WESTON SOLUTIONS, INC.

FINAL CONSOLIDATED REPORT

RECONNAISSANCE OF THE PROPOSED ENVIRONMENTAL RESTORATION PROJECT NEAR BARREN ISLAND DORCHESTER COUNTY, MARYLAND

Prepared for

MARYLAND ENVIRONMENTAL SERVICE
Annapolis, Maryland
Contract No. 01-07-30

Prepared by

WESTON SOLUTIONS, INC.
1400 Weston Way
West Chester, Pennsylvania 19380

August 2002

MARYLAND ENVIRONMENTAL SERVICE

Parris N. Glendening
Governor

James W. Peck
Director

September 19, 2002

Dr. Stephen Storms
Maryland Port Administration
Maritime Center II
2310 Broening Highway
Baltimore, Maryland 21224

Ref: MPA Contract No. 500912, PIN No. 600105P
Environmental Planning and Technical Services

Subj: Subtask 17.2.4: Final Consolidated Reconnaissance Study for Barren Island

Dear Dr. Storms:

Enclosed please find two copies of the Final Consolidated Reconnaissance Report for the Barren Island Environmental Restoration Project. A CD-ROM of the final report is also included. Per MPA's direction, the consolidated report includes the figures generated by the University of Maryland's (UM) resource mapping effort (Appendix E). The UM figures that include site-specific, sensitive resource information were referenced in the report, but not included in the appendix.

This final consolidated report is the final report deliverable of Subtask 17.2.4 of MES Proposal No. ED-07-01 for Reconnaissance Studies of Barren Island.

Sincerely,

Melissa Slatnick

Melissa Slatnick
Environmental Dredging Division

Attachment: Final Consolidated Reconnaissance Study for Barren Island Environmental Restoration Project (2 copies, 1 CD-ROM))

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

EXECUTIVE SUMMARY

Barren Island is an uninhabited island owned by the United States Fish and Wildlife Service (USFWS) that is located in the eastern portion of the middle Chesapeake Bay, to the east of the mouth of the Patuxent River, 1 mile off the eastern shore in Dorchester County, MD. The Island is currently approximately 180 acres, and is a federal wildlife refuge. Barren Island also serves as a satellite refuge for the Blackwater National Wildlife Refuge, located in Dorchester County, Maryland. Barren Island consists of several different types of high quality habitat including low and high salt marsh, tidal flats, and forested upland habitat. Barren Island is used as nesting habitat by several federally listed bird species. According to estimates by the USFWS, Barren Island is eroding along its western shore at a rate of approximately 10 to 14 feet per year, which is equivalent to a loss rate of 2.4 to 3.4 acres per year. The Island has lost approximately 450 acres in the past 325 years as the result of erosion caused by rising sea levels.

Barren Island is under consideration for a habitat restoration and beneficial use of dredged material project under the Maryland Port Administration's Dredged Material Management Program (DMMP), formerly the Dredging Needs and Placement Options Program (DNPOP). Four separate studies were conducted to evaluate the use of dredged materials in this environmentally sensitive area in order to provide shoreline stabilization and restoration for the island as well as provide additional marsh and upland habitat areas around the island.

These four studies include:

1. *Preliminary Assessment of Environmental Conditions on Barren Island* (ECR) - An environmental conditions assessment to document (including site visits, agency consultation, and literature review) environmental resources in the project area and determine the potential impacts of the proposed dredged material placement alternatives.

2. *Geotechnical Reconnaissance Study for Barren Island* (GRS) - A study of the geotechnical conditions (including foundation and borrow source conditions at Barren Island) of the area proposed for dredged material placement.

3. *Coastal Engineering Reconnaissance Study for Barren Island, Maryland* (CERS) - A preliminary coastal engineering analysis for use as a planning factor for dredging engineering and dike design.

4. *Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island (DECE)* – A study that provided a dredging engineering and cost analysis for each of the selected alternatives.

The two conceptual configurations assessed are an approximately 1,000-acre environmental restoration area (Alignment #1) and an approximately 2,000-acre environmental restoration area (Alignment #2). Both alignments are located in shallow water to the west and south of Barren Island. Both alignments would be constructed with stone armored sand dikes extending west and south from Barren Island towards the Chesapeake Bay mainstem and would include the generation of new habitat composed of 50% uplands and 50% wetlands. Both alignments would provide a tidal gut area between Barren Island proper and the environmental restoration area. For each alignment, two dike height options (10 and 20 feet) were assessed.

The results of these four reconnaissance studies are summarized in this consolidated report prepared for the Maryland Environmental Service on behalf of the Maryland Port Administration to evaluate the use of the area near Barren Island for habitat restoration and for shoreline stabilization of Barren Island.

1 INTRODUCTION

1.1 Project Description

Barren Island is an uninhabited island owned by the United States Fish and Wildlife Service (USFWS) that is located in the eastern portion of the middle Chesapeake Bay, to the east of the mouth of the Patuxent River, 1 mile off the eastern shore in Dorchester County, MD. The Island is currently approximately 180 acres, and is a federal wildlife refuge. Barren Island also serves as a satellite refuge for the Blackwater National Wildlife Refuge (BNWR), located in Dorchester County, Maryland. Barren Island consists of several different types of high quality habitat including low and high salt marsh, tidal flats, and forested upland habitat. According to estimates by the USFWS, Barren Island is eroding along its western shore at a rate of approximately 10 to 14 feet per year, which is equivalent to a loss rate of 2.4 to 3.4 acres per year. The Island has lost approximately 450 acres in the past 325 years as the result of erosion (Environmental Conditions Report [ECR] p.1).

Barren Island is under consideration for a beneficial use dredged material placement project under the Maryland Port Administration's Dredged Material Management Program (DMMP), formerly the Dredging Needs and Placement Options Program (DNPOP). There are two conceptual environmental restoration area configurations that would provide shoreline stabilization and restoration along the southern portion of the western shoreline of the Island, as well as provide additional marsh and upland habitat areas west of Barren Island (ECR p.1).

The two conceptual configurations assessed are an approximately 1,000-acre environmental restoration area (Alignment #1) and an approximately 2,000-acre environmental restoration area (Alignment #2) as shown in Figure 1. Both alignments are proposed for placement in shallow water west and south of Barren Island. Both alignments would be constructed with stone armored sand dikes extending west and south from Barren Island and would generate new habitat composed of 50% uplands and 50% wetlands. Both alignments will provide a tidal gut between Barren Island proper and the environmental restoration area. For each alignment, two dike height options were assessed (10 feet and 20 feet).

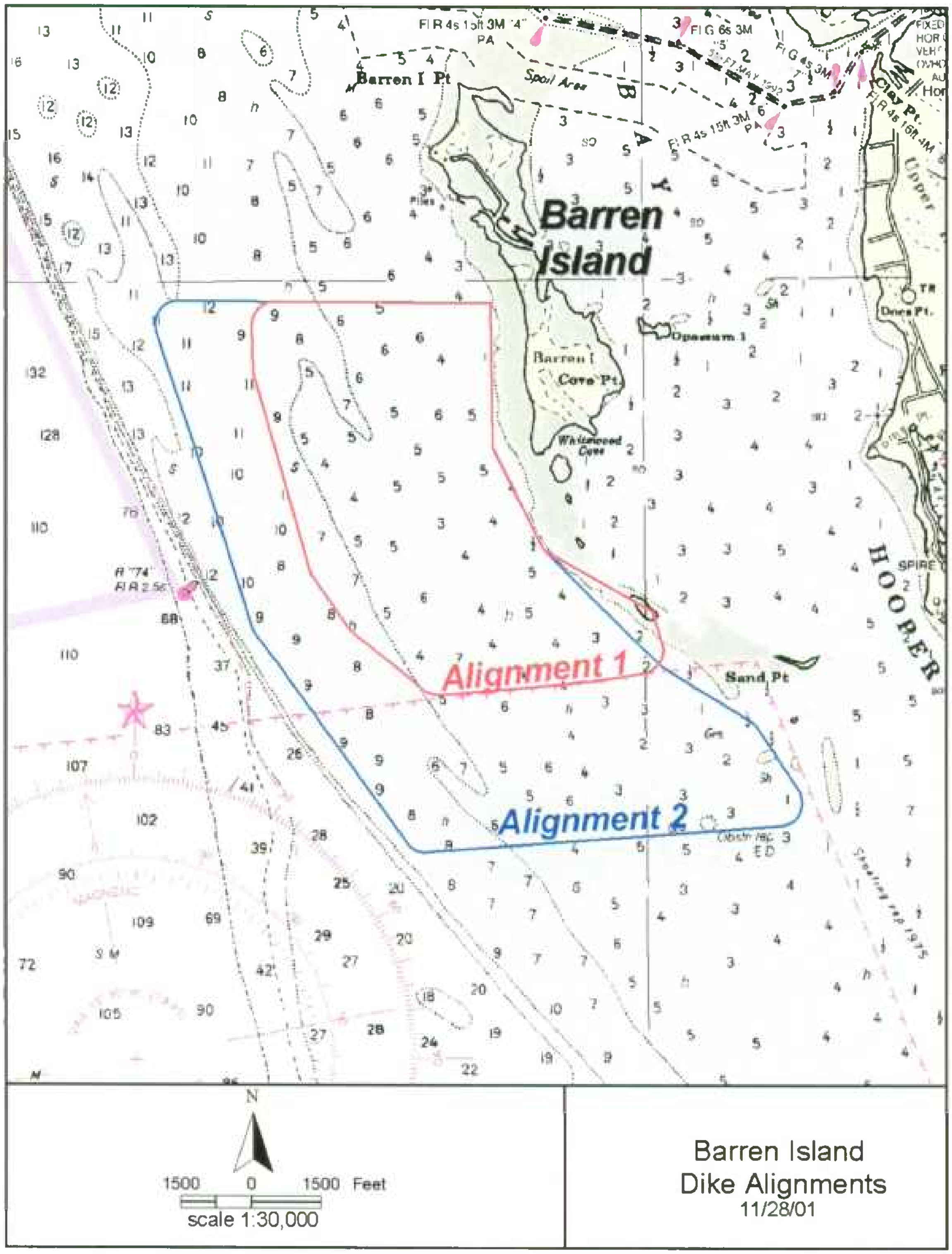


Figure 1: **Dike alignments for the proposed 1,000 and 2,000-acre expansions of Barren Island (Coastal Engineering Reconnaissance Study p.4)**

Two conceptual dike alignment options and two dike height options for each dike alignment are currently being considered for impact, quantity takeoffs (including excavation quantities for unsuitable base materials), and cost estimating. Figures 1 through 4 in the Dredging Engineering and Cost Estimate study (DECE) present dike alignment and typical dike section layouts. Alignment #1 is a reduced area option with a 20 and 10 ft upland dike height (see DECE Figures 3 & 4). The dike centerline area for Alignment #1 is 1,000 acres and the outside edge of toe armor area is 1,051 acres. Alignment #2 is an option utilizing local site characteristics with a 20 and 10 ft upland dike height (see DECE Figures 5 & 6). The dike centerline area for Alignment #2 is 2,000 acres and the outside edge of toe armor area is 2,074 acres. Tables 1 and 2 of the DECE provide site characteristics for both dike alignments and dike heights, including quantities for rock and hydraulic fill material. Both alignments would be constructed with stone armored sand dikes extending west and south from Barren Island into the Chesapeake Bay mainstem and would include marsh and upland habitat areas (ECR p.1).

1.2 Final Consolidated Report Purpose and Format

The purpose of this Final Consolidated Report is to consolidate the findings from four individual reports completed for the Barren Island Habitat Restoration Project Concept Area located in the Chesapeake Bay in Dorchester County, MD. These reports include:

- *Coastal Engineering Reconnaissance Study for Barren Island, Maryland* (CERS) prepared by Applied Coastal Research and Engineering, Inc. for Gahagan & Bryant Associates, Inc., February 2002.

- *Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island* (DECE) prepared by Gahagan & Bryant Associates, Inc. for Roy F. Weston, Inc., February 2002.

- *Geotechnical Reconnaissance Study for Barren Island* (GRS) prepared by E2CR, Inc. for Roy F. Weston, Inc., February 2002.

- *Preliminary Assessment of Environmental Conditions on Barren Island* (ECR) prepared by Roy F. Weston, Inc. (WESTON®) for Maryland Environmental Service, April 2002. Roy F. Weston, Inc. changed its name to Weston Solutions, Inc. in June 2002.

In order to retain the true intent of the language used in the various reports that comprise this Final Consolidated Report, little textual change has been made to the original language used in the various reports. Most of this report has been excerpted verbatim from these reports. References are provided at the end of each paragraph to specify the report and page referenced. The original four reports utilized for this consolidated report are provided as attachments (see Appendices A – D) and should be consulted directly for tables, figures, and detailed discussions of the various topics summarized by this report.

2 RECONNAISSANCE STUDIES

2.1 Coastal Engineering Reconnaissance Study (CERS)

The *Coastal Engineering Reconnaissance Study for Barren Island, Maryland* was prepared by Applied Coastal Research and Engineering, Inc. for Gahagan & Bryant Associates, Inc. in February 2002, and provides background and coastal engineering design guidance for the Barren Island beneficial use project. The report addresses two major needs of the project: 1) identification and evaluation of available data that can be used to describe environmental (meteorological and hydrological) conditions at Barren Island; and 2) design parameters (i.e., stone size and dike elevation) of the two proposed preliminary dike alignments based on the environmental conditions. In addition, recommendations for additional coastal engineering analysis and hydrodynamic modeling to optimize the dike layout have been provided (CERS p.ES-2.). To optimize shore protection design, an evaluation of local wind, wave, and storm surge conditions impacting this site was performed. In addition, preliminary dike heights and armor stone sizes were determined for the 35-year design (CERS p.23-24).

2.2 Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island (DECE)

The *Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island* was prepared by Gahagan & Bryant Associates, Inc. (GBA) WESTON in February 2002. GBA evaluated the suitability of this site to construct a beneficial habitat restoration dredged material placement facility. Each preliminary dike alignment included a 10 and 20 foot high upland dike height option. GBA also provided a dredging engineering assessment for constructing an environmental restoration beneficial use site at Barren Island. This report outlines the findings of the assessment (DECE p.1).

Specifically, GBA's tasks included the following items (DECE p.3):

- Analyze sand borrow options, including excavation, transport and placement methods.
- Lay out two preliminary perimeter dike alignments, enclosing 1,000 and 2,000 acres.
- Estimate neat quantities (quantity of material that fill the design template, not including material lost during construction) and construction quantities for the two alignments defined.
- Develop excavation, transport and placement costs for the two different sand borrow options, two perimeter dike alignments and two upland dike heights.
- Estimate neat quantities and construction quantities for all rock products based on dike cross-sections developed by Applied Coastal Research and Engineering, Inc. (Applied Coastal, 2001) in the Coastal Engineering Reconnaissance Study for Barren Island.
- Obtain unit costs and estimates based on the Poplar Island Phase I & Phase II for the toe dike (quarry run and armor), slope stone (underlayer and armor), road stone, geotextile, spillways, and nursery planting from Applied Coastal.

- Summarize all line items in bid format and include item, quantity, unit cost and total costs (including mobilization and demobilization cost).
- Estimate the transport and placement cost of material dredged from the Baltimore approach channels east of the North Point-Rock Point Line and proposed for placement at Barren Island.
- Estimate the site finishing cost including: plan and design, habitat monitoring, implementation of channels and seeding, and operations and maintenance.

2.3 Geotechnical Reconnaissance Study (GRS)

The *Geotechnical Reconnaissance Study for Barren Island* (GRS) was prepared by Engineering Consultation Construction Remediation, Inc. (E2CR, Inc.) for WESTON in February 2002.

The purpose of the GRS was to:

- Evaluate the geotechnical conditions at the site, especially along the proposed alignments.
- Design a stable dike section at the site in order to establish a preliminary cost estimate for developing the site.
- Evaluate the availability of borrow material (sand) at the site for the construction of the dike (GRS p.3).

The scope of this study included reviewing available data from sources such as the Maryland Geological Survey (MGS) and Soil Conservation Service (SCS), drilling 18 borings, obtaining Shelby tube samples, and conducting laboratory tests to determine the substrate stress history. The next steps in the process included determining the strength characteristics and index properties of various strata, evaluating the data, conducting slope stability analyses for the proposed containment dike, and evaluating the soils at the site for possible use in constructing the dike. The final step was the development of a dike section for use in preparing a cost estimate (GRS p.4).

2.4 Environmental Conditions Report (ECR)

The *Preliminary Assessment of Environmental Conditions on Barren Island* study, prepared by WESTON for Maryland Environmental Service (MES) in April 2002, evaluates the current environmental conditions on and in the vicinity of Barren Island. This study also evaluates the potential positive and negative environmental impacts associated with two conceptual environmental restoration area configurations that would provide shoreline stabilization, marsh and upland habitat area creation, and habitat restoration along the western and southern shoreline of the Island (ECR p.1). The assessments were based on an evaluation of existing literature and databases, site visits, and interviews and correspondence with Federal and state agencies.

3 RESULTS OF RECONNAISSANCE STUDIES

Each of the following sections contains a general discussion followed by Alignment #1 and Alignment #2 specific information, if applicable.

3.1 Location

Barren Island is an approximately 180-acre island located in the Chesapeake Bay in the southwestern side of Dorchester County in Maryland, approximately 27 miles northeast of the mouth of the Potomac River. As shown in Figure 2 of the ECR, Barren Island is located northeast of the Patuxent River Air Test Center. Tar Bay lies to the east of Barren Island, and the Chesapeake Bay lies to the west of Barren Island. The closest landmass to Barren Island, Upper Hooper Island, lies approximately one mile to the east, and is the northern-most island in the Hooper Island chain. The Honga River lies to the east of Upper Hooper Island. The location of Barren Island on a USGS quadrangle map is available in the Site Reconnaissance Report (ECR, Appendix A).

The proposed project would occur along the west and south side of Barren Island, extending west and south into the Chesapeake Bay towards the navigation channel. Two possible preliminary dike alignments for the project are proposed. Figure 1 shows the concept areas of the two alternate dike alignments for the proposed beneficial reuse and habitat restoration project at Barren Island. The dike alignment was developed to optimize the storage capacity of the island, while at the same time avoiding impacts to the Natural Oyster Bars (NOBs) that exist in the Barren Island region (CERS p.2).

Alignment #1

The 1,000-acre alignment (Alignment #1) would extend approximately 4,000 feet to the west from Barren Island at its widest point and approximately 2,000 feet to the south of Barren Island at its most southernmost point (ECR p.8).

Alignment #2

The 2,000-acre alignment (Alignment #2) would extend approximately 6,000 feet to the west from Barren Island at its widest point and approximately 4,000 feet to the south of Barren Island at its most southernmost point (ECR p.8).

3.2 Summary of Coastal Engineering Reconnaissance Study

3.2.1 Design Parameters

3.2.1.1 Bathymetry

Digital hydrographic data were obtained from the National Ocean Service GEODAS data set. This digital data set provides all of the National Oceanic and Atmospheric Administration

(NOAA) bathymetry utilized to generate the local navigation charts; therefore, the information provided is generally more detailed than found on the printed charts. Use of these data allowed for a site-specific evaluation of existing bathymetric conditions in the vicinity of each dike alignment. The western extent of the dike was designed to follow existing bathymetric contours (CERS p.2).

Water depths along the two preliminary dike alignments vary from approximately –3 feet mean lower low water (MLLW) along the east side to more than –10 feet MLLW along the west side. In general, the local bathymetric conditions are shallower to the east and south of the proposed dike alignments (CERS p.27).

The University of Maryland 1:50,000-scale map "Barren Island: Water Depth" (see Appendix E, Figure E-11) indicates that the majority of the proposed project area is located in 0 to 2 meter water depths. The northwestern portion of the proposed project area is depicted to have water depths ranging from 2 to 5 meters. This information appears to deviate slightly from the GEODAS data and from the site-specific information collected during the sediment coring completed by E2CR, Inc. for WESTON in September and October 2001. The GEODAS and site-specific information is presumed to more accurately reflect the water depths around Barren Island.

Alignment #1

Average water depths for Alignment #1 are approximately –6 feet MLLW (CERS p.27). The specific mean water depths (feet MLLW) for Alignment #1 are: -3.1 feet east dike; -4.3 feet south dike; -9.7 feet west dike; and –5.4 feet north dike.

Alignment #2

Average water depths for Alignment #2 are approximately –7 feet MLLW (CERS p.27). The specific mean water depths (feet MLLW) for Alignment #2 are: -2.2 feet east dike; -4.9 feet south dike; -9.6 feet west dike; and –7.7 feet north dike.

3.2.1.2 Wind Conditions

Design winds were developed from a 32-year data set from Baltimore-Washington International Airport. The fastest mile wind speeds were developed for selected return periods ranging from 5 to 100 years. These fastest mile wind speeds were then converted to one-hour wind speeds for incorporation into the wave analysis. Design winds were developed for each of the eight primary directions (N, NE, E, SE, S, SW, W, and NW) for return periods of 5, 10, 25, 50, and 100 years (CERS p.27).

One-hour wind speeds ranged from 27.2 mph (E) to 43.3 mph (NW) for the 5-year return period; 31.8 mph (E) to 47.5 mph (NW) for the 10-year return period; 38.6 mph (E) to 55.5 mph (SW) for the 25-year return period; 44.6 mph (E) to 64.1 mph (SW) for the 50-year return period; and 51.9 mph (E) to 74.7 mph (SW) for the 100-year return period. A complete listing of design wind speeds for each of the eight primary directions and 5 return periods is located on page 7 of the CERS.

Alignments #1 and #2

Design wind conditions for Alignment #1 and Alignment #2 are identical.

3.2.1.3 Storm Surge

Normal water levels at Barren Island are dictated by astronomical tides; however, the influence of other factors (e.g. wind and freshwater inflow) often accounts for more than 50% of the water surface fluctuation. The mean tide level is approximately 0.8 feet above MLLW and the mean tide range is approximately 1.4 feet. For coastal engineering structures, the effect of storm surge is incorporated into the design process. Based on hydrodynamic modeling predictions of storm surges within this portion of Chesapeake Bay, Virginia Institute of Marine Sciences (VIMS) researchers found that the 50-year surge elevation is 4.6 feet above mean sea level and the 100-year surge level is 5.4 feet above mean sea level (CERS p.27).

Wave conditions were determined for each of eight primary fetch sectors (N, NE, E, SE, S, SW, W, and NW) and for the 5, 10, 25, 50 and 100 year return periods. This analysis, summarized in Section 3.2.1.4 of this report, included storm surge levels above the mean fetch depth for each of the modeled return periods (CERS p. 11).

Alignments #1 and #2

Design storm surge conditions for Alignment #1 and Alignment #2 are identical. The storm surge levels are included in the wave conditions analysis summarized in Section 3.2.1.4 of this report.

3.2.1.4 Wave Conditions

As Barren Island is situated within Chesapeake Bay, wave exposure at the site results solely from wind generated waves. Therefore, using historical wind data from Baltimore-Washington International Airport, estimates of wave heights approaching from eight compass sectors were determined. The U.S. Army Corps of Engineers (USACE) computer application Automated Coastal Engineering System (ACES)was used in this analysis. Radially-averaged fetch distances and depths for N, NE, E, SE, S, SW, W, and NW were determined for the Barren Island site. Fetch depths were determined using NOAA bathymetry data from surveys of Chesapeake Bay. Wave conditions were determined for the 5, 10, 25, 50 and 100 year return periods. This analysis included storm surge levels above the mean fetch depth for each of the modeled return periods (CERS p.27).

Alignments #1 and #2

Design wave conditions for Alignment #1 and Alignment #2 are identical. Maximum significant wave heights for each of the five return periods and each of the eight radial sectors are presented in Table 8 (CERS p.14). The maximum significant wave heights for all return periods were from the south, which had the largest fetch, and range from 6.7 ft (5 year return) to 11.3 feet in height (100 year return). These wave height design parameters incorporate the effects of storm surge for the 50-year and 100-year storm surge levels as reported by VIMS.

3.2.1.5 Dike Construction

Cross-sections for Alignments #1 & #2 are shown in Figures 14 and 15 of the CERS. The dimensions of the dike reflect the stones sized for a 35-year design life, and a 3H:1V outer slope. The structure core is constructed using sand, and is separated from the overlying armors and underlayers by an additional layer of geotextile fabric. A 20-ft wide, 8-inch thick crushed stone roadway is provided at the crest of the dike (CERS p.25).

