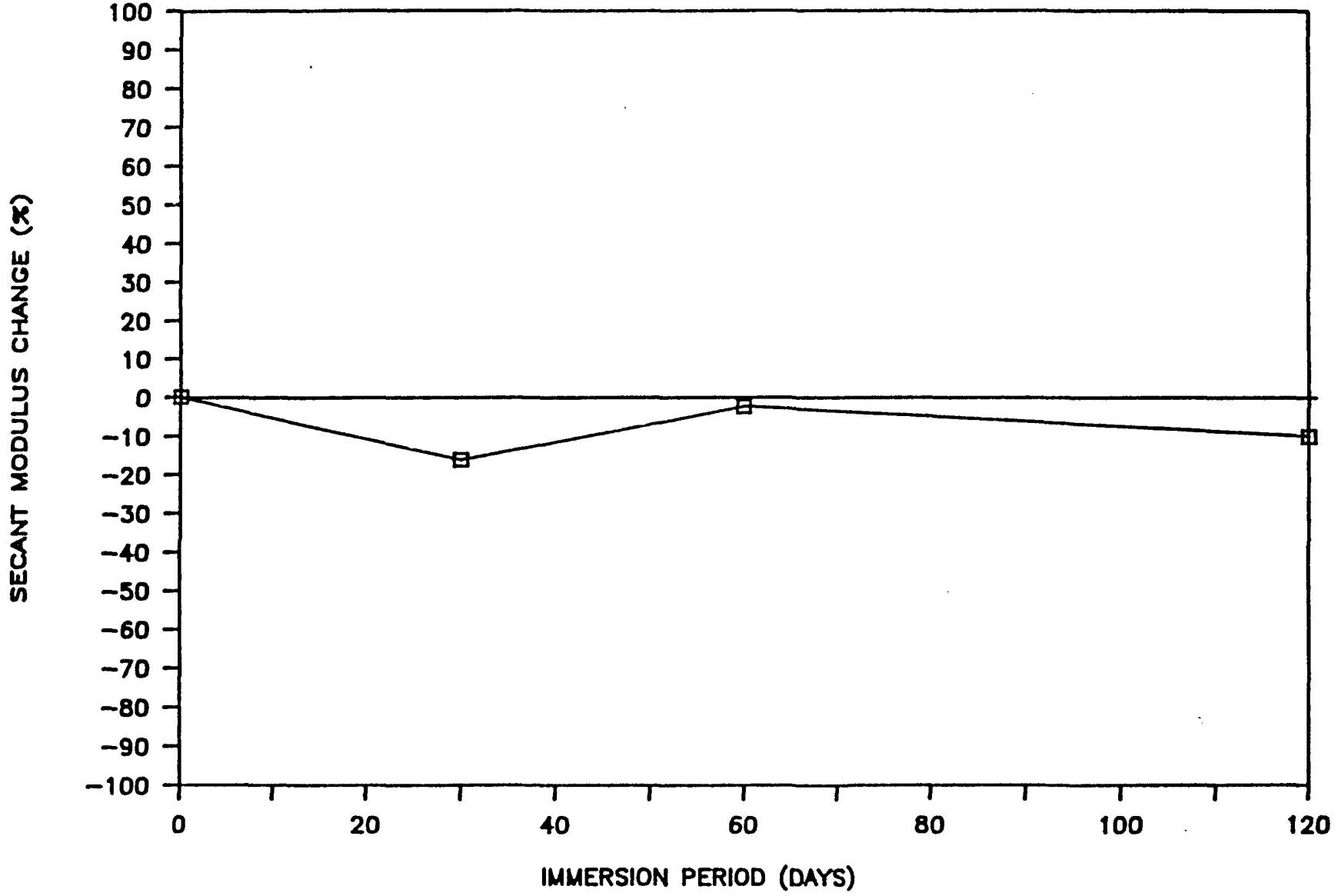
SECANT MODULUS AT 5% STRAIN

WOVEN POLYESTER GEOTEXTILE



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