Past experience has indicated that dikes constructed from silty sands (non-plastic) can achieve slopes as steep as 2H:1V below the water. However, 3H:1V is a more realistically obtainable slope. For this reconnaissance phase, it was assumed that the dike would be constructed by hydraulic dredging, and the slopes achievable would be 3H:1V below the water table. The acceptable safety factor was assumed to be 1.3, at the end of the dike construction phase. (GRS p.12)

Alignment #1

The total dike length for Alignment #1 is approximately 28,655 linear feet. For the 10-foot dike, the total capacity for Alignment #1 is 24.2 million cubic yards (DECE Table 4) and for the 20-foot dike, the total capacity is 36.6 million cubic yards (DECE Table 5).

Alignment #2

The total dike length for Alignment #2 is approximately 41,854 linear feet. For the 10-foot dike, the total capacity for Alignment #2 is 52.6 million cubic yards (DECE Table 6) and for the 20-foot dike, the total capacity is 77.4 million cubic yards (DECE Table 7).

3.2.1.5.1 Dike Design Values

Dike designs depend upon wave and hydrodynamic conditions at the site for the appropriate return period event. For this conceptual design study, a 35-year return period for winds and storm surge elevations was chosen as the design return period, based on the similar analyses for Poplar (GBA, 1995) and Parsons Islands (Moffatt & Nichol Engineers, 2001) within Chesapeake Bay. Dike crest elevations and stone sizes are presented also for the 5-, 10-, 25-, 50-, and 100-

year return conditions for comparison. Dike heights were computed separately for proposed dike Alignments #1 and #2 (shown in Figure 2 of the CERS) (CERS p.20).

3.2.1.5.2 Dike Crest Height

The primary functions of the proposed dike enclosure are to enable the hydraulic placement of suitable dredged sediments and protect the interior fill from waves. With the combination of waves and surge, it is likely that some amount of water will overtop the crest during the course of a severe storm event (CERS p.20). The design crest height depends greatly upon the hydrodynamic and wave climate of the area, as well as the chosen rate of allowable overtopping. The method of Van der Meer (1992) was utilized for the run-up analysis and crest height determination, for a structure with a 3H:1V slope. For the 35-year project design conditions, the estimated dike height is approximately 10 ft (MLLW) for the North, West, and South dike sections, and 8 ft (MLLW) for the East dike section. The reduced height of the eastern section is the result of lower waves from the eastern fetch (CERS pp.23).

Alignment #1

The design dike crest height ranges for return period extremes (5 years and 100 years) presented in the CERS (p.23) for Alignment #1 were as follows: North dike 7.2 ft (5 year return) to 10.5 ft (100 year return); West dike 7.7 ft (5 year return) to 10.9 ft (100 year return); South dike 7.7 ft (5 year return) to 11.4 ft (100 year return); and East dike 6.8 ft (5 year return) to 8.9 ft (100 year return).

Alignment #2

The design dike crest height ranges for return period extremes (5 years and 100 years) presented in the CERS (p. 23) for Alignment #2 were as follows: North dike 7.3 ft (5 year return) to 11.1 ft (100 year return); West dike 7.7 ft (5 year return) to 11.5 ft (100 year return); South dike 7.7 ft (5 year return) to 11.4 ft (100 year return); and East dike 6.8 ft (5 year return) to 8.9 ft (100 year return).

3.2.1.5.3 Armor Stone Sizing

To size the armor stones for the Barren Island dike, the method of Van der Meer (1988) was used. Maximum wave heights in the surf zone adjacent to the dike were used for stone sizing. These maximum wave heights were estimated using a method presented by Goda (1995) (CERS p.29).

Alignment #1

For the 35-year design return period, the approximate outer slope armor stone weight for Alignment #1 along the north, west, and south dike sections stone sizes vary between 1.3 and 1.5

tons, but stone weights are only 111 lbs (0.05 tons) for the eastern dike section, which is more sheltered (CERS p.24).

Alignment #2

For the 35-year design return period, the approximate outer slope armor stone weight for Alignment #2 along the north, west, and south dike sections stone sizes are similar to those of Alignment #1 and vary between 1.3 and 1.5 tons, but stone weights are only 111 lbs (0.05 tons) for the eastern dike section, which is more sheltered (CERS p.24).

3.2.1.5.4 Toe Protection and Underlayer

Toe stone sizes were computed assuming that the toe berm is located at the MLLW level as it was in the previous Parson and Poplar Island designs. Waves were also modeled as before, without using storm surge. Hydrodynamic forces on the dike toe would be greatest when waves are directly impinging upon it, hence modeled water levels where set at MLLW (CERS p.25).

An underlayer of finer sized stone is usually included as part of a dike design. The USACE recommends that the underlayer be composed of stones within the range of 0.07 to 0.10 times the weight of the overlying armor stone. The most important benefit of using properly-sized underlayer stones is that it permits surface interlocking with the armor stones, which enhances the stability of the armor layer (CERS p.25).

Alignment #1

The required toe armor stone size for the north, west, and south sections of the dike are 1.7 ft (0.4 ton) for Alignment #1 for 35-year return period waves with a still water elevation corresponding to MLLW. For the east dike section, toe stone size is computed to be 0.8 ft (70 lbs or 0.035 tons) for either of the proposed Alignments (CERS p.29).

As summarized in the CERS (p. ES-3), the required underlayer stone size for the north is 1.18 ft (0.13 ton), for the west is 1.18 ft (0.14 ton), for the south is 1.23 ft (0.15 ton), and for the east section of the dike is 0.41 ft (11.1 lbs).

Alignment #2

The required toe armor stone size for the north, west, and south sections of the dike are 2.0 ft (0.7 ton) for Alignment #2 for 35-year return period waves with a still water elevation corresponding to MLLW. For the east dike section, toe stone size is computed to be 0.8 ft (70 lbs or 0.035 tons) for either of the proposed Alignments (CERS p.29).

As summarized in the CERS (p. ES-3), The required underlayer stone size for the north is 1.22 ft (0.15 ton), for the west is 1.16 ft (0.13 ton), for the south is 1.23 ft (0.15 ton), and for the east section of the dike is 0.41 ft (11.1 lbs).

3.3 Summary of Geotechnical Reconnaissance Study

The sediment borings indicate that the subsurface stratigraphy along the perimeter Alignments #1 and #2 generally consist of three major strata, as shown on Figure 7 and 8 of the Generalized Subsurface Profile (GRS p.7).

Stratum I was encountered in borings G-2, G-4, G-14, and G18 at the mud line. It is approximately 5-ft to 15-ft thick, and predominantly consists of gray silty clay (CL) with interbedded silt (ML) and sand (SM-SC) layers. Standard penetration resistance varies from WOH (weight of hammer) to 14 blows/ft (GRS p.7).

Stratum II consists of very loose dense gray to brown silty sand (SM) with pockets of silty clay. Standard penetration resistance varies from about WOH to 50 blows/4 inches. Fines content is generally less than 30%. This stratum occurs below the mud line and beneath Stratum I and is generally about 10-ft to 30-ft thick (GRS pp.7-8).

Stratum III underlies the entire site (except at boring G-9), and consists of soft to very stiff green gray silty clay with pockets of silty sand. The top of this stratum varies from about El. –26 to El. –47. Standard penetration resistance varies from 2 to 18 blows/ft (GRS p.8).

The University of Maryland 1:50,000-scale map "Barren Island: Bottom Type" (see Appendix E, Figure E-1) generally agrees with sediment coring data collected by E2CR, Inc. in September and October 2001. The University of Maryland map indicates that the bottom type within the proposed project area is primarily sand. Small areas of cultch and sand with cultch are also identified within the proposed project area. Note that a small portion of the bottom type on the eastern side of the proposed project area is unclassified on this map. In general, the bottom type around Barren Island outside of the proposed project area consists primarily of sand and sand with cultch west and south of the Island; mud, sand, and mud with cultch east of the Island; and sand and sand with cultch north of the Island.

Slope stability analyses were conducted using one typical case for the subsurface profile. The Purdue University PC STABL-V program was used to analyze the stability of the slopes. Failures can be analyzed using different approaches, such as the Modified Bishop Method, the Modified Janbu Method and the Spencer Method. For this study, the Modified Bishop method was used (GRS p.11). Shear strength of the foundation was based on the evaluation of Standard Penetration Tests (SPT) blow counts, since the soils in the foundation are mostly silty sands (GRS p.12). The subsurface profiles did not warrant the use of a wedge type of failure, since there are no thin soft layers. Therefore, only circular failures were analyzed (GRS p.13).

Alignment #1

The foundation soils for Alignment #1 are anticipated to be mostly loose silty sands, except near borings G-2, G-4, and G-14, where the soils are predominantly layers of soft silty clay. The dike along Alignment #1 can be founded on the silty sand, using a slope of 3H:1V. However, the soft clays near borings G-2, G-4, and G-14 will have to be undercut about 10-ft average. A total of about 10 million cubic yards of silty sand and a net of about 8 million cubic yards of silty sand is available within the diked area (GRS p.15).

Alignment #2

The foundation soils for Alignment #2 are anticipated to be mostly loose silty sands, except near borings G-2, G-4, G-14 and G-18, where the soils are predominantly layers of soft silty clay. The sands are considered to be suitable for supporting the dike on a 3H:1V slope. However, the interbedded soft clays and silty sand will need to be undercut. The depth of undercut near boring G-2, G-4, G-14 and G-18 will have to be about 10 feet, average. The total volume of silty sand available within the diked area is estimated to be about 25+ million cubic yards and the net volume is estimated to be about 20+ million cubic yards (GRS p.16.)

3.4 Summary of Reconnaissance Study of Dredging Engineering and Cost Estimate

3.4.1 Borrow Material

The borrow material should ideally be a sand, with as little fines (i.e. percent passing U.S. Standard Sieve No. 200) as possible (GRS p.9).

Two different methods for providing sand borrow were considered to meet the estimated quantities: (1) hydraulically dredge directly from the on-site borrow area (2) dredge and transport the off-site sand by hopper dredge to an underwater placement site and place the sand in the dikes with a hydraulic dredge (DECE p.21).

Borrow method 1 and 2 both use a hydraulic dredge to place the sand in the dikes. In borrow method 1, suitable on-site sand fill is pumped directly to dikes where it is shaped and armored (DECE p.21).

Borrow method 2 assumes that suitable fill material is not available within two or three miles and must be transported by hopper dredge from about 53 nautical miles away. After transport, the material is bottom dumped in an on-site underwater stockpile and pumped into section by hydraulic dredge (DECE p.21).

Based upon estimates in the DECE, there is sufficient borrow material onsite to support borrow method number 1 for either alignment.

Alignment #1

The estimated neat sand fill quantities for construction of perimeter dike Alignment #1 at Barren Island are between 1.54 million cubic yards for an upland dike height of 10 ft and 2.58 million cubic yards for an upland dike height of 20 ft. A 'neat quantity' is the quantity of material that fills the design template, not including material lost during construction. This estimate does not include interior dikes to divide the island into cells (DECE p.21).

For Alignment #1 there is 8 million cubic yards of silty sand available for borrow source material (DECE p.21).

Alignment #2

The estimated neat sand fill quantities for perimeter dike Alignment #2 are between 2.65 million cubic yards for an upland dike height of 10 ft and 4.29 million cubic yards for an upland dike height of 20 ft. This estimate does not include interior dikes to divide the island into cells (DECE p.21).

For Alignment #2 there is 20 million cubic yards of silty sand available for borrow source material (DECE p. 21).

3.4.2 Cost Estimate

The costs to construct the Barren Island site were estimated based on the configurations and typical dike sections described in Section 3 of the DECE. Quantities for each material type were estimated based on the nine different typical dike sections, the alignment and average existing bottom elevation. Unit prices were estimated from similar construction projects at Poplar Island. A summary of the estimated construction costs for each borrow method alternative for the two dike alignments is presented in Table 3 of the DECE. The cost range for each alignment and both upland cell elevation options is $42.4 to $81.5 million (DECE p.22).

The Total Site Use Cost Analysis for each dike alignment and dike height is comprised of a Study Cost (conceptual, pre-feasibility and feasibility), Total Construction Cost, Site Development Cost (dredged material management, site maintenance and site monitoring and reporting), Habitat Development Cost (plans and design, monitoring, implementation, and operation & maintenance), and Dredging, Transport and Placement Cost (mobilization & demobilization, dredging, transport, and placement) (see Tables 4 thru 7 of the DECE). The total cost range for each alignment and upland dike height is $414 million to $1.29 billion. The total unit costs for both Alignments #1 and #2 and dike heights (10 and 20 ft) range from $16.57/cy to $17.16/cy (DECE p.22).

Alignment #1

For the 10-foot dike system, total construction cost (in 2001 dollars) for Alignment #1 is $42.3 million, or approximately $1.75 per cubic yard of capacity. The total site use cost is $413.6 million, or $17.12 per cubic yard of capacity. The total capacity is 24.2 million cubic yards (DECE Table 4).

For the 20-foot dike system, total construction cost (in 2001 dollars) for Alignment #1 is $51.2 million, or approximately $1.40 per cubic yard of capacity. The total site use cost is $601.4 million, or $16.44 per cubic yard of capacity. The total capacity is 36.6 million cubic yards (DECE Table 5).

Alignment #2

For the 10-foot dike system, total construction cost (in 2001 dollars) for Alignment #2 is $67.5 million, or approximately $1.28 per cubic yard of capacity. The total site use cost is $902.8 million, or $17.16 per cubic yard of capacity. The total capacity is 52.6 million cubic yards (DECE Table 6).

For the 20-foot dike system, total construction cost (in 2001 dollars) for a 20-foot dike system for Alignment #2 is $81.5 million, or approximately $1.05 per cubic yard of capacity. The total site use cost is $1.3 billion, or $16.57 per cubic yard of capacity. The total capacity is 77.4 million cubic yards (DECE Table 7).

3.5 Summary of Environmental Conditions

3.5.1 Habitat Description

3.5.1.1 Shallow Water Habitat

Shallow water habitat, defined as areas with water depth less than 10 feet, surrounds Barren Island on all sides. These shoal areas border the shoreline and extend outward into the Bay (ECR p.12).

Construction of the dike system and subsequent placement of dredged material will replace some shallow water with upland and marsh within the selected alignment concept area. These effects will be permanent. The benthic communities and aquatic habitat in the concept area of the proposed project have not been completely assessed at the reconnaissance level of study. However, existing data, particularly benthic invertebrate and oyster data, suggest that the benthic habitat in the proposed project area is of low quality. It is believed that the benefits of the beneficial use project outweigh the trade-offs of displacing some shallow water areas in this region. Benthic habitat will be created in marsh habitat construction by the proposed action. This habitat will replace some of the lost shallow water benthic habitat. The constructed tidal marsh areas will provide habitat for wildlife that utilize these systems and increase the area of salt marsh systems in the area (ECR pp. 84-87).

Alignment #1

Alignment #1 will replace approximately 1,051 acres of shallow water that could be used as habitat with upland and wetland habitat. The existing benthic habitat in the proposed project area is of low quality. It is believed that the benefits of the beneficial use project outweigh the trade-offs of displacing some shallow water areas in this region (ECR pp. 84-87).

Alignment #2

Alignment #2 will replace approximately 2,074 acres of shallow water that could be used as habitat with upland and wetland habitat. The existing benthic habitat in the proposed project area is of low quality. It is believed that the benefits of the beneficial use project outweigh the trade-offs of displacing some shallow water areas in this region (ECR pp. 84-87).

3.5.1.2 Shoreline Habitat

Shoreline habitats are located in the intertidal zone, the zone between mean low tide (MLT) and mean high tide (MHT), and the supratidal zone, the zone from MHT to the limit of spring tides. The intertidal zone contains tidal flats which are unvegetated wet areas of mud or sand that do not contain rooted plants, and are subject to tidal inundation. Mud flats occur sporadically along the shoreline of Barren Island, and also typically border marsh areas. Tidal flats on Barren Island include mud flats (mixture of silt, clay, and organic material) and sandy beaches (mixture of sand, pebbles, and shell material). A sandy beach occurs on the northwest side of Barren Island, behind the geotextile tubes placed in 2001 for the construction of an 11-acre tidal salt marsh (ECR p.13).

Salt marshes are also present along or near the shoreline of Barren Island. Salt marshes are communities of emergent grasses, low shrubs, or other herbaceous plants rooted in soils that are alternately inundated and drained by tidal action. Salt marshes are typically dominated by a few species of emergent, salt-tolerant grasses (*Spartina sp.*), although other species of herbaceous plants may be present. Low and high salt marshes are present throughout Barren Island, with large tracts in the northern, central, and southern portions of the island (ECR p.14).

The placement of dredged material should have minimal impact on the western shoreline habitats on Barren Island. In fact, additional shoreline habitat will be created along the outer boundary of the dike system, effectively increasing the shoreline habitat. Although this habitat will be different than the current habitat found along the western edge of the Island, it will provide additional habitat for shoreline species. Currently, the western shoreline is eroding quite rapidly. The addition of either proposed alignment will reduce or eliminate this erosion. In addition, both proposed alignments will augment the current habitat by providing a tidal gut between Barren Island and the dike alignment (ECR p.86).

Alignment #1

Additional shoreline habitat will be created along the outer boundary of the portion of the dike system proposed as wetlands habitat, effectively increasing the shoreline habitat by approximately 15,000 linear feet for Alignment #1 (ECR p.86, DECE pp. 11-12). By providing protection to Barren Island itself, this alignment will protect the currently eroding shoreline habitat as well.

Alignment #2

Additional shoreline habitat will be created along the outer boundary of the portion of the dike system proposed as wetlands habitat, effectively increasing the shoreline habitat by approximately 21,000 linear feet for Alignment #2 (ECR p.86, DECE pp.11-12). By providing protection to Barren Island itself, this alignment will protect the currently eroding shoreline habitat as well.

3.5.1.3 Upland Habitat

Uplands on Barren Island are comprised of shrub and forest areas. It is estimated that approximately 65-70% of the upland area on Barren Island is wooded (J. Gill, personal communication, 2001). A variety of upland shrubs were observed during the October 2001 site reconnaissance, and no dominant shrub species was evident. The forest areas consist of mixed coniferous and deciduous trees, and are dominated by loblolly pine (*Pinus taeda*). Mature forests are present on Barren Island, particularly on the southern end. Some of the largest loblolly pine specimens observed during the site reconnaissance (see Appendix A of the ECR) exceeded 2 foot diameter breast height (dbh). The mature loblolly pine forests serve as prime nesting habitat for larger species of waterfowl, such as great blue herons (*Ardea herodias*) and bald eagles (*Haliaeetus leucocephalus*) (ECR p.14).

Alignment #1

Based upon Table 1 of the DECE report, it is estimated that Alignment #1 will create 500 acres of upland habitat.

Alignment #2

Based upon Table 2 of the DECE report, it is estimated that Alignment #2 will create 1,000 acres of upland habitat.

3.5.2 Water Quality

3.5.2.1 Surface Water

Water quality impacts were evaluated in the ECR for both the construction and placement phases of the proposed project.

Short-term impacts on the water quality are expected during the construction of the dike system around the habitat restoration project. Impacts related to construction are expected to be temporary and turbidity-related only. Significant chemical impacts are not expected because the construction phase will be limited to disturbance of the natural conditions. Effects on pH are not expected to occur from the proposed project. If not monitored, uncontrolled sedimentation in the area around Barren Island resulting from construction activities could impact the two nearby

Natural Oyster Beds (NOB 23-2 and NOB 23-4) in the short term, and has the potential to affect the submerged aquatic vegetation beds located to the east of the Island. These effects are not expected to be pervasive. However, water quality during construction will be strictly regulated and monitored as during the construction of the Poplar Island Environmental Restoration Project.

Impacts relating to the placement of dredged materials could also result in increased short-term turbidity. As with the construction phase, this turbidity, if not controlled, could result in increased sedimentation around Barren Island with similar effects as those described above. However, water quality will be monitored closely during all phases of the Barren Island project for compliance with regulatory discharge permits that will be negotiated with the issuing agency if this project moves forward.

As all dredged material to be placed at the beneficial use site is expected to be uncontaminated sediments from the channels of the mainstem Chesapeake Bay, there is little potential for chemical and nutrient impacts on the area around Barren Island from the dredged material placement phase of the project. As dredged material is added to the environmental restoration area, ponded water within the constructed dike will be discharged to the surrounding waters, and this discharge will be strictly monitored for compliance with permit levels. It is not expected that this discharged water will increase nutrient, metal, and other contaminant levels at these times (ECR pp.84).

Alignments #1 and #2

It is possible that there will be short-term, localized surface water quality impacts resulting from the construction and placement phases of Alignments #1 and #2. Provided that adequate monitoring of water quality in the immediate area is performed in conjunction with reasonable preventive engineering controls, these impacts are not expected to be significant nor permanent. The total duration of potential water quality impacts was not estimated since the project schedule is not yet available. The types of water quality impacts are expected to be similar for both alignments; however, the duration of potential impacts is longer for Alignment #2 due to the larger size of the project.

3.5.2.2 Groundwater

Although groundwater impact is always a concern with the placement of dredged material, the clays and silt sediments underlying the project area are expected to provide adequate protection of groundwater resources. In addition, the dredge material proposed for use on this project is expected to be uncontaminated and is not expected to pose a significant threat to groundwater. (ECR p.92).

Alignment #1

Impacts on groundwater are not anticipated for Alignment #1.

Alignment #2

Impacts on groundwater are not anticipated for Alignment #2.

3.5.3 Sediment Quality

Based upon the sediment core logs, the predominant surface sediment layers immediately adjacent to the west side of Barren Island are interbedded silty sand and silty clay. To the northwest and southeast of the island, surface sediments are predominantly silty clay. Silty clay appears to also be locally isolated in a pocket just southwest of the island. Further into the channel and mainstem of the Bay, silty sand is the predominant surface sediment type, which is expected due to higher water velocities. An isolated pocket of mixed silty sand, clayey silt, and silty clay is located due west of the island, between the interbedded silty sand and silty clay sediments immediately adjacent to the island and the silty sand located further into the Bay mainstem (ECR p.32-36).

In general, sediments between 3.5 and 12.0 feet are split between silty sand, silty clay, and interbedded silty sand and silty clay. Between 12 and 27 feet, the majority of sediments are silty sand with a few cores showing silty clay, clayey sand, and interbedded silty sand, and silty clay at various depths. At 27 to 40 feet, sediments are once again split approximately equally between silty sand and silty clay, although several cores indicate more complex sediments including interbedded silty clay and silty sand, clayey sand and silt, and clayey sand (ECR p.32-36).

Of the 18 cores, 11 cores characterized sediments greater than 40 feet, and of these, 8 cores characterized sediments greater than 45 feet. It appears that the sediments at these depths trend from more complex mixtures and interbedded towards more homogenous sediments of silty clay or silty sand. The three deepest cores (G-06 at 55 feet, G-09 at 65 feet, and G-16 at 70 feet) indicate that sediments at these depths consist primarily of silty clay (G-06), and silty sand (G-09 and G-16). Sediment core G-16 encountered an eight-foot thick layer of peat from 54 to 62 feet, which is embedded between relatively thick layers of silty sand (ECR p.32-36).

As noted in Section 3.3, the University of Maryland 1:50,000-scale map "Barren Island: Bottom Type" (see Appendix E, Figure E-1) generally agrees with sediment coring data collected by E2CR, Inc. in September and October 2001. The map indicates that the bottom type within the proposed project area is primarily sand, with small areas of cultch and sand with cultch. In general, the bottom type around Barren Island outside of the proposed project area consists primarily of sand and sand with cultch west and south of the Island; mud, sand, and mud with cultch east of the Island; and sand and sand with cultch north of the Island.

Since the dredged material for this project wil! originate from outer channel areas, the dredged material is expected to be uncontaminated. Although these sediments will be slightly different in grain size than the local natural sediments and will alter the substrate within the project area, negative impacts resulting from sediment quality are not expected (ECR p.84).

Alignment #1

It is not anticipated that there will be any significant impacts on sediment quality for Alignment #1. It is possible that some sedimentation may occur in the immediate area of the project as the result of fines lost during placement and construction; however, these effects will be closely monitored. This effect is expected to be less pervasive for Alignment #1 than for Alignment #2 because of the shorter construction duration and smaller size of the dike construction and dredged material placement.

Alignment #2

It is not anticipated that there will be any significant impacts on sediment quality for Alignment #2. It is possible that some sedimentation may occur in the immediate area of the project as the result of fines lost during placement and construction; however, these effects will be closely monitored. Sedimentation effects are expected to be somewhat more pervasive for Alignment #2 than for Alignment #1 because of the longer construction duration and larger size of the dike construction and dredged material placement.

3.5.4 Biological Resources

Impacts on terrestrial biological resources during the construction phase are expected to be small because the majority of the activities will be conducted in the water. It is not expected that there will be a loss of vegetation or terrestrial habitats on the island itself. It is expected that the existing vegetated habitats on Barren Island will be protected since the proposed project is expected to substantially reduce erosion rates on the island (ECR pp. 84-86).

The proposed alignments are in a portion of the Barren Island Grounds (see Figure 14 of the ECR), which are used commercially for finfish and blue crab harvests. The proposed alignments will result in a permanent reduction of the Barren Island Grounds. However, there are larger and much more valuable shallow water areas around Barren Island, and the impact of the proposed project is not expected to be significant. Further assessment of the use of this area by commercial and recreational fishermen is suggested to verify these findings (ECR pp. 84-87).

The proposed project would provide additional nesting and feeding habitat for a wide variety of waterfowl, and would likely contribute to local fish habitat through increasing submerged aquatic vegetation (SAV) beds. These positive impacts are expected to outweigh the negative impact of reducing the size of local productive crabbing areas (ECR pp. 84-87).

Most of Barren Island and its surrounding habitats (e.g., SAVs, shallow water, intertidal wetland, bird nesting areas, threatened and endangered species) are considered Critical Areas. Critical Areas are defined as land within 1,000 feet of the MHW line of tidal waters or the landward edge of tidal wetlands and all waters of any lands under the Chesapeake Bay and its tributaries. As the concept areas are located in open water, they are considered to be within a critical area. Impacts from the proposed environmental restoration would be primarily limited to shallow water areas, but would benefit existing habitat on Barren Island and shallow waters to the east by controlling erosion and sedimentation. Indirect impacts from the construction and placement of dredged material could be minimized by using similar timing and techniques employed as part of the Poplar Island Environmental Restoration Project.

It should be noted that since Barren Island is owned by USFWS it is not directly subject to Maryland Critical Area regulations because it is not a private holding. However, the Coastal Zone Management Act (CZMA) of 1972 gives states the ability to require federal agencies to carry out activities within the coastal zone in a manner consistent with the state coastal program's policies. This will include consideration of the Critical Area regulations and programs for the state and Dorchester County (personal communication with Ren Serey, Maryland Department of Natural Resources (MDNR) Critical Area Commission) (ECR pp. 87).

Specific biological resource impacts for each of the two alignments are presented in subsections 3.5.4.1 through 3.5.4.9.

3.5.4.1 Finfish & Essential Fish Habitat

Numerous finfish species inhabit the mesohaline waters in the vicinity of Barren Island, and several of these species support valuable commercial and recreational fisheries in the Chesapeake Bay. No fish survey has been conducted in the vicinity of Barren Island or in the concept area of the proposed project (ECR p.37).

Barren Island is located in an area designated as the Chesapeake Bay mainstem. The section of the mainstem in which Barren Island is located may provide essential fish habitat (EFH) for nine species of fish, which are listed in Table 12 of the ECR. These nine species of fish include windowpane flounder (*Scopthalmus aquosus*), bluefish (*Pomatomus saltatrix*), Atlantic butterfish (*Peprilus triacanthus*), summer flounder (*Paralicthys dentatus*), black sea bass (*Centropristus striata*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculates*), cobia (*Rachycentron canadum*), and red drum (*Sciaenops occelatus*). According to the Maryland Natural Resources Police, summer flounder is the only one of these nine species of fish that is caught in nets deployed for commercial fishing in the area approximately one-quarter mile west of Barren Island (ECR pp.38-45).

The proposed project area is also located near Habitat Areas of Particular Concern (HAPC). HAPC are areas within EFH that are considered to provide an important ecological function, are considered to be rarer than other habitat types, and are critical to the survival of a life stage of a species (ASMFC, 1998). Examples of HAPC include spawning habitat and primary nursery areas. In the vicinity of Barren Island, the SAV beds to the east and south of the island are considered HAPC since they do provide habitat for spawning and nurseries for a number of fish species.

The University of Maryland 1:50,000-scale map "Barren Island: Potential Summer Flounder Habitat" (see Appendix E, Figure E-10) indicates that the entire Barren Island area is potential habitat for summer flounder, including the entire proposed project area. This information concurs with the site-specific information collected by WESTON as part of the ECR.

The University of Maryland 1:50,000-scale map "Barren Island: Anadromous and Semi-Anadromous Finfish Spawning Extents with Species Count" (see Appendix E, Figure E-5) indicates that there are no spawning areas within the proposed project area, nor in the immediate vicinity of Barren Island. The area to the east of Upper Hooper's Island and Meekin's Neck has been identified as a spawning area for one species of finfish. The spawning area is approximately 1 mile from Barren Island, and is separated from the proposed project by land.

The University of Maryland 1:50,000-scale map "Barren Island: Critical Finfish Habitat" (see Appendix E, Figure E-6) indicates that there have been several Atlantic Sturgeon catch locations in the vicinity of Barren Island, including one within the proposed project area along the western boundary. The map does not indicate any short nose sturgeon catch locations or high relief areas around Barren Island.

The proposed environmental restoration will convert an area of shallow water and substrates ranging from mixed silty sand to clayey silt and silty clay to a mixture of marsh and upland habitat. The loss of this habitat will reduce the size of the Barren Island Grounds and available fish habitat, primarily for those species that are bottom feeders (e.g., summer flounder). Water-column species would be less impacted from the loss of habitat (ECR p.85-87).

Impacts to finfish from the construction and placement of dredged material could be minimized by using similar timing and techniques employed as part of the Poplar Island Environmental Restoration Project.

Because the proposed environmental restoration areas are located in area of designated EFH, NMFS will need to be consulted for recommendations in order to determine potential impacts on EFH. Due to a lack of information on fish utilization of the project area, it is recommended that further studies of the area be conducted, including interviews of local commercial and recreational fishermen, and field surveys during the months when fish are generally expected to be most abundant in the area (ECR pp. 87).

Alignment #1

The extent of the Barren Island Grounds is not accurately defined, although some portion of Alignment #1 lies within the Barren Island Grounds. If it is designed entirely as an enclosed dike with no tidal wetlands, the proposed project will permanently eliminate approximately 1,051 acres of finfish and EFH area. If Alignment #1 is designed with tidal wetlands within the dike system, it will create up to 500 acres of new finfish nursery area and EFH area, therefore resulting in a net loss of approximately 551 acres of EFH and a net gain of 500 acres of finfish nursery area.

Alignment #2

The extent of the Barren Island Grounds is not accurately defined, although some portion of Alignment #2 lies within the Barren Island Grounds. If it is designed entirely as an enclosed dike with no tidal wetlands, the proposed project will permanently eliminate approximately

2,074 acres of finfish and EFH area. If Alignment #2 is designed with tidal wetlands within the dike system, it will create up to 1,000 acres of new finfish nursery area and EFH area, therefore resulting in a net loss of approximately 1,074 acres of EFH and a net gain of 1,000 acres of finfish nursery area.

3.5.4.2 Aquatic Invertebrates

Three key aquatic invertebrates present near Barren Island are blue crabs (*Callinectes sapidus*), American oysters (*Crassostrea virginica*) and soft shell clams (*Mya arenaria)*. Each of these species is critical to local commercial fisheries, and is discussed in more detail in Section 7.1, Section 7.2, and Section 7.3 of the ECR report, respectively (ECR p.46-48).

The Benthic Index of Biotic Integrity (BIBI) is a commonly used measure of the biological integrity, general health, and quality of the benthic community in the Chesapeake Bay. The Chesapeake Bay Program's online Bay Atlas indicated that several random BIBI sampling points were located around Barren Island, with one random BIBI sampling point located within, or very close to, the proposed 2,000-acre restoration boundary (ECR p.49).

The average BIBI is determined by calculating the following: Shannon-Weiner Species Diversity Index, Total Species Abundance, Total Species Biomass, Percent Abundance of Pollution-Indicative Species, Percent Biomass of Pollution-Sensitive Species, Percent Abundance of Carnivore and Omnivores, and Percent Abundance of Deep Deposit Feeders. Each of these factors are assigned a value of 1, 3, or 5, with 5 being the most pristine sites, and 1 being the most degraded sites. These values are then averaged to compute the BIBI score. The sampling point in the proposed project concept area at Barren Island had a BIBI score between 0 and 2.0, indicating that the benthic community in this area is highly degraded (ECR p.49).

Site specific surveys of benthic invertebrates in the vicinity of Barren Island have not been conducted. The Maryland Chesapeake Bay Long-Term Benthic Monitoring and Assessment Program does not have a fixed sampling station near Barren Island. A benthic survey in the concept area of the proposed alignments is recommended to determine the species distribution and abundance for this region (ECR p.46).

Alignment #1

It is expected that Alignment #1 will replace approximately 1,051 acres of aquatic invertebrate habitat with wetland and upland habitat.

Alignment #2

It is expected that Alignment #2 will replace approximately 2,074 acres of aquatic invertebrate habitat with wetland and upland habitat.

3.5.4.3 Birds

Barren Island provides valuable habitat for avian species. As mentioned in the introduction, Barren Island serves as a satellite refuge of the Blackwater National Wildlife Refuge, and is an important nesting, nursery, and wintering area for colonial waterbirds, wading birds, and some Federally-listed and State-listed endangered species. A great blue heron (*Ardea herodias*) rookery is located on the south end of the Island, as well as a bald eagle nest (federally threatened; *Haliaeetus leucocephalus*). A brown pelican (*Pelecanus occidentalis*) nesting area is located on a small breakaway portion of Barren Island located approximately 500 yards to the south of the Island. The least tern (federally endangered; *Sterna antillarum*) and black skimmer (state endangered; *Rynchops niger*) also utilize the island. The island is preferentially selected by migratory bird species because of its relative lack of human disturbance and predators (USACE, 1994) (ECR p.52-56).

Based upon a review of the University of Maryland 1:50,000-scale map "Barren Island: Protected Species", colonial nesting waterfowl and bald eagle nests occur in the vicinity of Barren Island. This information agrees with the site-specific information collected by WESTON as part of the ECR.

Some terrestrial species, particularly nesting birds, will likely avoid the western and southern shores of the island during construction activities. This impact will be short-term, lasting only during the construction and, to a lesser extent, placement phases.

Great blue herons (*Ardea herodias*) lay eggs in March and April, incubate the eggs for one month, and fledglings leave the nest by early July. Brown pelican (*Pelecanus occidentalis*) lays eggs from late winter to early spring, and incubates the eggs for 30 days. Bald eagles (*Haliaeetus leucocephalus)* lay eggs between January and March, incubate the eggs for 35 days, and the fledglings leave the nest in 10 to 12 weeks (ECR p.84).

The University of Maryland 1:50,000-scale "Barren Island: Waterfowl and Shorebird Usage" (see Appendix E, Figure E-12) indicates that the easternmost portion of the proposed project area is utilized by waterfowl, wading birds, and shorebirds. This map also indicates that Barren Island in its entirety and the area to the east of Barren Island are utilized by waterfowl, wading birds, and shorebirds. Lastly, this map indicates that there are two colonial nesting sites on Barren Island. This information agrees with the site-specific information collected by WESTON as part of the ECR.

Alignment #1

The potential negative impact on birds is expected to be somewhat less significant for Alignment #1 compared to Alignment #2 because of the shorter construction and placement periods. Impacts to birds from the construction and placement of dredged material could be minimized by using similar techniques and timing employed as part of the Poplar Island Environmental Restoration Project.

Once the Alignment is completed, the overall impact of the project is expected to be positive because of the construction of approximately 1,051 acres of new habitat, as well as the protection of existing avian habitat by protecting the shoreline of Barren Island from further erosion. If specialized habitats for certain bird species are created (e.g., bare oyster shell nesting areas for least terns), the overall positive impact is expected to be significant.

Alignment #2

The potential negative impact on birds is expected to be somewhat more significant for Alignment #2 compared to Alignment #1 because of the longer construction and placement periods. Impacts to birds from the construction and placement of dredged material could be minimized by using similar techniques and timing employed as part of the Poplar Island Environmental Restoration Project.

Once the Alignment is completed, the overall impact is expected to be positive because of the construction of approximately 2,074 acres of new habitat, as well as from the protection of existing avian habitat by protecting the shoreline of Barren Island from further erosion. If specialized habitats for certain bird species are created (e.g., bare oyster shell nesting areas for least terns), the overall positive impact is expected to be significant.

3.5.4.4 Wildlife

Barren Island is known to support white-tailed deer (*Odocoileus virginianus*), diamondback terrapin (*Malaclemys terrapin terrapin*), redbelly turtle (*Pseudemys rubriventrus*), and various other terrestrial mammals, reptiles, and amphibians, although BNWR Refuge Manager John Gill indicated that the USFWS has not conducted any mammal or herpetological surveys on Barren Island (ECR p.55-57).

Impacts on terrestrial biological resources during the construction phase are expected to be small because the majority of the activities will be conducted offshore. It is not expected that there will be a loss of vegetation or terrestrial habitats on the island itself. Some terrestrial species, particularly nesting birds, will likely avoid the western and southern shores of the island during construction activities. This impact will be short-term, lasting only during the construction and, to a lesser extent, placement phases (ECR p.85).

The constructed tidal marsh areas will provide habitat for wildlife that utilize these systems and increase the area of salt marsh systems in the area (ECR p.84).

Alignment #1

Alignment #1 will create an estimated 500 acres of upland and 500 acres of marsh habitat for the wildlife on and around Barren Island. In addition, Alignment #1 will protect the current habitats present on Barren Island, including old-growth forest that cannot be easily replaced. Alignment #1 provides approximately ½ the area of additional habitat than Alignment #2, and therefore the positive impact on wildlife habitat is not as significant as Alignment #2.

Alignment #2

Alignment #2 will create an estimated 1,000 acres of upland and 1,000 acres of marsh habitat for the wildlife on and around Barren Island. In addition, Alignment #2 will protect the current habitats present on Barren Island, including old-growth forest that cannot be easily replaced. Alignment #2 will provide almost twice the available habitat for wildlife than Alignment #1, and therefore is expected to be a more positive impact in this regard.

3.5.4.5 Threatened and Endangered Species

No formal survey of threatened and endangered species has occurred on Barren Island to the knowledge of USFWS. An active bald eagle (federally threatened) nest is located on the island. A brown pelican nesting area is located on a small breakaway portion of Barren Island located approximately 500 yards to the south of the Island. Suitable habitat for the Delmarva fox squirrel (federally endangered; *Sciurus niger cinereus)* and the northeastern beach tiger beetle (federally threatened, *Cicindela dorsalis dorsalis*) were observed on the island. The least tern (federally endangered) and black skimmer (state endangered) are known to frequent the island. Sea turtles such as the endangered Atlantic loggerhead (*Caretta caretta*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and leatherback sea turtle (*Dermochelys coriacea*), are occasionally found in the waters surrounding Barren Island, Bishops Head Point, and Spring Island (BNWR, 1999) (ECR p.57-58).

Several species in Need of Conservation (MD list) also occur on BNWR and could potentially occur on Barren Island: black rail (*Laterallus jamaicensis*), Henslow's sparrow (*Ammodramus henslowii*), sedge wren (*Cistothorus platensis*), northern harrier (*Circus cyaneus*), and rare skipper (*Problema bulenta*) (BNWR, 1999) (ECR p.57-58).

Based upon a review of the University of Maryland 1:50,000-scale "Barren Island: Protected Species" map, colonial nesting waterfowl and bald eagle nests occur in the vicinity of Barren Island. This information agrees with the site-specific information collected by WESTON as part of the ECR.

Alignment #1

Alignment #1 will create an estimated 500 acres of upland and 500 acres of marsh habitat for the threatened and endangered species on and around Barren Island. In addition, Alignment #1 will protect the current habitat of Barren Island, including old-growth forest that cannot be easily replaced. A component of the environmental restoration could be the creation of habitat suitable for use by threatened and endangered species (i.e., the placement of oyster shells in upland areas for least tern nesting). Alignment #1 provides approximately ½ the area of additional habitat than Alignment #2, and therefore the positive impact on wildlife habitat is not as significant as Alignment #2.

Alignment #2

Alignment #2 will create an estimated 1,000 acres of upland and 1,000 acres of marsh habitat for the threatened and endangered species on and around Barren Island. In addition, Alignment #2 will protect the current habitat of Barren Island, including old-growth forest that cannot be easily replaced. Alignment #2 will provide almost twice the available habitat for wildlife than Alignment #1, and potentially greater opportunity to construct protected species-specific habitats (i.e., bare oyster shells for least tern nesting) to benefit threatened and endangered species.

3.5.4.6 Submerged Aquatic Vegetation

SAV beds have been documented on the south and east sides of Barren Island by VIMS, as shown in Figure 11 of the ECR. Dense beds of SAV were observed to the east and south of Barren Island during the Site Reconnaissance on 10 October 2001 (ECR Appendix A) (ECR p.59).

The proposed project would provide additional wave shadow around Barren Island, which would likely increase the potential SAV habitat in the area. Increasing SAV habitat around Barren Island would contribute to the Chesapeake Bay Program's overall goal to increase SAV beds in the Bay. The proposed project would provide additional nesting and feeding habitat for a wide variety of waterfowl, and would likely contribute to local fish habitat through increasing SAV beds (ECR p.87).

The Chesapeake Bay Program has developed a three-tiered framework of SAV restoration goals or targets, these are:

- Tier I goal: To restore or establish SAV in areas of historic (1971 to 1990) distribution.
- Tier II target: To restore or establish SAV in potential habitat to a depth of 1 meter.
- Tier III target: To restore or establish SAV in potential habitat to a depth of 2 meters.

These goals and targets imply protection of potential habitat that currently is unvegetated. In 1993, the Chesapeake Executive Council adopted an interim goal to restore 114,000 acres of SAV Baywide, which corresponds to the Tier I SAV goal (see Directive 93.3) (CBP, 2002).

The University of Maryland 1:50,000-scale map "Barren Island: Submerged Aquatic Vegetation with Tier 1 and Tier 2 Habitat" (see Appendix E, Figure E-9) indicates that there are no Tier 1 habitat locations in the proposed project area. There are several Tier 1 locations identified east of Barren Island, and SAV is identified in several of these areas during the 1970's, 1990's and 2000. Water depths depicted on this map indicate that a mixed environment ranging from 0-1 meter Tier 2 habitat, 1-2 meter Tier 3 habitat, and >2 meter (i.e., non-SAV) habitats are present within the proposed project area.

Alignments #1 and #2

A review of the SAV bed data from 1991 through 2000 confirms that there are currently no, nor have there been during that time period, any SAV beds within the concept area of either of the proposed alignments. SAV beds are located to the east, north, and south of Barren Island. To the east and south, these beds are shown to be immediately adjacent to Barren Island in the most recent SAV maps (1999 and 2000) (ECR p.62). The proposed project would provide additional wave shadow around Barren Island, which would likely increase the potential SAV habitat in the area.

3.5.4.7 Estuarine Wetlands

WESTON consulted the United States National Wetlands Inventory (NWI) maps for the Barren Island area (Barren Island and Honga, MD, quadrangles) to determine wetland types present on the island. NWI maps indicate that both estuarine and palustrine wetlands are present on Barren Island, as shown in Figure 12 of the ECR (ECR p.63-67).

The types of habitat that comprise these wetland areas include high quality tracts of salt marshes, and to a lesser extent brackish bay marsh. The salt marshes are dominated by a few species of emergent, salt-tolerant grasses (*Spartina sp.*), although other species of herbaceous plants may be present. Brackish bay marshes contain a wider array of plant species. Table 19 of the ECR lists the species of plants expected to occur in the estuarine wetlands on Barren Island (ECR p.63-67).

Currently, the western shoreline is eroding quite rapidly. The addition of either proposed alignment will reduce or eliminate this erosion. In addition, both proposed alignments will augment the current habitat by providing a tidal gut between Barren Island and the dike alignment (ECR p.84-87).

It is possible that increased turbidity could potentially impact some of the low marsh areas on the western shore of Barren Island by increasing sedimentation in these areas. Any potential impacts would be monitored closely during construction of the dike system and placement of the dredged material to reduce impacts (ECR pp. 84-87).

Alignment #1

By providing protection to Barren Island itself, this alignment will protect the current estuarine wetlands on the Island.

It is estimated that upon completion of the beneficial use project, Alignment #1 will create approximately 500 acres of estuarine wetlands.

Alignment #2

By providing protection to Barren Island itself, this alignment will protect the current estuarine wetlands on the Island.

It is estimated that upon completion of the beneficial use project, Alignment #2 will create approximately 1000 acres of estuarine wetlands.

3.5.4.8 Forested Areas

An estimated 65-70% of Barren Island uplands consist of forested areas (J. Gill, personal communication, 2001). The canopy is dominated by loblolly pine (*Pinus taeda*), with lesser coverage by other deciduous and coniferous trees and shrubs (ECR p.67-69).

Alignment #1

Initially, there will be no additional forested areas created by Alignment #1. However, Alignment #1 will protect the currently eroding, old-growth forest of Barren Island from further erosion. In addition, over time, it is anticipated that some of the upland portion of the alignment will gradually and naturally become forested.

Alignment #2

Initially, there will be no additional forested areas created by Alignment #2. However, Alignment #2 will protect the currently eroding, old-growth forest of Barren Island from further erosion. In addition, over time, it is anticipated that some of the upland portion of the alignment will gradually and naturally become forest.

3.5.4.9 Commercial Fisheries

3.5.4.9.1 Blue Crab

The commercial harvesting of blue crabs (*Callinectes sapidus*) is vital to the life and culture of the Chesapeake Bay region. The Hillsboro Office of the Maryland Natural Resources Police (MNRP) regularly patrol the waters of Dorchester County. This agency was contacted regarding the level of commercial fishing activity in the vicinity of proposed project. Corporal Randy Bowman, the officer that patrols the area including Barren Island, indicated that crab pots are regularly deployed on the west side of the Island, from approximately 100 yards offshore to the navigation channel. Crabbing occurs during the spring, summer, and fall in the area that is colloquially called 'Barren Island Grounds' (Bowman, personal communication, 2001) (ECR p.70-71).

The University of Maryland 1:50,000-scale map "Barren Island: Winter Mean Crab Abundance (1990 – 1998) (see Appendix E, Figure E-2) indicates that the proposed project area lies within the transition zone from a high crab abundance area just east of Barren Island to a lower crab abundance area west of the Island. Overall, it appears that the crab abundance in the proposed project area is classified as medium-high, and winter crab abundance to the east of Barren Island is classified uniformly as high.

Placement of the dike system and subsequent placement of dredged material will result in a reduction of crabbing areas within the selected alignment. These effects will be permanent. These areas are currently considered productive based upon conversations with local MNDP, and from the visual observations of >30 crab pots near Barren Island during the Site Reconnaissance. There is currently no way to accurately assess the productivity of these crabbing areas without conducting personal interviews with local waterman; therefore, it is impossible to adequately determine the economic and ecological impact of the loss of these crab areas (ECR p.90).

Alignment #1

It is expected that Alignment #1 will result in a loss of commercial blue crab fishing grounds.
Alignment #2

It is expected that Alignment #2 will result in a loss of commercial blue crab fishing grounds. The overall loss of crab fishing grounds is expected to be higher for Alignment #2 than Alignment #1, since the project concept area is twice as large for Alignment #2.

3.5.4.9.2 Oysters

The MDNR Fisheries Service was contacted and Maryland Natural Oyster Bar Charts were used to determine whether any natural oyster bars (NOBs) were located within the proposed concept area of the proposed project. Based upon this review, it was determined that two NOBs (NOB 23-2 and NOB 23-4) are in areas adjacent to the proposed dike alignment (MD DNR, 1961). NOB 23-2 is located to the north and NOB 23-4 to the east of both proposed alignments. The location of the NOBs relative to the two proposed alignments are shown in Figure 7 of the ECR. The specific productivity of individual oyster beds is not available; however, oyster harvest data (in bushels) from this region (MD DNR Zone 129) is available and listed in Table 22 of the ECR. Since 1990 the greatest number of bushels harvested was in 1998, and has decreased in 1999 and 2000. Oystering is not permitted in Tar Bay or the Honga River (ECR p.71-75).

The University of Maryland 1:50,000-scale map "Barren Island: Classified Shellfish Areas" (see Appendix E, Figure E-3) indicates that the entire Barren Island area is considered to have low oyster abundance.

The University of Maryland 1:50,000-scale map "Barren Island: Oyster Bar Delineations" (see Appendix E, Figure E-8) indicates that there are several legally designated Natural Oyster Bars (NOB) and several historical oyster bars around Barren Island. In addition, the University of Maryland map also indicates that there are two oyster restoration areas located to the east and southeast of the Island. None of the restoration areas are located within the proposed project area. The University of Maryland map information correlates well with other oyster bar information presented in the ECR report.

The dike alignment was developed to optimize the storage capacity of the island, while at the same time preventing coverage of the Natural Oyster Bars (NOBs) that exist in the Barren Island region (CERS p.2). As shown in Figure 3 of the CERS, NOBs exist to the north, south, and east of Barren Island. The two alignments for the proposed project do not directly impact either of the two NOBs in the vicinity of Barren Island. If the project moves forward, turbidity of the surrounding waters will be closely monitored and addressed during construction to reduce impacts to surrounding oyster bars. The impact of potential increased sedimentation on the overall oyster productivity in the Bay is not expected to be significant (ECR p.90).

Based upon the figures presented in the GRS, it appears that two portions of the borrow area used for borrow volume calculations lie partially within NOB 23-2 and NOB 23-6.

Alignment #1

Alignment #1 for the proposed project does not directly impact either of the two NOBs in the vicinity of Barren Island. If the project moves forward, turbidity of the surrounding waters will be closely monitored and addressed during construction to reduce impacts to surrounding oyster bars. The impact of potential increased sedimentation on the overall oyster productivity in the Bay is not expected to be significant (ECR p.90).

Alignment #2

Alignment #2 for the proposed project does not directly impact either of the two NOBs in the vicinity of Barren Island. If the project moves forward, turbidity of the surrounding waters will be closely monitored and addressed during construction to reduce impacts to surrounding oyster bars. The impact of potential increased sedimentation on the overall oyster productivity in the Bay is not expected to be significant (ECR p.90).

3.5.4.9.3 Soft Shell Clams

The MNRP indicated that no clamming occurs in the concept area of the proposed project. The closest clamming activity is for soft shell clams, and is located south of the Island, north of Ferry Bridge (Bowman, personal communication, 2001). Clamming is not permitted in Tar Bay or the Honga River (ECR p.76).

Information on the health and productivity of soft shell clams in the vicinity of Barren Island is not available. MDNR Shellfish Division reviewed all soft shell clam survey information available for the last 5 years, and determined that no specific survey information on the health and/or productivity of soft shell clams in the vicinity of Barren Island is available (E. Campbell, personal communication, 2001) (ECR p.76).

The University of Maryland 1:50,000-scale map "Barren Island: Classified Shellfish Areas" (see Appendix E, Figure E-8) indicates that the soft shell clam abundance is either not classified in this area or is non-existent. This information correlated well with the information presented in the ECR.

Alignments #1 and #2

Fisheries statistics from MDNR indicate that soft shell clamming does not occur in the vicinity of Barren Island; therefore, there will be no direct impacts to clamming from either Alignment #1 or #2.

3.5.4.9.4 Finfish

The MNRP indicated that 4-pound nets for commercial fishing are regularly deployed on the west side of Barren Island, approximately one-quarter mile offshore of the island in the area locally called 'Barren Island Grounds'. MNRP estimated that there are 8 potential pound nets sites in this stretch, although only 4 nets have been deployed during the last 4 to 5 years. Pound nets in this vicinity catch weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), striped bass (*Marone saxatilis*), Atlantic croaker (*Micropogonias undulates*), and summer flounder (*Paralychthys dentatus*). Nets range in length from 300 to 500 yards (500 yards is the maximum permitted length). Trotlines and eel pots are occasionally sited in Tar Bay (Bowman, personal communication, 2001). The location of the Barren Island Grounds in shown in Figure 14 of the ECR. Both of the proposed alignments will be sited in the southern half of the Barren Island Grounds (compare Figures 3 and 15) (ECR p.76-79).

MNRP have confirmed that commercial fishing of menhaden, rockfish, and summer flounder is conducted west of Barren Island, presumably in the concept area of the proposed alignments on Barren Island Grounds. As with commercial blue crab fishing, there is no way to accurately assess the productivity of these fishing areas without conducting personal interviews with local waterman. Therefore, it is impossible to adequately determine the economic and ecological impact of burying these fisheries. The overall impact of the project on Bay commercial fishing is not expected to be significant (ECR p.90).

The University of Maryland 1:50,000-scale map "Barren Island: Commercial and Recreational Fishing Grounds" (see Appendix E, Figure E-7) indicates that there are no commercial or recreational fishing grounds within the proposed project area. This information does not appear to be complete, however. Personal communications with local authorities, including the Maryland Natural Resources Police and information obtained during the 10 October 2001 site visit by WESTON, indicate that there are commercial fishing grounds within the proposed project area and in very close proximity to Barren Island. The University of Maryland map does indicate that there is a recreational fishing ground approximately 2 miles south of the southernmost boundary of the proposed project area.

Alignment #1

It is expected that Alignment #1 will result in a loss of commercial fin fishing grounds.

Alignment #2

It is expected that Alignment #2 will result in a loss of commercial fin fishing grounds. The overall loss of commercial fin fishing grounds is expected to be higher for Alignment #2 than Alignment #1, since the project concept area for Alignment #2 is twice as large.

3.5.5 Recreational Resources

Recreational fishing and boating that occurs within the proposed project areas will be permanently displaced as the result of this action. It is anticipated that these activities will resume around Barren Island when the project is completed, and will ultimately be enhanced by island stabilization and the creation of additional habitat. Because Barren Island is a federal wildlife refuge and its access is restricted by USFWS permit only, no other impact on recreational activities is expected. USFWS has considered opening Barren Island to the public for kayak tours and similar activities, but no formal proposals have been made. It is likely that the proposed project would enhance the ability of Barren Island to support and maintain this type of recreational activity by increasing available habitat and providing additional refuge areas for sensitive species. Increasing the human recreational activities around Barren Island in a controlled, constructive manner could ultimately raise the public awareness and involvement with conservation and habitat restoration in the Chesapeake Bay and positively impact similar, future projects (ECR p.91).

Alignment #1

Alignment #1 will create an estimated 1,000 acres of habitat that may also support limited recreation. This type of recreational usage would be beneficial to the overall protection of the Chesapeake Bay through increased awareness and recognized value for such areas.

Alignment #2

Alignment #2 will create an estimated 2,000 acres of habitat that may also support limited recreation. This type of recreational usage would be beneficial to the overall protection of the Chesapeake Bay through increased awareness and recognized value for such areas.

3.5.6 Historical and Cultural Resources

The Maryland Historical Trust was contacted to determine whether any sites of historical or archaeological significance are present on Barren Island. The Maryland Historical Trust indicated via letter that no documented historical, cultural, or archaeological sites are present on the island that would be impacted by the proposed project. Correspondence from this agency is included in Appendix C of the ECR. In addition, no listings for Barren Island were found on the National Register of Historic Places on the Maryland Historical Trust web site (www.marylandhistoricaltrust.net) (ECR p.80).

The University of Maryland 1:50,000-scale map "Barren Island: Cultural Resources" (see Appendix E, Figure E-4) indicates that there are six identified archaeological sites on or very close to Barren Island. The map detail is not sufficient to pinpoint the exact locations of these sites; however, it does not appear that any of these sites are located within the proposed project area. The map does not indicate the presence of any sites on Barren Island or in the proposed project area that are designated as a National Historic Site, Maryland Historic Site, or protected by a historic easement.

A colonial-era cemetery (confirmed during the October 2001 WESTON site visit) is located on the western-central portion of the Island, which is currently eroding into the Chesapeake Bay. The proposed project could potentially afford protection to the cemetery and other undocumented historic and cultural resources by reducing or halting further erosion of Barren Island (ECR p.80).

Alignments #1 and #2

Historical and cultural concerns are identical for Alignment #1 and Alignment #2, with an overall positive effect through erosion protection for the colonial-era cemetery.

3.5.7 Navigation

The proposed project area (i.e., the Barren Island habitat restoration area concept areas, both the 1,000-acre and 2,000-acre proposals) lies east of the main shipping channel in the Chesapeake Bay. The proposed environmental restoration areas range in depth from approximately 3 to 12 feet deep, which makes this area too shallow for commercial shipping. It is likely that this area is utilized by small, private vessels including fishing, recreational, and sailboats. Commercial fisherman and crab-boats also navigate through this area, although this traffic is anticipated to be light due to the shallow depths (ECR p.81).

During construction activities, the local barge and tug traffic will increase around Barren Island. This increased traffic will have a minor impact on overall shipping traffic in the area. This effect is not expected to be significant, although it will be slightly greater for Alignment #2 because of the increased size and length of construction period (ECR p.92).

Alignment #1

Boat traffic around Barren Island is limited due to the shallow waters surrounding the area, including the concept areas. Alignment #1 will force these boats to either travel further east along the eastern shore of Maryland, or further westward near the navigational channel. Alignment #1 could potentially have a minor impact on shipping in the channel resulting from additional smaller boats traveling around Barren Island and passing closer to the navigational channel.

Alignment #2

Similar to Alignment #1, Alignment #2 will force smaller boats to either travel further eastward along the eastern shore of Maryland or further westward near the navigational channel to access the mainland. Alignment #2 could potentially have more of an impact than Alignment #1 in this regard because it will extend further westward from Barren Island. A minor impact on shipping in the channel is possible resulting from additional smaller boats traveling around Barren Island and passing closer to the navigational channel.

3.5.8 Aesthetics/Noise

Barren Island is currently uninhabited, and there are no structures on the island, with the exception of the ruins of the 1930s hunting lodge. "Noise" on Barren Island is typically limited to natural sources such as birds, wildlife, wind, and waves. Anthropogenic noise from passing recreational boats and fishing boats could potentially occur at the island, although these noises were not evident during the site reconnaissance (ECR Appendix A) (ECR p.81).

The noise resulting from activities associated with the proposed project are not expected to significantly impact these areas. Noise from construction may impact nesting birds and other wildlife as previously discussed in this report; however, these impacts are expected to be short-term (ECR p.92).

The viewshed from the island to the north and west is the Bay, with the Maryland's eastern and western shores visible across the Bay. To the east, Upper Hoopers Island lies approximately ½ to ¾ miles east, and is easily seen from the shoreline. Upper Hoopers Island is inhabited, and private homes and docking areas are visible. To the south, a small remnant island that was formerly a part of Barren Island, is prominent. This small island (unnamed) lies approximately 500 yards south of Barren Island (ECR p.81).

Because the proposed project will be located on the western side of Barren Island and will include habitat similar to that currently present on the Island, the impact on the viewscape from the Eastern Shore is expected to be negligible. Barren Island is too far from the Western Shore to impact the viewscape from that direction (ECR p.92).

Alignment #1

Alignment #1 is smaller than Alignment #2 and is, therefore, expected to have a smaller impact on the viewscape around Barren Island. Construction and placement-related noise will occur, although these temporary impacts will be smaller for Alignment #1.

Alignment #2

Alignment #2 is larger than Alignment #1 and is, therefore, expected to have a more significant impact on the viewscape around Barren Island. Construction and placement-related noise will occur as part of the proposed project.

3.5.9 CERCLA Liability

No research to date has indicated that any hazardous, toxic, or radioactive substances exist within or in the vicinity of the proposed project area. The lack of degraded areas near Barren Island supports this finding. No liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) would be associated with the site (ECR p.81-83).

A review of U.S. EPA Region III CERCLA Sites within a 2-mile radius of Barren Island indicated that no CERCLA sites are present (USEPA Region III, no date). Within a 4-mile radius of Barren Island, two CERCLA sites were identified: the Patuxent River Naval Air Station, located approximately 2-1/2 miles west of Barren Island; and the USN Surface Warfare Center - Solomon's Island, located approximately 3 miles west of Barren Island. Figure 15 of the ECR graphically presents these two CERCLA sites, as well as several other CERCLA sites outside of the 4-mile radius, in relation to Barren Island (ECR pp.81-83).

There are no known areas of waste disposal or storage on Barren Island. The USFWS did remove several fuel tanks from the hunting lodge area in the 1990's. These tanks were associated with electrical power generation at the lodge, and they were removed completely. Based upon conversations with Refuge Manage John Gill, there does not appear to be any CERCLA liability issues remaining on Barren Island (ECR p.91).

Alignments #1 and #2

There does not appear to be any CERCLA liability issues associated with either Alignment #1 or Alignment #2.

4 ADDITIONAL STUDY NEEDS

In addition to the evaluation of coastal engineering design parameters for the dike, the CERS recommended that future analyses of regional hydrodynamics be performed. The regional hydrodynamic modeling effort will guide the optimization of the final dike layout and ensure hydrodynamic impacts of the dike system are minimized. The CERS specified that this modeling effort should include an analysis of existing tidal currents around the island, as well as tidal current patterns associated with alternative dike alignments (CERS p. ES-2).

The ECR recommended that additional studies of the shallow water around Barren Island are needed to accurately assess the overall impact of the proposed project, particularly with regard to crabbing productivity, commercial fishing, and the benthic community. (ECR p.94)

The following additional study needs are recommended prior to the implementation of the proposed project (ECR p.94):

- Interview local watermen in the region to assess the commercial and recreational value of the proposed alignments to fisheries.

- Conduct an ecological survey of the shallow water in the concept areas of the proposed project, including an evaluation of benthic communities.

- Delineate existing SAV beds in and around the concept area for the proposed project either through the verification of existing data or through the implementation of field surveys.

- Determine the extent of oyster bar production in and around the concept area.

- Contact National Marine Fisheries Service regarding Essential Fish Habitat after the proposed alignment for the project has been selected.

- Consult with USFWS, MDNR, and other appropriate agencies regarding the proposed project, impacts, and permitting requirements.

- Although not an additional study need, a surface water quality monitoring program should be prepared prior to the onset of the proposed project. Monitoring parameters should at a minimum include DO, TSS, and nutrients.

The final engineering design should incorporate the creation of habitat for selected target species, as well as the proposed ratios of upland and marsh habitat (1:1). It is assumed that Federal, State and Local agencies will provide input regarding the final engineering design. As an example, the least tern, a federally endangered species, requires significant areas of bare oyster shell for nesting. Set-aside areas within each alignment could be incorporated into the overall design at relatively little cost to provide for these types of specific habitat requirements and significantly add to the overall positive impact of this project.

Alignments #1 & #2

No additional alignment-specific study needs, other than those specified above, are anticipated for the proposed project.

5 CONCLUSIONS

Based upon the information presented in the four studies summarized by this report, Barren Island shows great promise as an environmental restoration project. It is strongly recommended that the Barren Island site receive further consideration for the following reasons: 1) very few lasting negative environmental impacts; 2) relatively minor negative impact on overall Chesapeake Bay commercial fishing grounds; 3) significant positive environmental impacts including increased habitat for threatened and endangered species, erosion protection for the rapidly dwindling old-growth forest and pristine habitats on Barren Island, and contribution to the overall goal of the Chesapeake Bay Program by potentially increasing the area of SAV beds around Barren Island; and 4) more than sufficient volume of resident borrow material for dike construction; and 5) competitive placement costs for dredge material.

Based upon the information presented in the four studies summarized in this report, it is recommended that the Barren Island habitat restoration project proceed for further consideration. In order to support the selected alignment option, some additional studies are required as presented in Section 4. Once these studies are complete and a selection is made to proceed with a particular alignment option, a formal engineering design should be prepared.

The currently available information indicates that the 10-foot and 20-foot elevations for both Alignments are feasible at Barren Island. Based on the information from the four studies summarized in this Consolidated Report, it appears that the overall impact of the project would be positive. It also appears that the required volume of borrow material for dike construction is available on-site, and the foundation substrate (with some undercutting) can handle the maximum height dike loads. Note that two portions of the borrow area used for borrow volume calculations lie partially within NOB 23-2 and NOB 23-6. It is recommended that the portions of the borrow areas overlapping NOBs should be eliminated from consideration for use as borrow areas. These overlap areas are small relative to the total size of the borrow areas.

6 REFERENCES

Note: Each of the four Reconnaissance Reports (see Appendices A – D) contains its own reference section. This reference section includes only those sources cited in the Consolidated Report.

ASMFC (Atlantic States Marine Fisheries Commission). 1998. *Guidance for the Development of ASMFC: Fishery Management Plan Habitat Sections and Source Documents*. ASMFC Habitat Management Series # 4. Online: http://www.asmfc.org/Programs/Habitat/Guidelinesfinal.pdf.

Applied Coastal Research and Engineering, Inc. 2002. *Coastal Engineering Reconnaissance Study for Barren Island, Maryland.* February 2002.

BNWR (Blackwater National Wildlife Refuge). 1999. *Environmental Assessment Prepared for the Management Conflicts Associated with Non-migratory (Resident) Canada Geese.* Prepared for the United States Fish and Wildlife Service. Available online: http://blackwater.fws.gov/rcg.html.

CBP (Chesapeake Bay Program). 2001. *Preserving and Restoring Bay Grasses.* Online: http://www.chesapeakebay.net/savrest.htm. Last updated: January 2001. Accessed: August 2002.

E2CR, Inc. (Engineering Construction Consulting Remediation, Inc.). 2002. Geotechnical Reconnaissance Study for Barren Island Chesapeake, MD. February 2002.

Gahagan & Bryant Associates, Inc. 2002. *Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island.* February 2002.

Gahagan & Bryant Associates, Inc. and Moffatt & Nichol Engineers. 1995. *Poplar Island Restoration Project Hydrodynamic and Coastal Engineering Draft Final Report.*

Goda, Y. 1985. *Random Seas and Design of Maritime Structures.* University of Tokyo Press, Japan.

MD DNR (Maryland Department of Natural Resources). 1961. Natural Oyster Bars in Maryland, Chart No. 23.

Moffatt & Nichol Engineers. 2001. *Parsons Island Coastal Engineering Investigation, Preliminary Study.*

USACE (United States Army Corps of Engineers). 1994. *Environmental Assessment: Maintenance Dredging, Honga River and Tar Bay Navigation Channel, Dorchester County, Maryland.* USACE Baltimore District. June 1994.

Van der Meer (1988). Rock Slopes and Gravel Beaches Under Wave Attack. Doctoral Thesis, Delft University of Technology, Netherlands.

Van der Meer (1992). Wave Runup and Overtopping on Coastal Structures. *Journal of Coastal Engineering*.

WESTON (Roy F. Weston, Inc.). 2002. *Preliminary Assessment of Environmental Conditions on Barren Island, Dorchester County, Maryland – Final Report*. Prepared for Maryland Environmental Service. April 2002.

APPENDIX A

APPENDIX A

COASTAL ENGINEERING RECONNAISSANCE STUDY

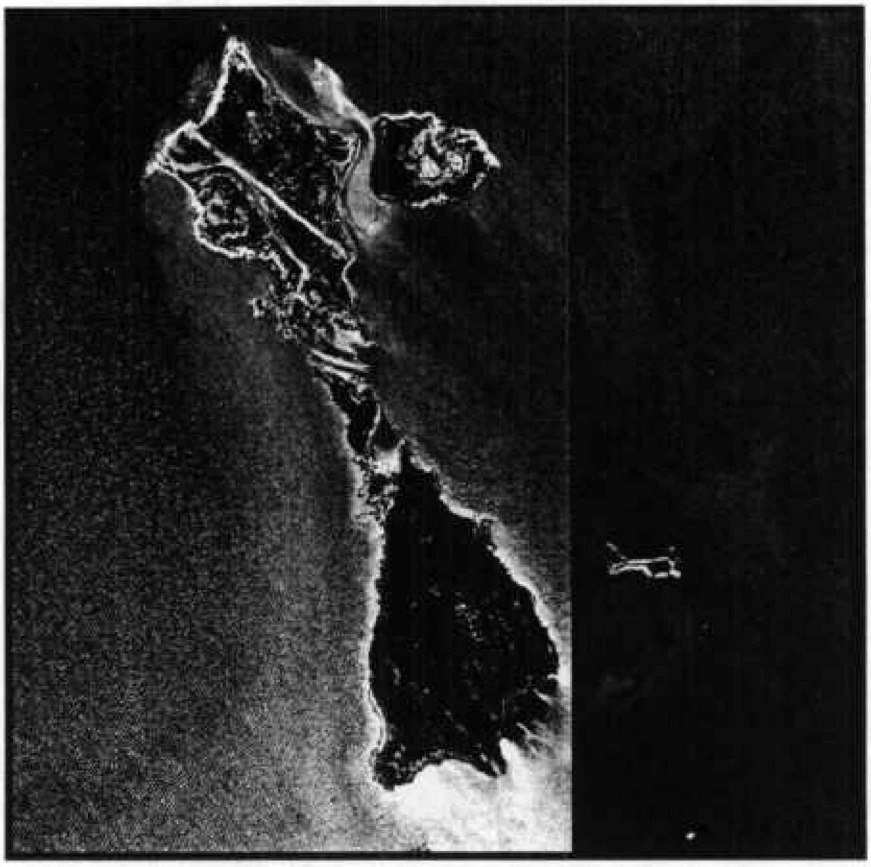
Coastal Engineering Reconnaissance Study for Barren Island, Maryland
Applied Coastal Research and Engineering, Inc.
February 2002

COASTAL ENGINEERING RECONNAISSANCE STUDY FOR BARREN ISLAND, MARYLAND

by Sean W. Kelley
John S. Ramsey
Jessica L. Baker

Applied Coastal Research and Engineering, Inc.
766 Falmouth Road, Building A, Unit 1C
Mashpee, MA 02649

Applied COASTAL



REVISED DRAFT REPORT – February 2002

Prepared for: Gahagan & Bryant Associates, Inc.
9008 Yellow Brick Road, Unit O
Baltimore, MD 21237

EXECUTIVE SUMMARY

This feasibility study provides background and coastal engineering design guidance for the Barren Island site being investigated as a beneficial use dredged material project. The report addresses two major needs of the project, 1) identification and evaluation of available data that can be used to describe environmental (meteorological and hydrological) conditions at the Barren Island site, and 2) design parameters (i.e., stone size and dike elevation) of the two proposed dike alignments based on the environmental conditions. In addition, recommendations for additional coastal engineering analysis and modeling to optimize the dike layout have been provided.

Environmental Site Conditions

Water depths along the two preliminary dike alignments vary from approximately –2 feet MLLW along the east side to more than –9 feet MLLW along the west side. Average water depths for Alignments 1 and 2 are approximately –6 feet. In general, the local bathymetric conditions are shallower to the east and south of the proposed dike alignments.

Design winds were developed from a 32-year data set from Baltimore-Washington International (BWI) Airport. Fastest mile wind speeds were developed for selected return periods ranging from 5 to 100 years. Design winds were developed for each of the eight primary directions (N, NE, E, SE, S, SW, W, and NW).

The mean tide level is approximately 0.8 feet above MLLW and the mean tide range is approximately 1.4 feet. Based on hydrodynamic modeling predictions of storm surges within this portion of Chesapeake Bay, the 50-year surge elevation is 4.6 feet above mean sea level and the 100-year surge level is 5.4 feet above mean sea level.

Using historical wind data from Baltimore-Washington International Airport, estimates of wave heights approaching from eight compass sectors were determined. The USACE computer application ACES was used in this analysis. Wave conditions were determined for the 5, 10, 25, 50 and 100 year return periods.

Coastal Engineering Design

The method of Van der Meer (1992) was utilized for the run up analysis and crest height determination, for a structure with a 3:1 slope. For the 35-year project design conditions, the estimated dike height is approximately 10 ft (MLLW) for the North, West, and South dike sections, and 8 ft (MLLW) for the East dike section. The reduced height of the eastern section is the result of lower waves from the eastern fetch.

Stone sizes determined for the two dike alignments are given in the following table. Maximum wave heights in the surf zone adjacent to the dike were used for stone sizing. For the 35-year design return period, the approximate stone weight for Alignment 1 along the North, West, and South portions of the dike varies between 1.3 tons and 1.5 tons, but is only 111 lbs for the eastern dike section, which is more sheltered. For Alignment 2, there is a similar range in stone sizes between the North, West, and South dike sections.

The required toe armor stone size for the North, West, and South sections of the dike are 1.7 ft (0.4 ton) for Alignment 1, and 2.0 ft (0.7 ton) for Alignment 2, both for 35-year return period waves with a still water elevation corresponding to MLLW. For the East dike section, toe stone size is computed to be 0.8 ft (70 lbs or 0.035 tons) for either of the proposed Alignments.

Dike outer slope armor and underlayer, and toe armor stone sizes (W50 in tons or lbs, and D50 in ft) computed for 35-year return conditions and the two proposed dike alignments, for 3:1 slope.

Dike Section	Dike Layer		
	Outer Slope	*Toe*	*Under-layer*
North Dike Align. 1 (Typical Dike Section No. 4)	1.34 ton 2.54 ft	0.38 ton 1.67 ft	0.13 ton 1.18 ft
West Dike Align. 1 (Typical Dike Section No. 3)	1.35 ton 2.54 ft	0.38 ton 1.67 ft	0.14 ton 1.18 ft
South Dike Align. 1 (Typical Dike Section No. 2)	1.53 ton 2.65 ft	0.38 ton 1.67 ft	0.15 ton 1.23 ft
East Dike Align. 1 (Typical Dike Section No. 1)	111 lbs 0.88 ft	70 lbs 0.75 ft	11.1 lbs 0.41 ft
North Dike Align. 2 (Typical Dike Section No. 4)	1.48 ton 2.62 ft	0.69 ton 2.03 ft	0.15 ton 1.22 ft
West Dike Align. 2 (Typical Dike Section No. 3)	1.30 ton 2.50 ft	0.69 ton 2.03 ft	0.16 ton 1.13 ft
South Dike Align. 2 (Typical Dike Section No. 2)	1.53 ton 2.65 ft	0.69 ton 2.03 ft	0.15 ton 1.23 ft
East Dike Align. 2 (Typical Dike Section No. 1)	111 lbs 0.88 ft	70 lbs 0.75 ft	11.1 lbs 0.41 ft

Recommendations for Additional Coastal Engineering Analyses

In addition to the evaluation of coastal engineering design parameters for the dike, it is recommended that future analyses of regional hydrodynamics be performed. The regional hydrodynamic modeling effort will guide the optimization of the final dike layout and ensure hydrodynamic impacts of the dike system are minimized. This modeling effort should include an analysis of existing tidal currents around the island, as well as tidal current patterns associated with alternative dike alignments.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of the Coastal Engineering Reconnaissance Study is to identify existing data and provide preliminary coastal engineering analyses for the Barren Island beneficial use site immediately west of the existing land. To optimize shore protection design for the proposed beneficial use of dredged material project, it first is necessary to evaluate the wind, wave, and storm surge conditions impacting this site. A statistical analysis of local wind conditions was performed to evaluate the driving forces generating waves within the confines of the Chesapeake Bay. Once "extreme" wind conditions were determined, this information was input to a standard U.S. Army Corps of Engineers program to determine local wave growth.

The design of shore protection for the proposed project site along the Barren Island shoreline is dependent on several factors including site environmental conditions (e.g. local wave activity), construction materials utilized for coastal structures, anticipated life of the structure, and maintenance needs. To assist with the design process, an evaluation of various engineering parameters associated with local wind and wave conditions was performed. The methodology and results of these analyses are described in the following sections.

Combined with the local wave calculations, site-specific topography/bathymetry and storm surge information was utilized to assess various engineering alternatives for shore protection along the Barren Island shoreline. Proposed structures evaluated included various dike layouts needed for the proposed upland and wetland cells.

In addition to the evaluation of coastal engineering design parameters for the dike, it is recommended that future analyses of regional hydrodynamics be performed. The regional hydrodynamic modeling effort will guide the optimization of the final dike layout and ensure hydrodynamic impacts of the dike system are minimized.

1.2 Project Description

The project consists of preparing a preliminary study to determine the feasibility of using the Barren Island area as a beneficial use and habitat restoration site. Overall, this preliminary assessment consists of an evaluation of existing literature and data regarding the environmental, geotechnical, coastal, and dredging engineering aspects of the island.

2.0 SITE CONDITIONS

Barren Island is located in the northern portion of Chesapeake Bay, slightly north and east of the Patuxent River Air Test Center (see Figure 1). In general, waves within this portion of Chesapeake Bay are fetch-limited, where local winds generate the observed wave conditions. The proximity of the island to the eastern shoreline of the Bay prevents significant waves from impacting the island from the east. However, wave exposure in other directions, especially from the south, is more substantial. In addition, surge associated with tropical and extra-tropical storms will expose more of the upland portions of the island to wave attack. An assessment of these environmental factors is described in the following paragraphs.

2.1 Bathymetry

Digital hydrographic data were obtained from the National Ocean Service GEODAS data set. This digital data set provides all of the NOAA bathymetry utilized to generate the local navigation charts; therefore, the information provided generally is more detailed than found on the printed charts. Use of this data allows site-specific evaluation of existing bathymetric conditions in the vicinity of each dike alignment. Based on this data, water depths are relatively shallow along the east and south shorelines of the proposed island, with depths ranging from –3.0 to –4.9 feet MLLW. Depths along the west and north sides were slightly deeper, ranging between –6.4 and -10.3 feet MLLW. Table 1 shows the mean water depths adjacent to proposed Alignments 1 and 2 along each shoreline stretch, where each shoreline stretch is depicted in Figure 2.

The dike alignment was developed to optimize the storage capacity of the island, while at the same time preventing coverage of the Natural Oyster Bars (NOBs) that exist in the Barren Island region. As shown in Figure 3, NOBs exist to the north, south, and east of Barren Island. Therefore, the geographical extent of the preliminary dike alignment was limited. In addition, the western extent of the dike was designed to follow existing bathymetric contours. In this manner, the preliminary alignment minimized the water depth along the western dike that also should minimize construction costs.

Table 1: Mean water depths adjacent to each shoreline segment for Alignments Number 1 and Number 2.

	Mean Water Depth for each Shoreline Segment (feet, MLLW)			
Alignment	East	South	West	North
Number 1	-3.1	-4.3	-9.7	-5.4
Number 2	-2.2	-4.9	-9.6	-7.7

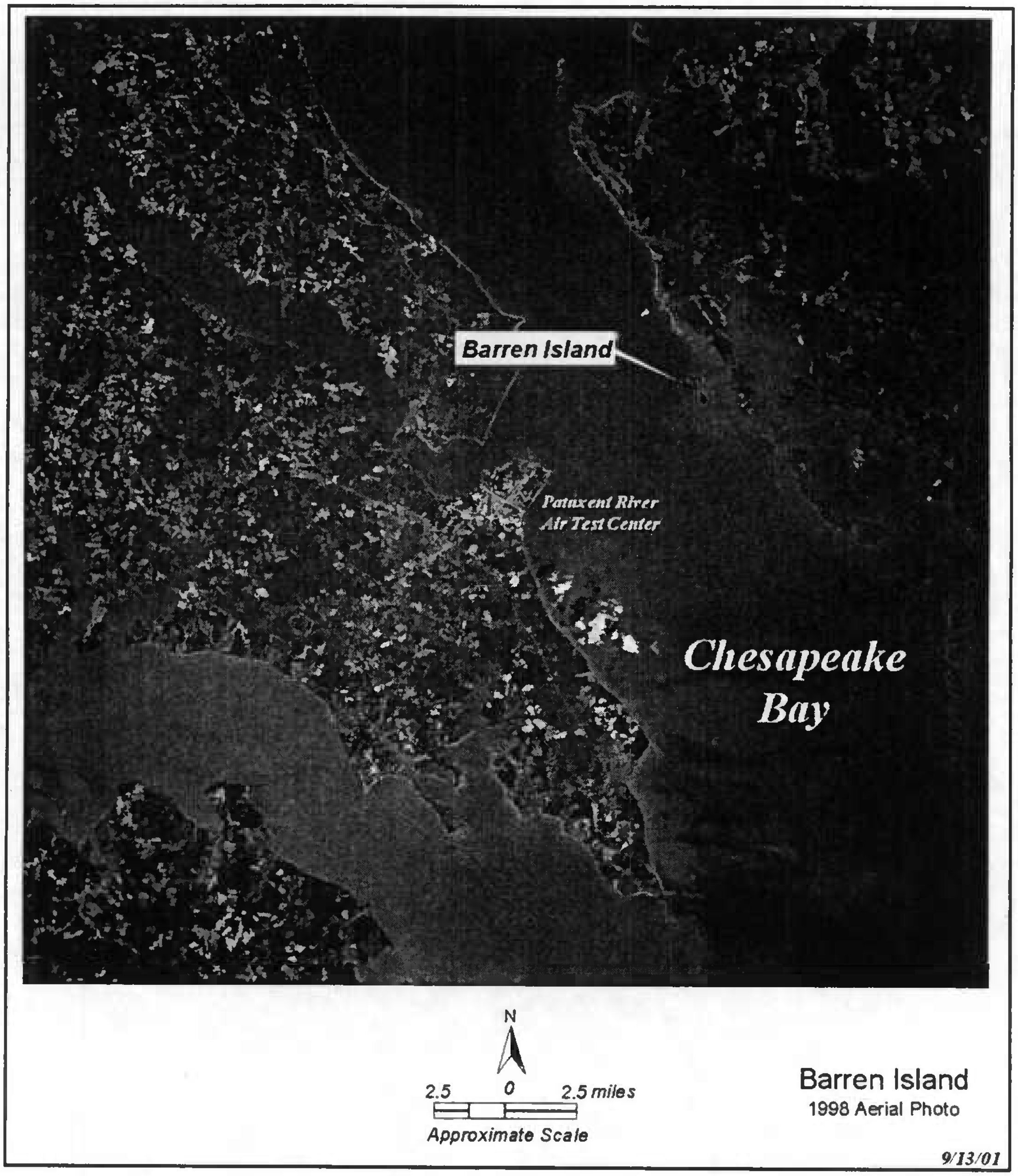


Figure 1: Location of Barren Island in the upper Chesapeake Bay.

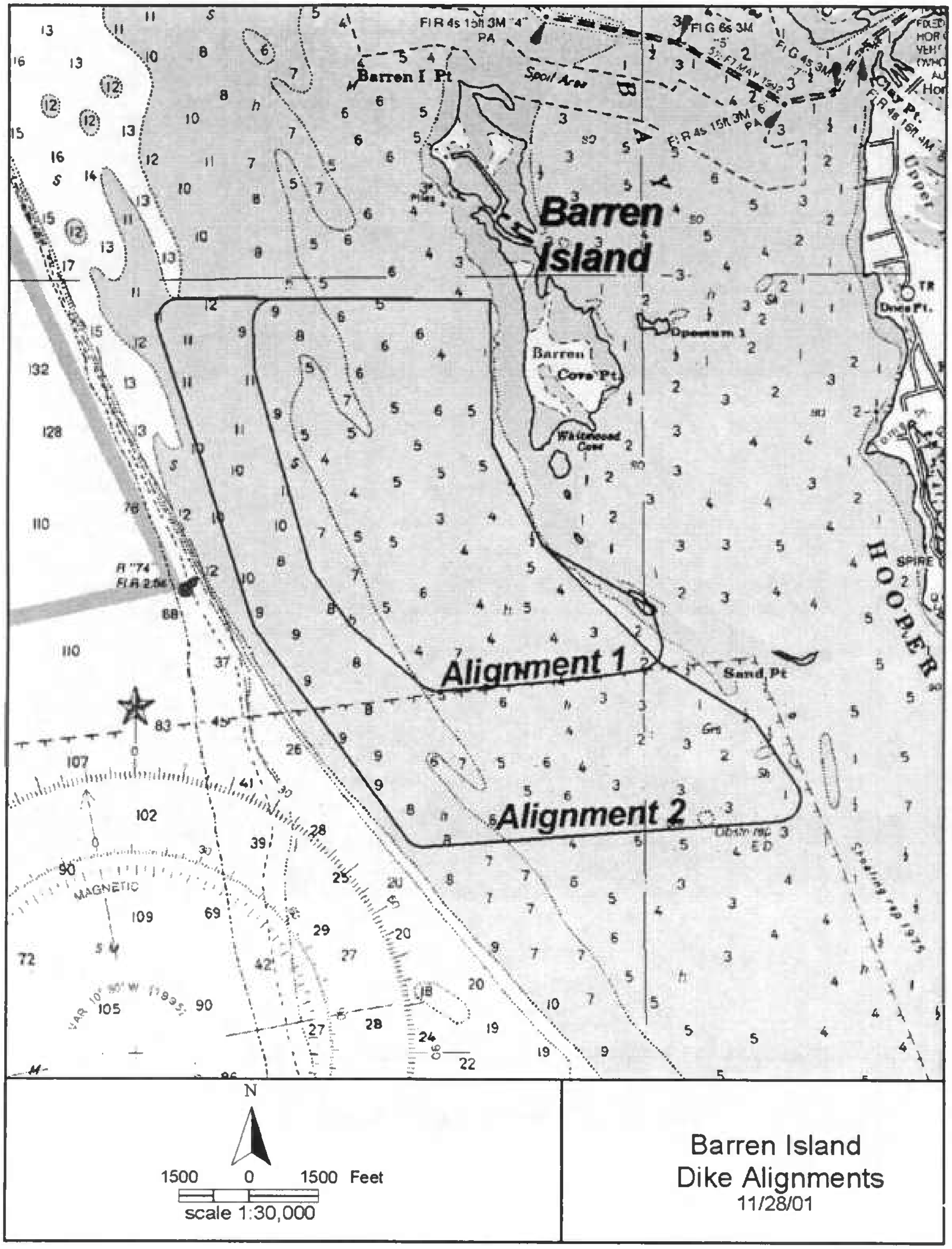


Figure 2: Dike alignments for the proposed 1,000 and 2,000-acre expansions of Barren Island.

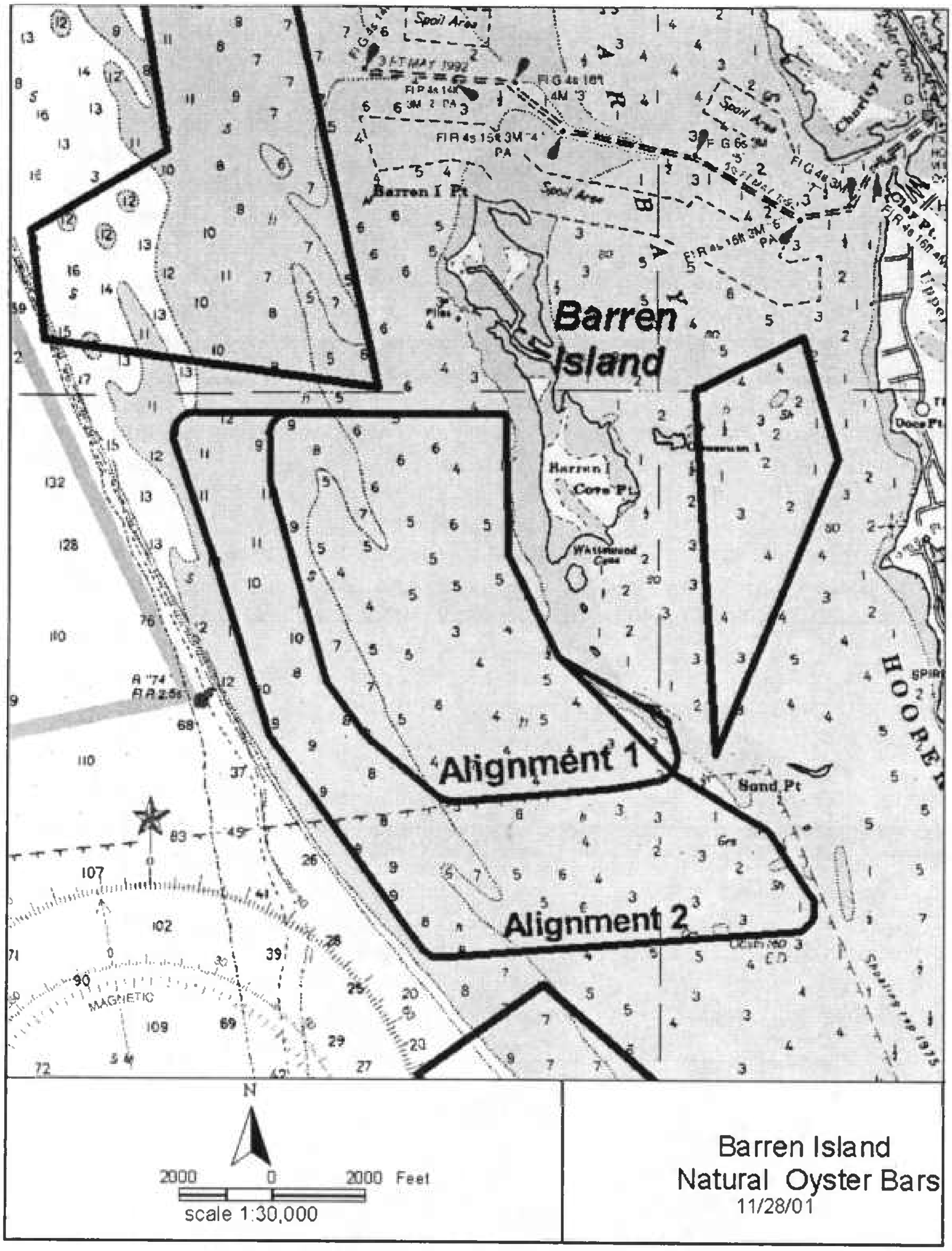


Figure 3: **Dike alignments for the proposed 1,000 and 2,000-acre expansions of Barren Island relative to the limits of the local Natural Oyster Bars (NOBs) shown in green.**

2.2 Wind Conditions

To evaluate wind conditions within the northern portion of the Chesapeake Bay, a statistical analysis of digital wind records from Baltimore Washington International (BWI) Airport was performed. This information was from the National Climatic Data Center, a division of the National Oceanic and Atmospheric Administration (NOAA), and represented data recorded between 1951 and 1982. This same data was utilized for the Coastal Engineering Investigation for Parsons Island (Moffatt & Nichol Engineers, 2001). The wind data set used was the peak daily wind gusts over this period. Since these wind conditions were peak values, they provide a conservative or "worst-case" estimate of the wind conditions that generate the local wave climate. The data shown in Table 2 provides an annual summary of the extreme wind speeds, defined as the highest recorded wind speeds that last long enough to travel one mile during the daylong recording period. For example, a wind speed of 50 miles per hour would require duration of 72 seconds to travel a distance of one mile. Wind speed data was utilized to develop return period relationships based on a Gumbel Distribution for the eight primary directions: N, NE, E, SE, S, SW, W, and NW.

Other wind data sources were available including the Mid Bay station for the Chesapeake Bay Observing System (CBOS) located at 38°28.4' N 76°22.8' W and the Thomas Point, MD NOAA station located at 38.90° N 76.44° W. Although both of these stations are located geographically closer to Barren Island than BWI Airport, the longest data record is only 16 years (1985 to 2000 for the Thomas Point station). Therefore, the 32-year record at BWI Airport represents the best overall wind data set for calculation of extremal characteristics within the northern portion of Chesapeake Bay.

To determine the return frequency of various extreme wind events, a statistical analysis of the data set was performed. The analysis technique required a curve-fit of the statistical distributions derived from the annual extreme wind speed information. Distributions were developed for each of the primary wind directions evaluated above. The results are presented in Table 3. Since the primary purpose for developing wind information is to assess the local wave climate, fastest mile wind speed was converted to one-hour wind speed for input to the U.S. Army Corps of Engineers Automated Coastal Engineering System (ACES). These revised extremal wind conditions are shown in Table 4 and graphically in Figure 3.

Table 2: Annual extreme wind speed for BWI Airport, 1951-1982 (Fastest Mile Wind Speed in mph)								
	Wind Direction							
Year	N	NE	E	SE	S	SW	W	NW
1951	24	41	27	34	39	29	42	46
1952	66	25	47	66	41	66	46	43
1953	20	28	22	27	34	39	47	43
1954	31	27	22	60	28	39	57	44
1955	21	43	29	28	43	53	40	43
1956	29	34	25	24	28	34	56	40
1957	29	53	35	33	33	30	46	46
1958	30	52	25	33	37	43	40	43
1959	28	26	20	27	23	38	46	43
1960	26	38	28	27	25	35	40	53
1961	45	28	28	29	24	70	41	54
1962	56	41	28	17	25	36	42	61
1963	38	32	18	34	25	28	44	60
1964	34	31	23	24	47	23	48	61
1965	36	26	28	34	36	54	44	44
1966	32	25	29	24	47	43	50	48
1967	30	29	25	39	27	46	53	43
1968	45	30	36	26	19	45	48	50
1969	28	21	20	34	26	45	45	53
1970	28	28	18	21	39	34	48	60
1971	31	45	26	18	21	41	39	58
1972	28	25	35	26	20	41	41	41
1973	40	26	26	38	26	35	49	33
1974	32	23	46	29	33	33	45	41
1975	40	26	21	24	25	38	54	45
1976	31	18	20	28	32	28	45	54
1977	32	31	19	28	26	25	49	48
1978	39	28	36	28	19	52	33	45
1979	32	25	27	36	32	32	45	47
1980	33	27	18	32	20	32	45	50
1981	24	24	19	26	23	28	41	42
1982	31	20	23	23	29	34	40	48
Data adjusted to 10-meter (32.8 feet) height.								

Table 3: Design wind speeds for different return periods (Fastest Mile Wind Speed in mph)								
	Wind Direction							
Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	40	37	32	37	36	47	50	54
10	48	44	38	45	43	56	54	59
15	52	48	41	50	47	61	56	62
20	56	52	45	55	51	67	59	65
25	59	55	47	58	54	70	60	67
30	62	57	49	61	56	73	61	68
35	64	60	51	63	58	76	62	70
40	66	62	53	65	60	78	63	71
50	69	66	55	69	63	82	64	73
100	81	76	65	82	74	97	69	81

Table 4: Design wind speeds for different return periods (One-Hour Wind Speed in mph)								
	Wind Direction							
Return Period (years)	N	NE	E	SE	S	SW	W	NW
5	33.4	31.1	27.2	31.1	30.3	38.6	40.9	43.3
10	39.4	36.4	31.8	37.1	35.6	45.3	43.8	47.5
25	47.5	44.6	38.6	46.8	43.8	55.5	48.2	53.3
50	54.8	51.9	44.6	54.8	50.4	64.1	51.1	57.6
100	63.4	59.8	51.9	64.1	58.4	74.7	54.8	63.4

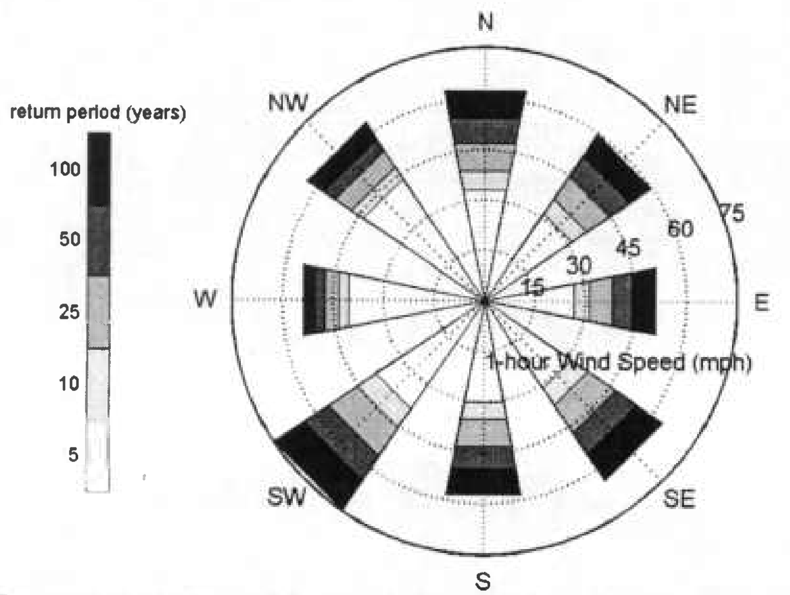


Figure 4: Rose plot of storm 1-hour wind speed from eight compass sectors, for five return periods indicated by gray shaded segments.

2.3 Astronomical Tides

Water levels in the upper Chesapeake Bay typically are dominated by astronomical tides; however, the influence of winds and freshwater discharge also can be important. Based on data from the Solomons Island NOAA Station near the mouth of the Patuxent River, tides within this portion of the Chesapeake Bay are semi-diurnal (twice daily), with a mean tide range of 1.35 feet. The mean tide level is 0.76 feet above MLLW. Table 5 shows the observed tidal characteristics at the Solomons Island NOAA Station. As stated above, the relatively small astronomical tide range combined with wide shallow Chesapeake Bay embayment often allows wind effects to dominate the observed tidal signal. Figure 4 provides predicted and observed water elevations for a typical two-week time period (June 2001). This figure indicates that the meteorological influence during typical conditions can be more than 50% of the tide range (for this two-week period, a maximum of approximately 0.7 feet on June 23rd).

In addition to water level fluctuations, astronomical tides drive currents within the Chesapeake Bay estuary. Based on the XTIDE program, maximum predicted tidal currents off of Cove Point (near the center of the Bay adjacent to Barren Island) are relatively weak, at about 0.8 kts or 1.4 feet/sec. It is anticipated that tidal currents would be lower along the Barren Island Shoreline.

Table 5: Water elevations referred to Mean Lower Low Water (MLLW) datum at Solomons Island, MD NOAA Station

Water Level	Elevation (feet, MLLW)
Highest Observed Water Level (8/13/1955)	4.53
Mean Higher High Water (MHHW)	1.51
Mean High Water (MHW)	1.35
Mean Tide Level (MTL)	0.76
Mean Low Water (MLW)	0.17
Mean Lower Low Water (MLLW)	0.00
Lowest Observed Water Level (12/31/1962)	-3.47

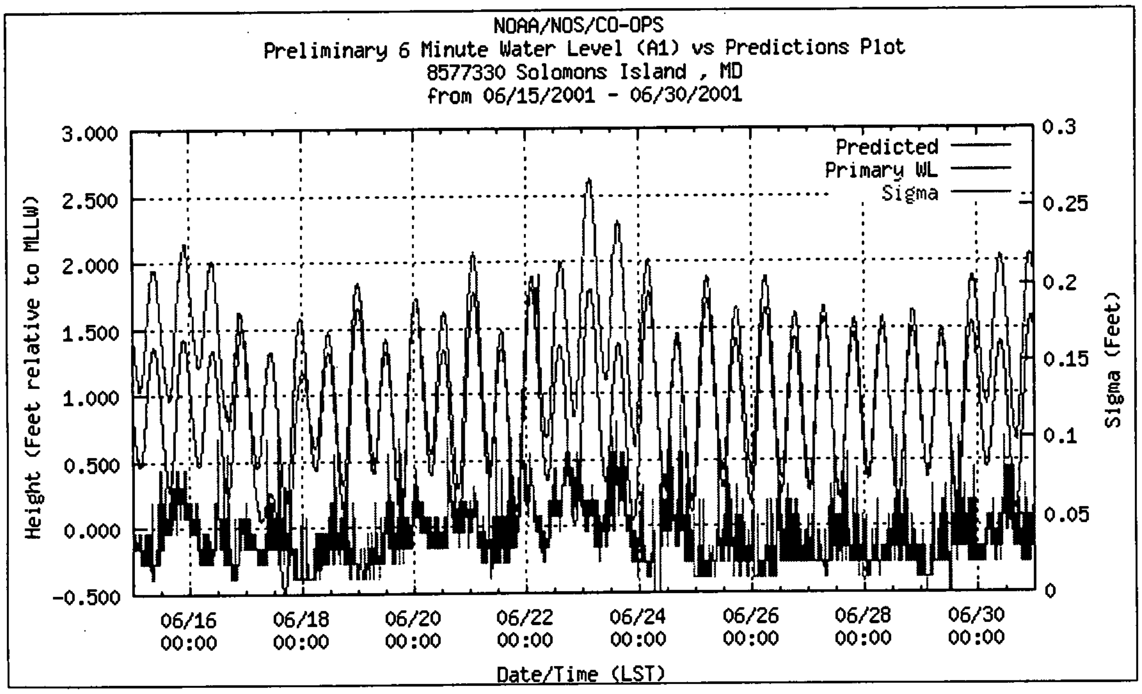


Figure 5: Predicted and observed (Primary WL) water levels at the Solomons Island, MD NOAA Station for the period beginning June 15, 2001 and ending June 30, 2001.

2.4 Storm Surge

Due to the significant influence of storms on Chesapeake Bay water levels, design water levels for coastal engineering structures typically utilize estimates of these extreme conditions. In general, the types of storms causing surge can be divided into two categories: extratropical cyclones (northeasters) and tropical cyclones (hurricanes and tropical storms). Extratropical storms are caused by a frontal wave disturbance originating from the middle latitudes and propagating along the U.S. East Coast in a northeasterly direction. Tropical cyclones originate in lower latitudes and have a distinct rotary circulation at the surface, with wind speeds of 39 to 73 mph for tropical storms and greater than 74 mph for hurricanes. Typically, the relatively high travel speed of tropical cyclones in the middle latitudes limits the storm duration to less than one day. However, the duration of extratropical storms may be several days.

The Virginia Institute of Marine Science (VIMS) conducted a comprehensive evaluation of storm-induced water levels utilizing a numerical hydrodynamic model (Boon, *et al.*, 1978). The modeling analysis extrapolated the influence of various return period surge heights based on observed storm surge levels throughout Chesapeake Bay. Return frequency curves for various surge levels were computed from combined probability distributions of tropical and extratropical storms. From the output generated by the VIMS model, a water level versus frequency curve (Figure 5) was developed for the Solomons Island site (located approximately 8 miles west of Barren Island). Data from this curve for five return frequencies are shown in Table 6.

Table 6: Storm surge levels for selected return periods at Solomons Island, MD		
Return Period (years)	Surge Level (feet, MSL)	Surge Level (feet, MLLW)
5	2.9	3.7
10	3.2	4.0
25	3.8	4.6
35	4.1	4.9
50	4.6	5.4
100	5.4	6.2

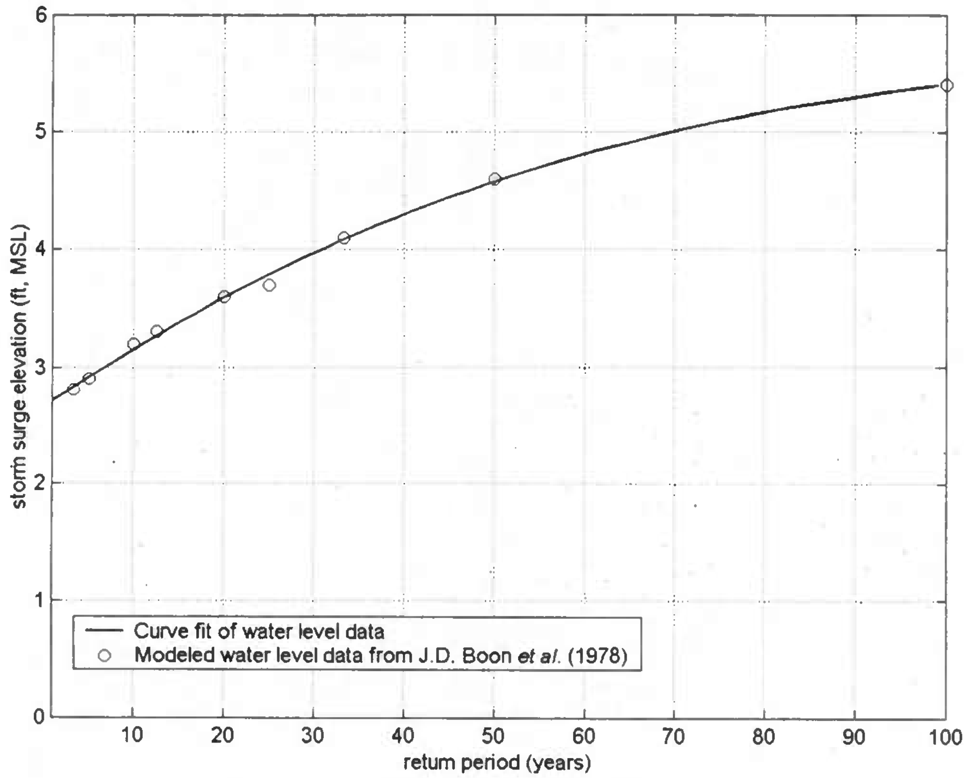


Figure 6: Modeled storm surge elevations versus return period at Solomons Island, MD. The curve fit provides surge elevations at return frequencies not modeled.

2.5 Wave Conditions

As Barren Island is situated within Chesapeake Bay, wave exposure at the site results solely from wind generated waves. Therefore, using historical wind data from Baltimore-Washington International Airport, estimates of wave heights approaching from eight compass sectors were determined. The USACE computer application ACES was used in this analysis. Radially averaged fetch distances and depths for N, NE, E, SE, S, SW, W, and NW sectors (as shown in Figure 6) were determined for the Barren Island site and are presented in Table 7. Fetch depths were determined using NOAA bathymetry data from surveys of Chesapeake Bay. Wave conditions were determined for the 5, 10, 25, 50 and 100 year return periods. This analysis included storm surge levels above the mean fetch depth for each of the modeled return periods. Wave hindcast results are presented in Table 8 (significant wave height, H_s) and Table 9 (peak period, T_p) for the indicated return periods. This same hindcast data is presented as rose plots in Figures 7 and 8.

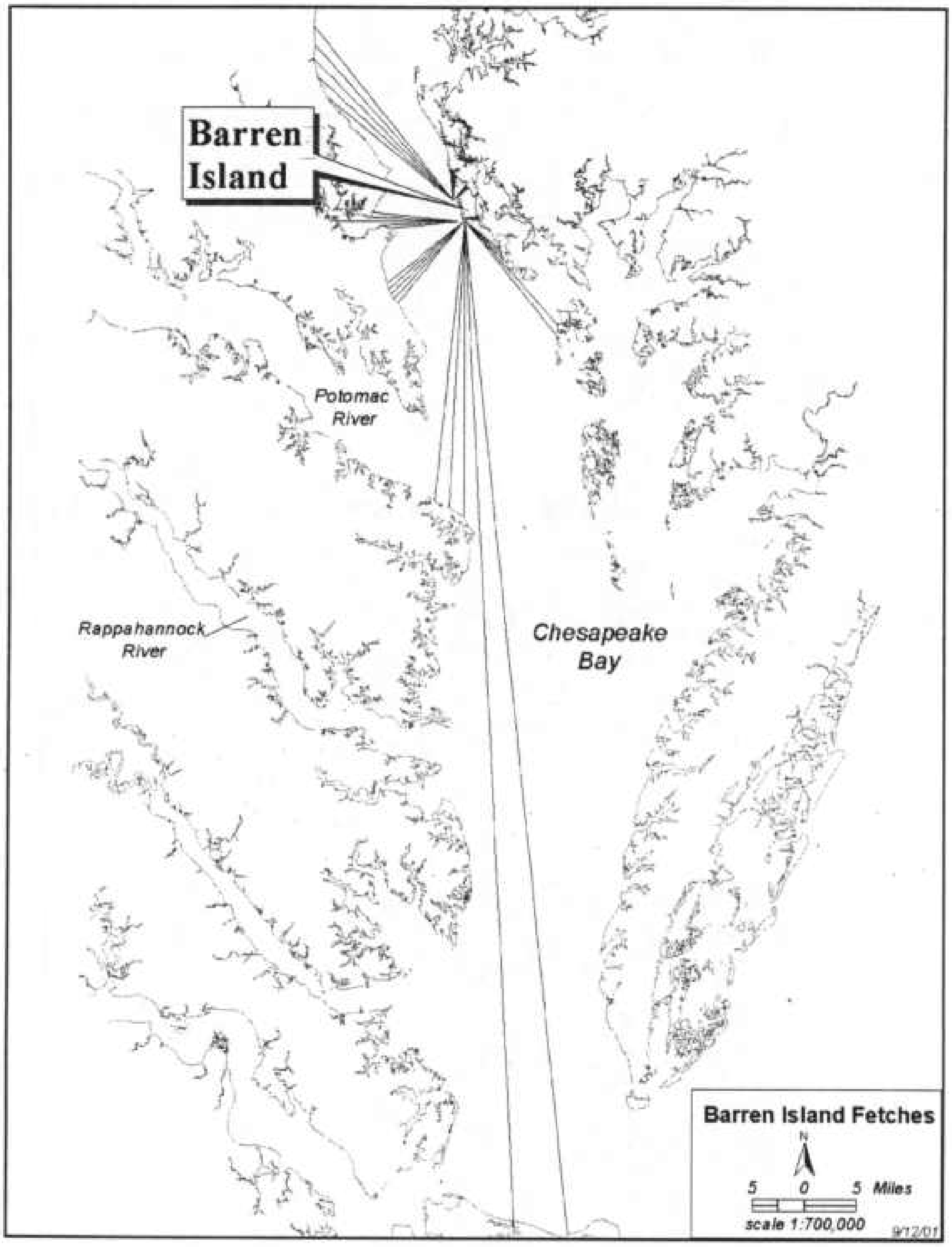


Figure 7: Fetches used to determine average distances and depths for the analysis of wind-waves approaching Barren Island.

Table 7: Radially averaged fetch distance and depth for approaches to Barren Island.		
Compass Sector	Mean Distance (miles)	Mean Water Depth (ft, MLW)
N	2.8	3
NE	1.9	2.6
E	1.6	2.7
SE	8.5	5.5
S	55.3	40
SW	9.9	37.5
W	8.5	40.5
NW	18.6	43.2

Table 8: Hindcast H_s wave height (feet) determined using ACES wind-wave application.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	6.7	4.1	4.1	6.8	1.5	1.2	1	2.1
10	7.6	4.6	4.4	7.4	1.7	1.4	1.2	2.4
25	9	5.9	4.9	8.3	2.1	1.8	1.5	2.9
50	10.1	6.8	5.2	8.9	2.4	2.1	1.7	3.4
100	11.3	7.9	5.6	9.8	2.6	2.4	2.1	3.9

Table 9: Hindcast T_p wave period (sec) determined using ACES wind-wave application.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	5.7	3.9	3.9	5.1	2.3	2.1	1.9	3
10	6	4.2	4	5.3	2.5	2.2	2	3.2
25	6.5	4.5	4.1	5.5	2.7	2.4	2.1	3.5
50	6.7	4.8	4.2	5.7	2.8	2.5	2.3	3.8
100	7.3	5	4.3	5.9	3	2.7	2.4	4

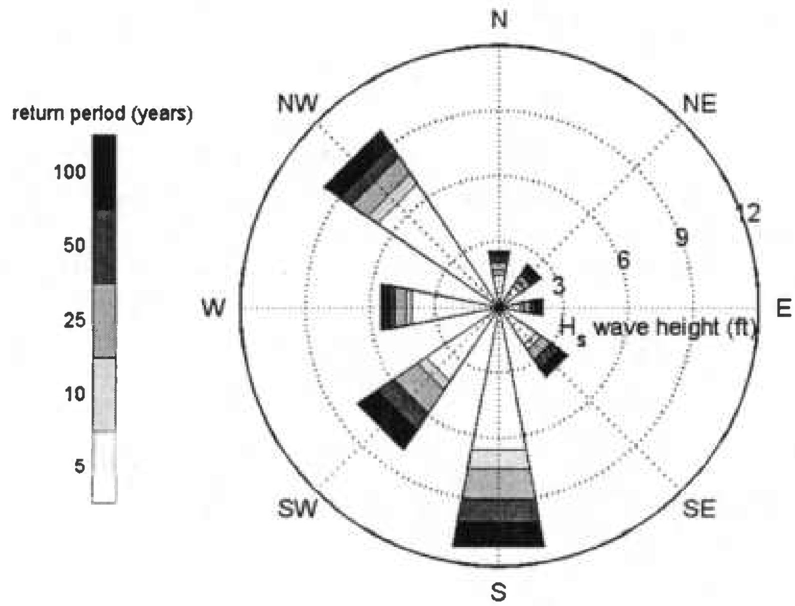


Figure 8: Rose plot of offshore storm wave heights from eight compass sectors, for five return periods. Significant wave heights (H_s) were computed using the USACE program ACES.

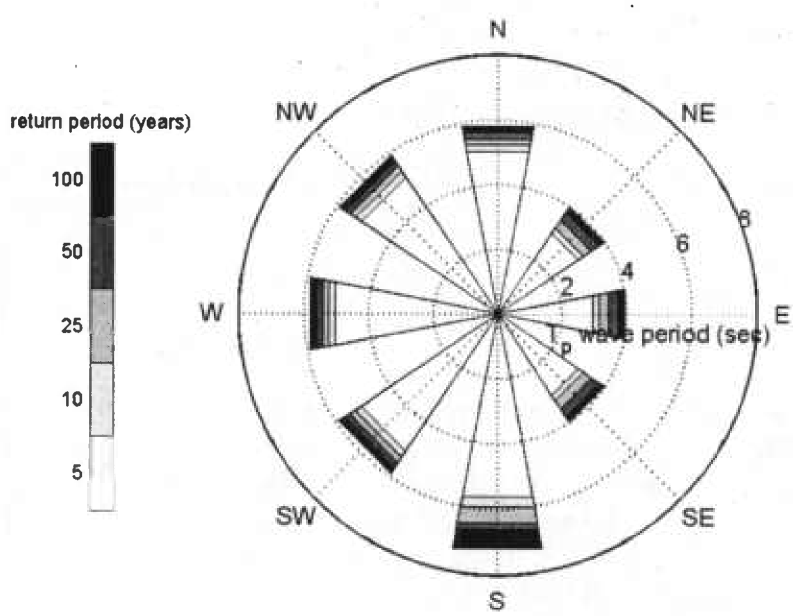


Figure 9: Rose plot offshore storm wave peak periods from eight compass sectors, for five return periods. Wave periods (T_p) were computed using the USACE program ACES.

For the Barren Island site, the highest waves are estimated to approach from the South, were the 100-yr return wave height was computed to be 11.3 ft, with a peak period of 7.3 seconds. For the same southerly exposure, the 35-yr return wave height is estimated to be 9.4 ft. with a peak period of 6.6 seconds.

Random breaking wave relationships developed by Goda (1985) were used to extend the ACES hindcast results to the toe of the dike at Barren Island. This additional step is required because the ACES results represent the offshore wave conditions propagating to the site, and do not include the effects of wave breaking (energy dissipation) and shoaling (wave steepening) in the immediate vicinity of the dike structure. The following relationships from Goda (1985) where used to determine significant wave heights (H_s) and maximum wave heights (H_{max}) in the surf zone at the dike:

$$H_s \equiv H_{1/3} = \begin{cases} K_s H'_0 & : h/L_0 \geq 0.2, \\ \min\{(\beta_0 H'_0 + \beta_1 h), \beta_{max} H'_0, K_s H'_0\} & : h/L_0 < 0.2, \end{cases}$$

$$H_{max} \equiv H_{1/250} = \begin{cases} 1.8 K_s H'_0 & : h/L_0 \geq 0.2, \\ \min\{(\beta_0^* H'_0 + \beta_1^* h), \beta_{max}^* H'_0, 1.8 K_s H'_0\} & : h/L_0 < 0.2, \end{cases}$$

where H_o and L_0 are the deepwater wave height and wavelength, h is the bottom depth at the dike, K_s is the shoaling coefficient, and the symbol $\min\{a,b,c\}$ stands for the minimum value among a, b, and c. The shoaling coefficient K_s is expressed as:

$$K_s = \left\{\left[1 + \frac{4\pi h/L_0}{\sinh(4\pi h/L_0)}\right]\tanh\frac{2\pi h}{L_0}\right\}^{-0.5}.$$

The coefficients β_0, β_1, and β_{max} are formulated as follows, according to Goda (1985):

Coefficients for H_s	Coefficients for H_{max}
$\beta_0=0.028(H'_0/L_0)^{-0.38}\exp[20\tan^{1.5}\theta]$	$\beta_0^*=0.052(H'_0/L_0)^{-0.38}\exp[20\tan^{1.5}\theta]$
$\beta_1=0.52\exp[4.2\tan\theta]$	$\beta_1^*=0.63\exp[3.8\tan\theta]$
$\beta_{max}=\max\{0.92, 0.32\,(H'_0/L_0)^{-0.29} \times \exp[2.4\tan\theta]\}$	$\beta_{max}^*=\max\{1.65, 0.53\,(H'_0/L_0)^{-0.29} \times \exp[2.4\tan\theta]\}$

Results from this surf zone analysis are presented in Tables 10 and 11 for Alignment 1, and Tables 12 and 13 for Alignment 2. These tables show the significant wave heights (H_s) and maximum wave heights (H_{max}) that are expected at the site. These results are also presented as rose plots in Figures 9 to 12 for both proposed dike Alignments. Generally, the offshore maximum wave height is approximately 1.8 times the significant wave height, but within the surf zone, H_{max} will approach H_s as the local bottom depth determines the maximum wave height that can be supported. For the design of the dike, the H_s wave height was used in the determination of the dike crest elevation, and H_{max} was used to determine the size of the stone used to armor the slope. The depths used in the surf zone analyses were determined using NOAA bathymetry, surge levels determined for each specified return period, and the height of mean high water above mean sea level.

Table 10: Significant wave height H_s (ft) at dike toe for Alignment 1, determined using Goda's (1985) formulas for wave height estimation within the surf zone.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	5.19	6.26	6.26	6.26	5.75	1.92	1.92	1.92
10	5.43	6.81	6.81	6.81	5.96	2.20	2.20	2.20
25	5.87	7.64	7.64	7.64	6.35	2.67	2.67	2.67
50	6.38	8.19	8.19	8.19	6.83	3.13	3.13	3.13
100	6.93	9.02	9.02	9.02	7.33	3.59	3.59	3.59

Table 11: Maximum wave height H_{max} (ft) at dike toe for Alignment 1, determined using Goda's (1985) formulas for wave height estimation within the surf zone.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	6.67	6.73	6.73	6.73	7.33	1.92	1.92	1.92
10	7.01	7.42	7.42	7.42	7.61	2.20	2.20	2.20
25	7.62	8.38	8.38	8.38	8.13	2.68	2.68	2.68
50	8.29	9.02	9.02	9.02	8.74	3.15	3.15	3.15
100	9.02	9.96	9.96	9.96	9.39	3.62	3.62	3.62

Table 12: Significant wave height H_s (ft) at dike toe for Alignment 2, determined using Goda's (1985) formulas for wave height estimation within the surf zone.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	5.51	6.26	6.26	6.26	6.26	1.93	1.93	1.93
10	5.75	6.81	6.81	6.81	6.81	2.21	2.21	2.21
25	6.19	7.64	7.64	7.64	7.60	2.67	2.67	2.67
50	6.71	8.19	8.19	8.19	8.08	3.13	3.13	3.13
100	7.25	9.02	9.02	9.02	8.58	3.59	3.59	3.59

Table 13: Maximum wave height H_{max} (ft) at dike toe for Alignment 2, determined using Goda's (1985) formulas for wave height estimation within the surf zone.								
Return Period	S	SW	W	NW	N	NE	E	SE
5	7.07	6.74	6.74	6.74	7.04	1.94	1.94	1.94
10	7.40	7.43	7.43	7.43	7.78	2.23	2.23	2.23
25	8.01	8.40	8.40	8.40	8.78	2.72	2.72	2.72
50	8.68	9.03	9.03	9.03	9.42	3.20	3.20	3.20
100	9.42	9.98	9.98	9.98	10.38	3.67	3.67	3.67

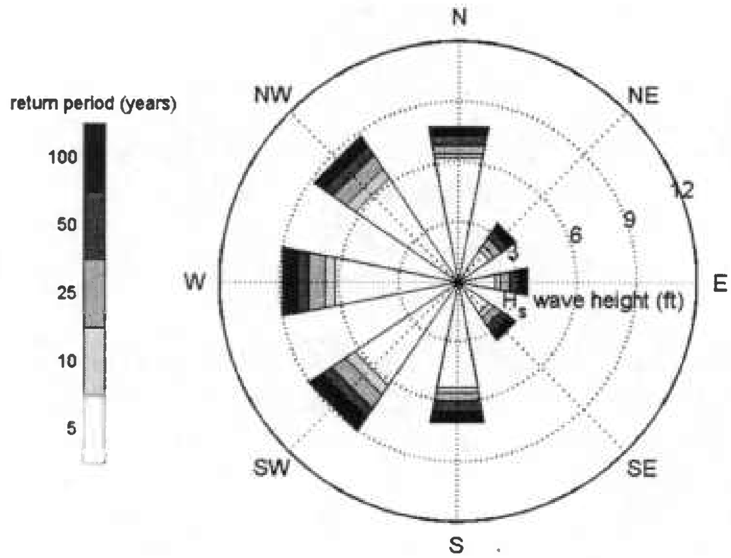


Figure 10: Rose plot of storm wave heights in the vicinity of the dike of proposed Alignment 1, from eight compass sectors, and for five return periods. Significant wave heights (H_s) where computed using Goda's method of determining wave heights in the surf zone.

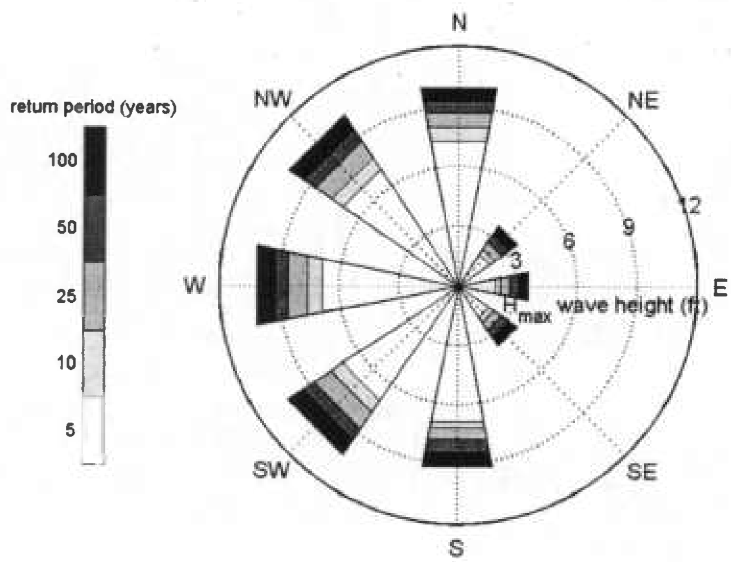


Figure 11: Rose plot of maximum storm wave heights in the vicinity of the dike of proposed Alignment 1, from eight compass sectors, and for five return periods. Maximum wave heights (H_{max}) where computed using Goda's method of determining wave heights in the surf zone.

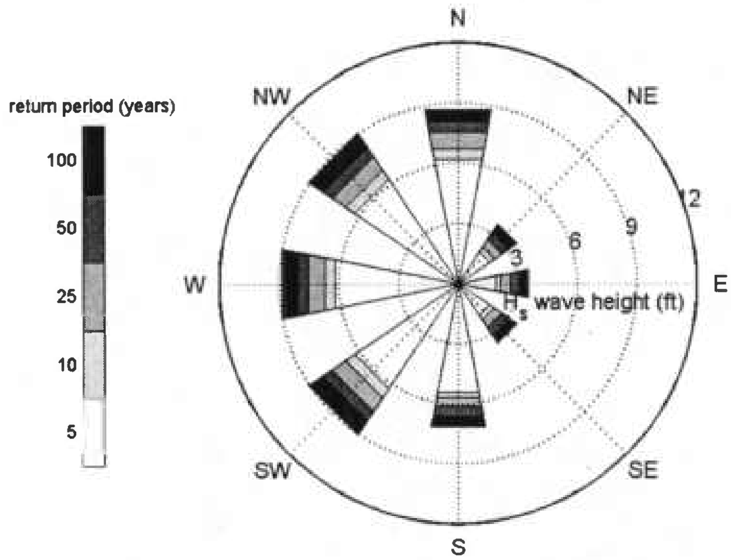


Figure 12: Rose plot of storm wave heights in the vicinity of the dike of proposed Alignment 2, from eight compass sectors, and for five return periods. Significant wave heights (H_s) where computed using Goda's method of determining wave heights in the surf zone.

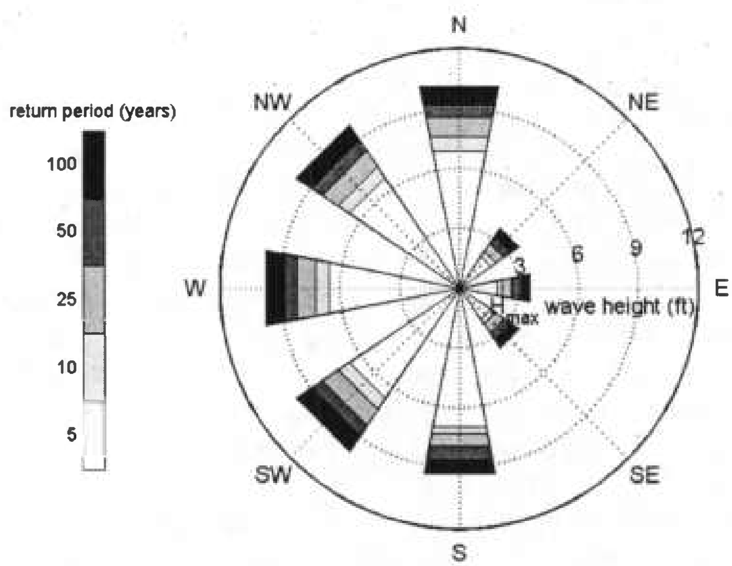


Figure 13: Rose plot of maximum storm wave heights in the vicinity of the dike of proposed Alignment 2, from eight compass sectors, and for five return periods. Maximum wave heights (H_{max}) where computed using Goda's method of determining wave heights in the surf zone.

3.0 DIKE CONSTRUCTION

As outlined in the previous reports for Poplar (GBA, 1995) and Parsons Islands (Moffatt & Nichol Engineers, 2001), the principle components of a coastal protection dike include:

- Toe Protection
- Berm (if included)
- Upper Slope
- Dike Crest and Roadway
- Dike Core

The dike layout developed for this preliminary study utilizes a dike core of sand, an outer slope comprised of a double layer of armor stones to protect the core, an additional layer of toe protection at the outside base of the dike, and a dike crest which is provided with a crushed stone roadway.

3.1 Dike Design Values

Dike designs depend upon wave and hydrodynamic conditions at the site for the appropriate return period event. For this conceptual design study, a 35-year return period for winds and storm surge elevations was chosen as the design return period, based on the similar analyses for Poplar (GBA, 1995) and Parsons Islands (Moffatt & Nichol Engineers, 2001) within Chesapeake Bay. Dike crest elevations and stone sizes are presented also for the 5-, 10-, 25-, 50-, and 100-year return conditions for comparison. Dike heights were computed separately for proposed dike Alignments 1 and 2 (shown Figure 2)

3.2 Dike Crest Height

The primary functions of the proposed dike enclosure are to enable the hydraulic placement of suitable dredged sediments and protect the interior fill from waves. With the combination of waves and surge, it is likely that some amount of water will overtop the crest during the course of a severe storm event. The final dike crest elevation is strongly dependent on the allowable overtopping rate of water, i.e., the less the design overtopping rate, the higher the dike crest is required to be. For this design study, the computed crest height was determined for overtopping rates that would maintain the structural integrity of the dike, but still permit a reasonable rate of overtopping in order to reduce the height and cost of the structure.

The method used to determine the dike crest elevation was presented by Van der Meer (1992) based on the computed 2% wave runup for a seawall or dike. This method has been outlined previously in the preliminary design study for Parsons Island (Moffatt & Nichol Engineers, 2001). The 2% runup elevation is expressed as

$$R_{2\%} = 1.5\gamma_f \gamma_h \xi_p$$

where, γ_f and γ_h are influence factors based on slope roughness and toe water depth, respectively, and ξ_p is the surf similarity parameter. The slope roughness influence factor was set at 0.55, based on Van der Meer (1992) for rubble stone. The influence factor for shallow water at the structure toe is expressed as

$$\gamma_h = 1 - 0.03[4 - h/H_s]$$

for $1 \leq h/H_s \leq 4$, assuming a gentile foreshore slope less than 1:100. The surf similarity parameter is a function of H_s (significant wave height), T_p (peak period) and bottom slope angle (α), and is expressed as

$$\xi_p = \tan\alpha \left(\frac{2\pi H_s}{g T_p^2} \right)^{-0.5}.$$

Finally, the dike crest elevation (R_c) required for a particular overtopping discharge rate (q) is determined using the following relationship, determined by Van der Meer (1992):

$$\frac{q}{\sqrt{g H_s^3}} = 8 \times 10^{-5} \exp\left[3.1 \frac{R_{2\%} - R_c}{H_s} \right].$$

The values of H_s as shown in Tables 10 and 12, were used for this analysis. The side slope of the dike was set at 3:1 in this study, and a toe berm with a 10 ft crest width was also included. For the purpose of determining the dike crest elevation, wave conditions from the south, northwest, and southeast were selected, as they represented the largest offshore wave conditions approaching the dike sections. Since wave conditions vary around the island, dike elevations and armor stone sizes were evaluated for four sections (South = Typical Dike Section No. 2, West = Typical Dike Section No. 3, North = Typical Dike Section No. 4, and East = Typical Dike Section No. 2) as shown in Figure 13. The southern wave condition was used for the South dike section, the northwestern wave condition was used for the North and West dike sections, and finally the southeast wave condition was used to size the East section of the dike.

For this application, an allowable overtopping rate of 10 L/sec·meter was used. In the previous studies of Parsons and Poplar Islands, the rate had been set to 5 L/sec·meter. The present value of 10 L/sec·meter is given by Pilarczyk (2000) for dikes with a clay protective layer and grass on the crest and inner slope. This value is also supported by the United Kingdom (UK) Construction Industry Research and Information Association (CIRIA) in conjunction with the Netherlands Centre for Civil Engineering Research and Codes (CUR) (e.g., Besley and Allsop, 2000) where overtopping rates up to 20 L/sec·meter are tolerable when the dike crest is protected. As stated previously, dike crest elevation is dependent on the allowable overtopping rate of water, i.e., the less the design overtopping rate, the higher the dike crest is required to be. It is assumed that the dike at Barren Island will be constructed with a compacted roadway surface at the crest following the Poplar Island example, which will provide protection similar to a vegetated crest.

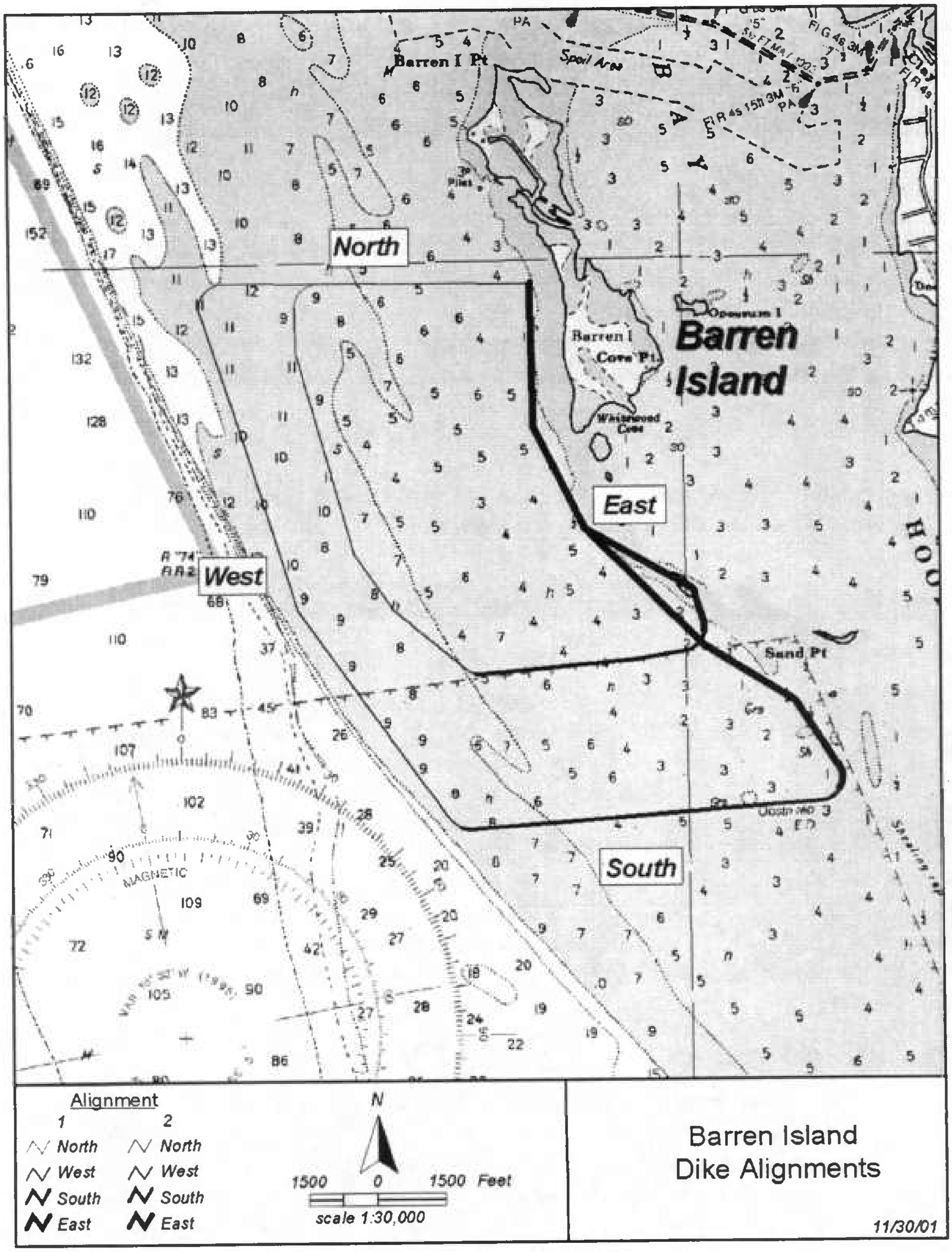


Figure 14: South, West, North, and East dike sections used to determine dike elevations and armor stone sizes.

Computed dike heights are presented in Table 14 for four dike exposures (North, West, South, and East) and the two proposed alignments. For the 35-year project design conditions, the estimated dike height is approximately 10 ft (MLLW) for the North, West and South dike sections, and 8 ft (MLLW) for the East dike section. The reduced height of the eastern section is the result of lower waves from the eastern fetch.

Table 14: Dike crest elevations (ft, MLLW) computed for various return conditions and the two proposed dike alignments, for 3:1 dike slope.

Dike Section	Return Period (years)					
	5	*10*	*25*	*35*	*50*	*100*
North Dike Align. 1	7.2	7.7	8.5	8.9	9.5	10.5
West Dike Align. 1	7.7	8.2	8.9	9.5	10.4	10.9
South Dike Align. 1	7.7	8.2	9.2	9.5	10.1	11.4
East Dike Align. 1	6.8	7.0	7.4	7.7	8.2	8.9
North Dike Align. 2	7.3	7.9	8.8	9.3	10.0	11.1
West Dike Align. 2	7.7	8.2	9.2	9.7	10.4	11.5
South Dike Align. 2	7.7	8.2	9.2	9.5	10.1	11.4
East Dike Align. 2	6.8	7.0	7.4	7.7	8.2	8.9

3.3 Armor Stone Sizing

Several methods have been developed to determine armor stone size requirements for dikes and revetments. Similar to previous studies for Parsons and Poplar Islands, the method of Van der Meer (1988) was utilized in this study. The H_{max} wave heights presented in Tables 11 and 13 where used in this analysis as recommended by Van der Meer. The stones were sized for a double armor layer with a 0.1 permeability factor, 3:1 slope, and a structural damage level of 2 (corresponding to 0-5% allowable damage). The number of waves in the storm was set to 7000, as in GBA (1995), and as recommended by the USACE (1995). As in the dike crest determination, for the purpose of stone sizing, wave conditions from the south, northwest, and southeast were selected, as they represented the largest offshore wave conditions approaching the dike. The southern wave condition was used for the South dike section, the northwestern wave condition was used for the North and West dike sections, and finally the southeast wave condition was used to size the East section of the dike. Stone sizes for the evaluated return periods are presented in Tables 15 and 16. The armor layer as conceptualized would have two layers of similarly-sized stones.

Table 15: Dike outer slope armor stone sizes (W_{50} in tons or lbs) computed for various return conditions and the two proposed dike alignments, for 3:1 slope.						
Dike Section	**Return Period (years)**					
	5	*10*	*25*	*35*	*50*	*100*
North Dike Align. 1	0.83 ton	0.96 ton	1.18 ton	1.34 ton	1.46 ton	1.81 ton
West Dike Align. 1	0.60 ton	0.80 ton	1.29 ton	1.35 ton	1.40 ton	2.16 ton
South Dike Align. 1	0.80 ton	0.97 ton	1.32 ton	1.53 ton	1.67 ton	2.31 ton
East Dike Align. 1	31 lbs	46 lbs	82 lbs	111 lbs	134 lbs	198 lbs
North Dike Align. 2	0.69 ton	0.93 ton	1.30 ton	1.48 ton	1.61 ton	2.18 ton
West Dike Align. 2	0.61 ton	0.81 ton	1.14 ton	1.30 ton	1.41 ton	1.93 ton
South Dike Align. 2	0.80 ton	0.97 ton	1.32 ton	1.53 ton	1.67 ton	2.31 ton
East Dike Align. 2	31 lbs	46 lbs	82 lbs	111 lbs	134 lbs	198 lbs

Table 16: Dike outer slope armor stone sizes (D_{50} in feet) computed for various return conditions and the two proposed dike alignments, for 3:1 slope.						
Dike Section	**Return Period (years)**					
	5	*10*	*25*	*35*	*50*	*100*
North Dike Align. 1	2.2	2.3	2.4	2.5	2.6	2.8
West Dike Align. 1	1.9	2.1	2.5	2.5	2.6	3.0
South Dike Align. 1	2.1	2.3	2.5	2.6	2.7	3.0
East Dike Align. 1	0.6	0.7	0.8	0.8	0.9	1.1
North Dike Align. 2	2.0	2.2	2.5	2.6	2.7	3.0
West Dike Align. 2	1.9	2.1	2.4	2.5	2.6	2.9
South Dike Align. 2	2.1	2.3	2.5	2.6	2.7	3.0
East Dike Align. 2	0.6	0.7	0.8	0.8	0.9	1.1

For the 35-year design return period, the approximate stone weight for Alignment 1 along the North, West, and South portions of the dike varies between 1.3 tons and 1.5 tons, but is only 111 lbs for the eastern dike section, which is more sheltered. For Alignment 2, there is a similar range in stone sizes between the North, West, and South dike sections. The estimated stone size of Alignment 2 is larger for the North section because dike toe depths are greater for this case and therefore waves do not break much as they do for Alignment 1, and therefore higher wave heights (both H_s and H_{max}) reach the dike slope. Also, even though the wave heights at the toe of the South dike section are smaller than those for the North and West sections, the stone sizes for the South section are the heaviest. This is due to the larger periods (longer length) of waves approaching from the south, which has the effect of increasing the required armor stone size.

3.4 Toe Protection and Underlayer

Toe stone sizes were computed assuming that the toe berm is located at the MLLW level as it is in the previous Parson and Poplar Island designs. Waves were modeled as before, without including storm surge. Hydrodynamic forces on the dike toe would be greatest when waves are directly impinging upon it, hence modeled water levels where set at MLLW. From this analysis, the required stone size for the North, West, and South sections of the dike are 1.7 ft (0.4 ton) for Alignment 1, and 2.0 ft (0.7 ton) for Alignment 2, both for 35-year return period waves with a still water elevation corresponding to MLLW. For the East dike section, toe stone size is computed to be 0.8 ft (70 lbs) for either of the proposed Alignments.

An underlayer of finer sized stone is usually included as part of a dike design. The USACE recommends that the underlayer be composed of stones within the range of 0.07 to 0.10 times the weight of the overlying armor stone. The most important benefit of using properly-sized underlayer stones is that it permits surface interlocking with the armor stones, which enhances the stability of the armor layer.

3.5 Dike Cross-sections

Cross-sections for alignments 1 & 2 are shown in Figures 14 and 15. The dimensions of the dike reflect the stones sized for a 35-year design life, and a 3:1 outer slope. The structure core is constructed using sand, and is separated from the overlying armors and underlayers by an additional layer of geotextile fabric. A 20 ft wide, 8-inch thick crushed stone roadway is provided at the crest of the dike.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The Coastal Engineering Feasibility Study identifies existing data sources and provides preliminary coastal engineering analyses for the Barren Island site. To optimize shore protection design, an evaluation of local wind, wave, and storm surge conditions impacting this site was performed. In addition, preliminary dike heights and armor stone sizes were determined for the 35-year design.

Water depths along the two dike alignments vary from approximately –3 feet MLLW along the east side to more than –10 feet MLLW along the west side. Average water depths for Alignment 1 are approximately –6 feet MLLW and for Alignment 2 are approximately –7 feet MLLW. In general, the local bathymetric conditions are shallower to the east and south of the proposed dike alignments.

Design winds were developed from a 32-year data set from Baltimore-Washington International (BWI) Airport. Fastest mile wind speeds were developed for selected return periods ranging from 5 to 100 years. These fastest mile wind speeds were then converted to one-hour wind speeds for incorporation into the wave analysis. Design winds were developed for each of the eight primary directions (N, NE, E, SE, S, SW, W, and NW).

Normal water levels at Barren Island are dictated by astronomical tides; however, the influence of other factors (e.g. wind and freshwater inflow) often accounts for more than 50% of the water surface fluctuation. The mean tide level is approximately 0.8 feet above MLLW and the mean tide range is approximately 1.4 feet. For coastal engineering structures, the effect of storm surge is incorporated into the design process. Based on hydrodynamic modeling predictions of storm surge within this portion of Chesapeake Bay, VIMS researchers found that the 50-year surge elevation is 4.6 feet above mean sea level and the 100-year surge level is 5.4 feet above mean sea level.

Using historical wind data from Baltimore-Washington International Airport, estimates of wave heights approaching from eight compass sectors were determined. The USACE computer application ACES was used in this analysis. Radially averaged fetch distances and depths for N, NE, E, SE, S, SW, W, and NW were determined for the Barren Island site. Fetch depths were determined using NOAA bathymetry data from surveys of Chesapeake Bay. Wave conditions were determined for the 5, 10, 25, 50 and 100 year return periods. This analysis included storm surge levels above the mean fetch depth for each of the modeled return periods.

The design crest height depends greatly upon the hydrodynamic and wave climate of the area, as well as the chosen rate of allowable overtopping. The method of Van der Meer (1992) was utilized for the runup analysis and crest height determination, for a structure with a 3:1 slope. For the 35-year project design conditions, the estimated dike height is approximately 10 ft (MLLW) for the North, West, and South dike sections, and 8 ft (MLLW) for the East dike section. The reduced height of the eastern section is the result of lower waves from the eastern fetch.

To size the armor stones for the Barren Island dike, the method of Van der Meer (1988) was used. Maximum wave heights in the surf zone adjacent to the dike were used for stone sizing. These maximum wave heights were estimated using a method presented by Goda (1995). A summary of computed stone sizes is given in Table 17A. An additional Table 17B is provided that give adjusted stone sizes for the purposes of quarry production and construction in the field. For the 35-year design return period, the approximate stone weight for Alignment 1 along the North, West, and South dike sections stone sizes vary between 1.3 and 1.5 tons, but stone weights are only 111 lbs (0.05 tons) for the eastern dike section, which is more sheltered. For Alignment 2, there is a similar range in stone sizes.

The required toe armor stone size for the North, West, and South sections of the dike are 1.7 ft (0.4 ton) for Alignment 1, and 2.0 ft (0.7 ton) for Alignment 2, both for 35-year return period waves with a still water elevation corresponding to MLLW. For the East dike section, toe stone size is computed to be 0.8 ft (70 lbs or 0.035 tons) for either of the proposed Alignments.

In addition to the evaluation of coastal engineering design parameters for the dike, it is recommended that future analyses of regional hydrodynamics be performed. The regional hydrodynamic modeling effort will guide the optimization of the final dike layout and ensure hydrodynamic impacts of the dike system are minimized. This modeling effort should include an analysis of existing tidal currents around the island, as well as tidal current patterns associated with alternative dike alignments.

Table 17A

Actual Computed Dike Stone Values for the 35-Year Return Period Storm

Dike Section	Dike Layer					
	Slope				Toe	
	Armor Stone (Two Layers)		Under-layer (Two Layers)		Armor Stone (Two Layers)	
	W_{50} (lbs)	D_{50} (ft)	W_{50} (lbs)	D_{50} (ft)	W_{50} (lbs)	D_{50} (ft)
North Dike Align. 1	2680	2.54	260	1.18	760	1.67
West Dike Align. 1	2680	2.54	280	1.18	760	1.67
South Dike Align. 1	3060	2.65	300	1.23	760	1.67
East Dike Align. 1	111	0.88	11.1	0.41	70	0.75
North Dike Align. 2	2960	2.62	300	1.22	1380	2.03
West Dike Align. 2	2600	2.50	320	1.13	1380	2.03
South Dike Align. 2	3060	2.65	300	1.23	1380	2.03
East Dike Align. 2	111	0.88	11.1	0.41	70	0.75

Table 17B

Dike Stone Values for the 35-Year Return Period Storm

(W_{50} and D_{50} Values Adjusted for Quarry Production and Construction in the Field)

Dike Section	Dike Layer(1)					
	3:1 Slope				2:1 Toe	
	Armor Stone (Two Layers)		Under-layer (Two Layers)		Armor Stone(2) (Two Layers)	
	W_{50} (lbs)	D_{50} (ft)	W_{50} (lbs)	D_{50} (ft)	W_{50} (lbs)	D_{50} (ft)
North Dike Align. 1	3000	2.50	300	1.20	800	1.75
West Dike Align. 1	3000	2.50	300	1.20	800	1.75
South Dike Align. 1	3000	2.50	300	1.20	800	1.75
East Dike Align. 1	100	0.85	N/A(3)	N/A(3)	70	0.75
North Dike Align. 2	3000	2.50	300	1.25	1400	2.00
West Dike Align. 2	3000	2.50	300	1.25	1400	2.00
South Dike Align. 2	3000	2.50	300	1.25	1400	2.00
East Dike Align. 2	100	0.85	N/A(3)	N/A(3)	70	0.75

1. Adjusted W_{50} and D_{50} values are used for the construction cross section dimensions. It should be understood that reasonable gradation ranges will be applied during the design phase.
2. Quarry run will be placed beneath the toe armor stone layer.
3. Not Applicable.

5.0 REFERENCES

Besley, P.B. and Allsop, N.W.H. (2000). "Wave Overtopping of Coastal and Shoreline Structures." *Handbook of Coastal Engineering,* J.B. Herbich, ed., McGraw-Hill, New York, NY.

Boon, J.D., Welch, C.S., Chen, H.S., Lukens, R.J. Fang, C.S., Zeigler, J.M. (1978). "A Storm Surge Model Study." *Special Report No. 189*, Virginia Institute of Marine Sciences, Gloucester Point, VA.

Gahagan & Bryant Associates (GBA), Inc. and Moffatt & Nichol Engineers (1995). "Poplar Island Restoration Project Hydrodynamic and Coastal Engineering Draft Final Report.", GBA, Baltimore, MD.

Goda, Y. (1985). Random Seas and Design of Maritime Structures. University of Tokyo Press, Japan.

Moffatt & Nichol Engineers (2001). " Parsons Island Coastal Engineering Investigation, Preliminary Study." Baltimore, MD.

Pilarczyk, K.W. (2000). "Design of Dikes and Revetments – Dutch Practices." *Handbook of Coastal Engineering,* J.B. Herbich, ed., McGraw-Hill, New York, NY.

United States Army Corps of Engineers (USACE) (1995). "Design of Coastal Revetments, Seawalls, and Bulkheads", *Engineer Manual EM 110-2-1614*. Department of the Army, Washington, DC.

Van der Meer (1988). Rock Slopes and Gravel Beaches Under Wave Attack. Doctoral Thesis, Delft University of Technology, Netherlands.

Van der Meer (1992). Wave Runup and Overtopping on Coastal Structures. Journal of Coastal Engineering.

APPENDIX B

RECONNAISSANCE STUDY OF DREDGING ENGINEERING AND COST ESTIMATE

Reconnaissance Study of Dredging Engineering and Cost Estimate for Habitat Restoration at Barren Island
Gahagan & Bryant Associates, Inc.
February 2002

APPENDIX B

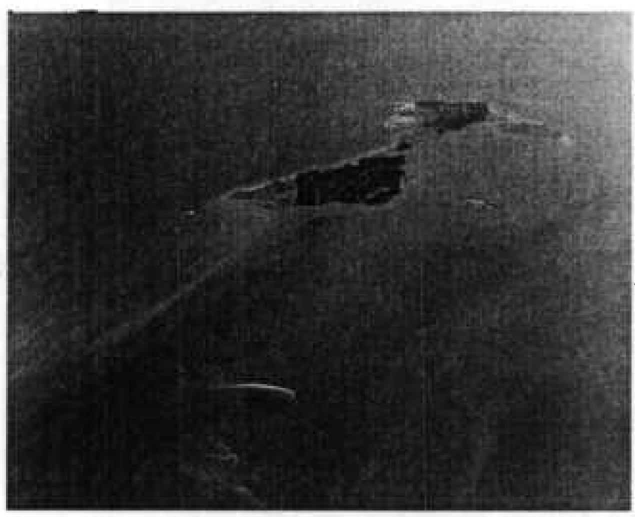
RECONNAISSANCE STUDY

OF

DREDGING ENGINEERING AND COST ESTIMATE FOR HABITAT RESTORATION

AT

BARREN ISLAND



Prepared for:

Roy F. Weston, Inc.
1309 Continental Drive
Suite M
Abingdon, MD 21009-2335

Prepared by:

GBA
ENGINEERS ★ SURVEYORS

Gahagan & Bryant Associates, Inc.

Baltimore, MD

February 2002

TABLE OF CONTENTS

TABLES

FIGURES

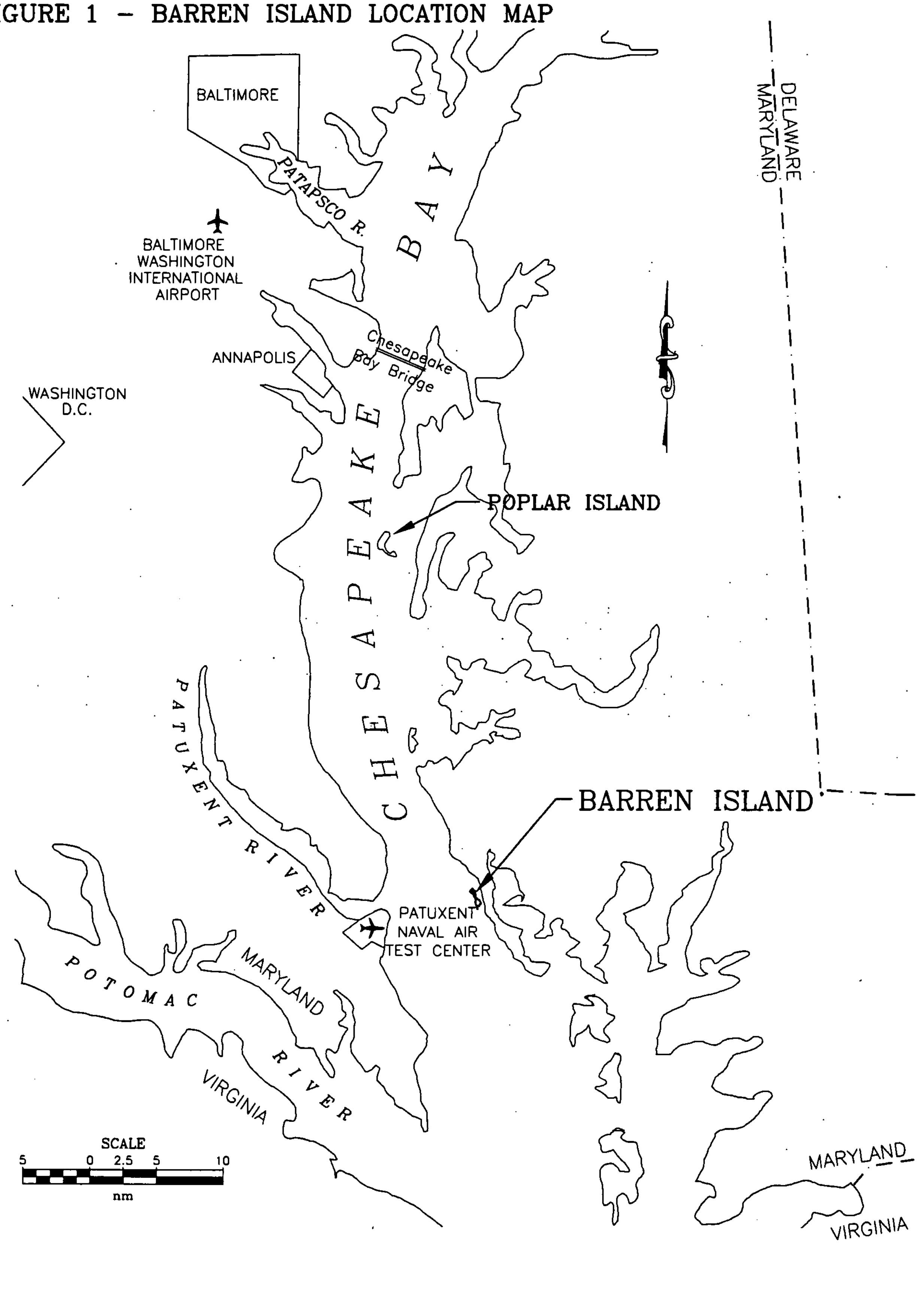
1.0 PROJECT BACKGROUND

The Maryland Environmental Service (MES), under sponsorship by the Maryland Port Administration (MPA), is examining the feasibility and suitability of various sites for the placement of dredged material.

Barren Island (See Figure 1) is one site being studied for possible placement of dredged material for beneficial use. It is located east of the mouth of the Patuxent River approximately 30 nautical miles south of the Poplar Island Restoration Project. Gahagan & Bryant Associates, Inc. (GBA) was retained by Roy F. Weston (Weston), to provide an initial dredging engineering assessment of site feasibility and construction costs.

GBA's scope is to evaluate the suitability of this site for construction to enclose two island habitat restoration site configurations. Each dike alignment will be characterized by a 10 or 20 ft upland dike height. This report outlines the findings of our assessment.

FIGURE 1 – BARREN ISLAND LOCATION MAP



2.0 PROJECT OBJECTIVES

GBA's task is to provide a dredging engineering assessment for the feasibility of constructing a habitat restoration site at Barren Island. Specifically, GBA's tasks are comprised of the following:

Task 1 – Analyze sand borrow options, including excavation, transport and placement methods. From the Engineering, Construction, Consulting, Remediation (E2CR, 2001) Geotechnical Feasibility Study for Barren Island, there is sufficient sand on site to construct all proposed dikes. The sand will be hydraulically dredged directly from the on-site borrow area.

Task 2 - Layout two perimeter dike alignments, enclosing 1,000 and 2,000 acres. For each dike alignment, there will be two upland dike heights 10 ft and 20 ft and each alignment will have a 50/50 split of upland area to wetland area. Prepare plan drawings with overlays of shoreline data and other significant features.

Task 3 - Estimate neat quantities (quantity of material that fill the design template, not including material lost during construction) and construction quantities for the two alignments defined. Develop excavation, transport and placement costs for the two different sand borrow options, two perimeter dike alignments and two upland dike heights. Quantities and costs for unsuitable excavation and backfill will also be estimated from E2CR, 2001.

Task 4 - Estimate neat quantities and construction quantities for all rock products based on dike cross-sections developed by Applied Coastal Research and Engineering, Inc (Applied Coastal, 2001) Coastal Engineering Feasibility Study for Barren Island. Obtain unit costs from Applied Coastal and estimates based on Poplar Island Phase I & Phase II for the following products:

1. Toe dike (quarry run and armor), slope stone (underlayer and armor), road stone, and geotextile.
2. Spillways, nursery planting

Summarize all line items in bid format and include item, quantity, unit cost and total costs (including mobilization and demobilization cost).

Task 5 - Estimate transport and placement cost of material dredged from Baltimore approach channels east of the North Point-Rock Point Line and proposed for placement at Barren Island. Estimate site finishing cost including: plan and design, habitat monitoring, implementation of channels and seeding, and operations and maintenance.

3.0 SITE CHARACTERISTICS

3.1 Site Characteristics

Barren Island is owned by the United States Fish and Wildlife Service (USFWS), located in Dorchester County, Maryland on the eastern side of the Chesapeake Bay within the Tar Bay. Existing natural oyster bars are located in the vicinity of Barren Island. NOB 23-2 is to the North, NOB 23-6 is to the South and NOB 23-4 is to the east of Barren Island (see Figure 2). Also to the west, there is deep water that reaches a depth of 132 ft.

MPA, MES, Weston and GBA prepared two conceptual dike alignment options and two dike height options for each dike alignment for quantity takeoffs and cost estimating. Each alignment was revised several times to develop the current configurations. These alignments were developed because of NOB constraints to the north and south, deep water to the west and the existing island with another NOB to the east. Each figure contains dike alignment and typical dike section layouts. Alignment No. 1 is a reduced area option with a 20 and 10 ft upland dike height (see Figures 3 & 4). The dike centerline area for Alignment No. 1 is 1,000 acres and the outside edge of toe armor area is 1,051 acres. Alignment No. 2 is an option utilizing local site characteristics with a 20 and 10 ft upland dike height (see Figures 5 & 6). The dike centerline area for alignment No. 2 is 2,000 acres and the outside edge of toe armor area is 2,074 acres. Tables 1 and 2 provide site characteristics for both dike alignments and dike heights, including quantities for rock and hydraulic fill material.

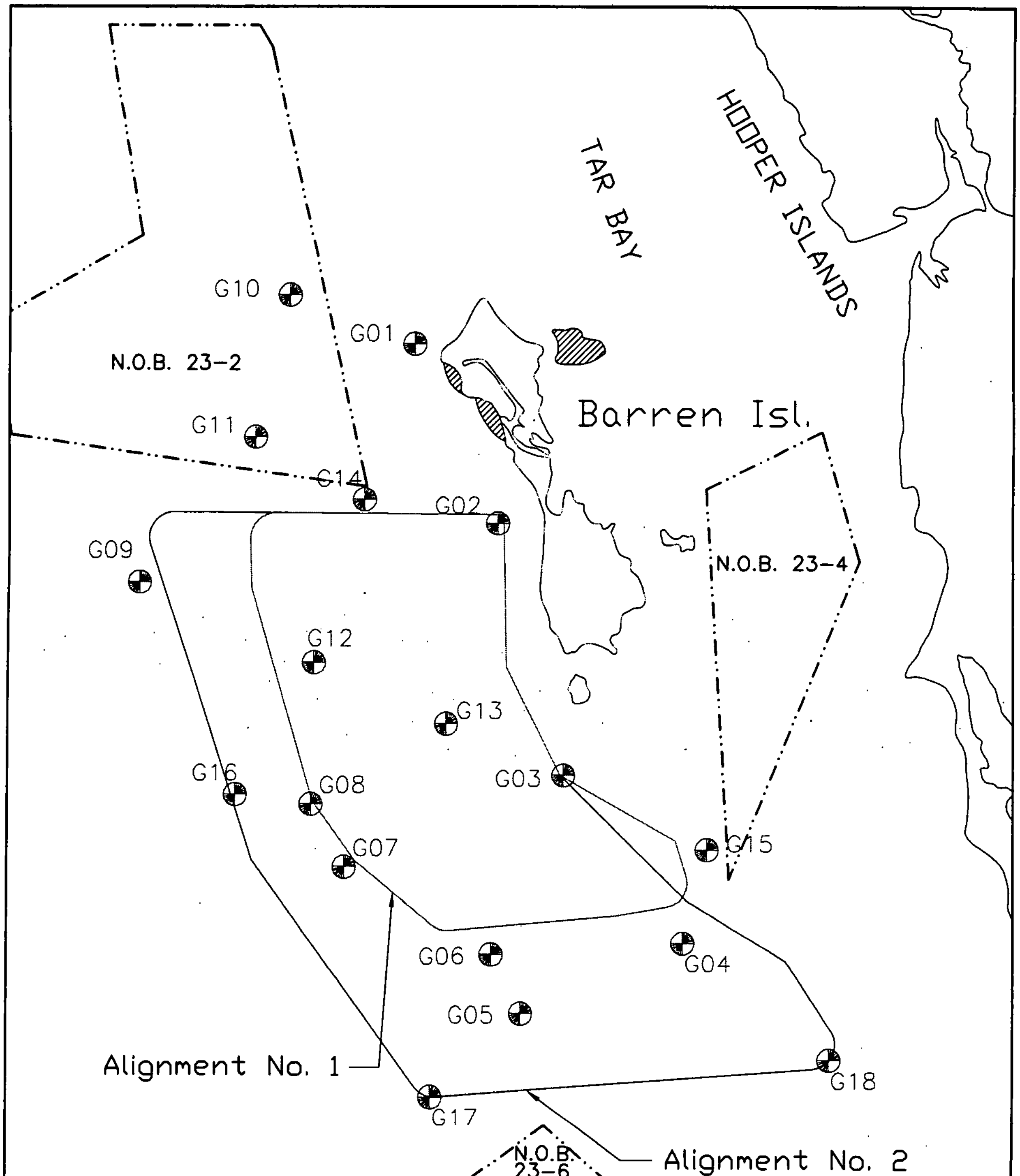
3.2 Design Characteristics

The primary exposure of the Barren Island shoreline to heavy wave action is from the north, south and west from Applied Coastal's Coastal Engineering Investigation (Applied Coastal, 2001). For preliminary quantity estimates, the dike sections used are very similar to the Poplar Island Restoration Project.

Moderate armor was used for all typical dike sections that are exposed to heavy wave action (Figures 7 thru 14). Typical dike section No. 1 is the same for both alignments and upland dike heights and runs parallel to the existing Barren Island. Typical dike section No. 2A & 2B for alignment No. 1 have the same essential coastal rock design, the "B" signifies an upland dike height of 20 feet and the "A" signifies an upland dike height of 10 feet. Typical dike section No. 2C & 2D for alignment No. 2 have the same essential coastal rock design, the "D" signifies an upland dike height of 20 feet and the "C" signifies an upland dike height of 10 feet. This nomenclature was used for other typical dike sections No. 3 and 4. Typical dike section No. 5A & 5B is the longitudinal dike that splits the alignment between upland and wetland cell, the "B" signifies an upland dike height of 20 feet and the "A" signifies an upland dike height of 10 feet. These planning factors were selected based on the assumption that environmental conditions would be generally similar to those experienced at the Poplar Island Restoration Project. Site-specific analysis would be needed for feasibility and design studies.

Bathymetric information for the Barren Island area was limited during the preparation of this report. The bathymetry was obtained from Applied Coastal 2001, using bathymetry that is available for NOAA navigation charts. The dike alignments and geotechnical boring plan used by Engineering, Consultation, Construction, Remediation, Inc. (E2CR) were correlated for this study (see Figure 2). Nautical charts show a deep shelf with greater than 100 ft. of water immediately west of the proposed dike alignments for Barren Island.

Additional bathymetric, geotechnical and environmental data will be required for the feasibility, planning and design phases of this project, if undertaken.



LEGEND

▨ ***PREVIOUSLY CREATED MARSH***

⊕ ***ACTUAL BORING LOCATION***

BARREN ISLAND FIGURE 2	N.O.B. AND BORING PLAN

GAHAGAN & BRYANT ASSOCIATES

DATE: DEC. 2001 | SCALE: 1" = 3000' | SHEET 01 OF 01

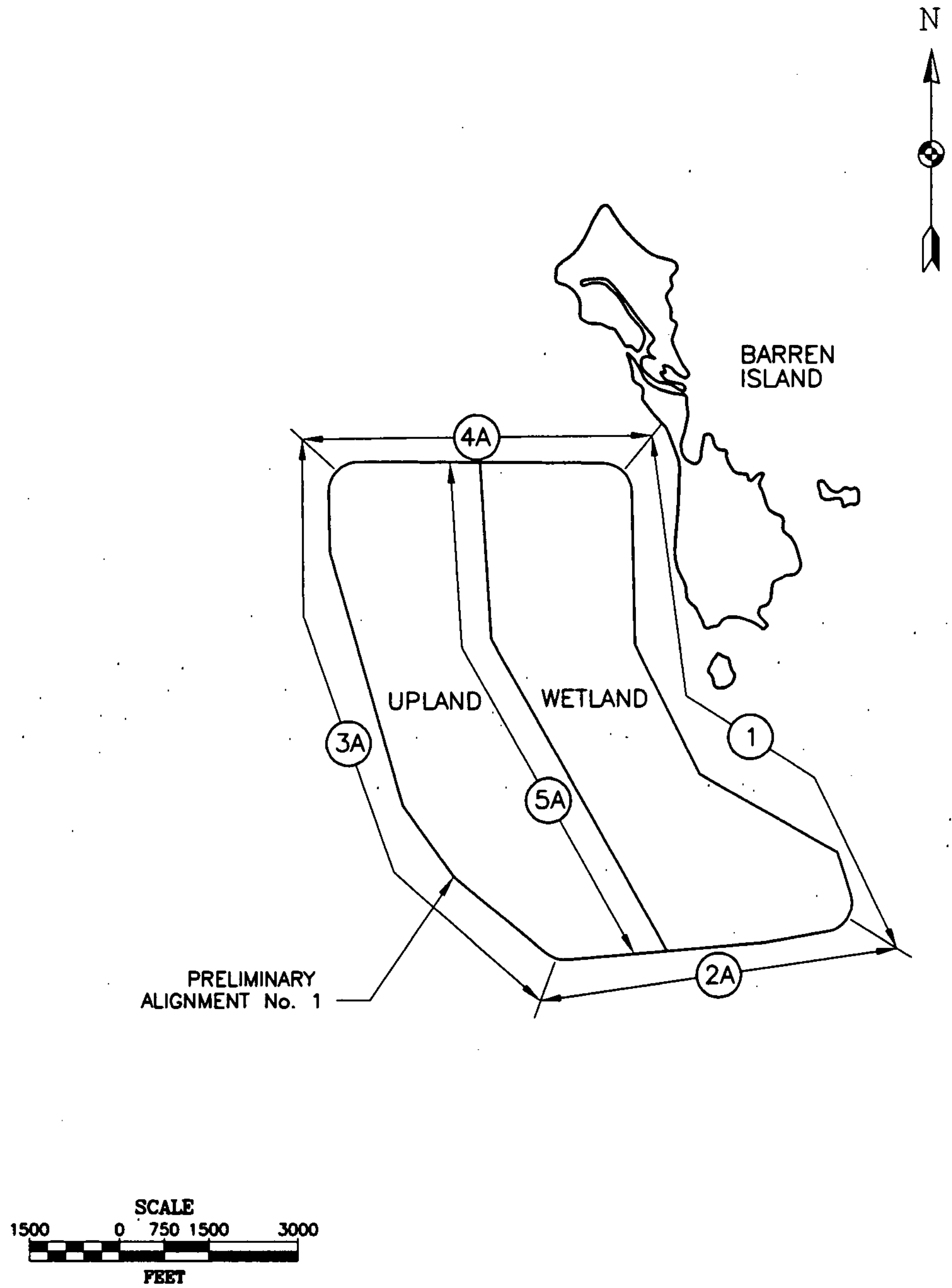


FIGURE 3. PRELIMINARY DIKE ALIGNMENT NO. 1 (10 FT)

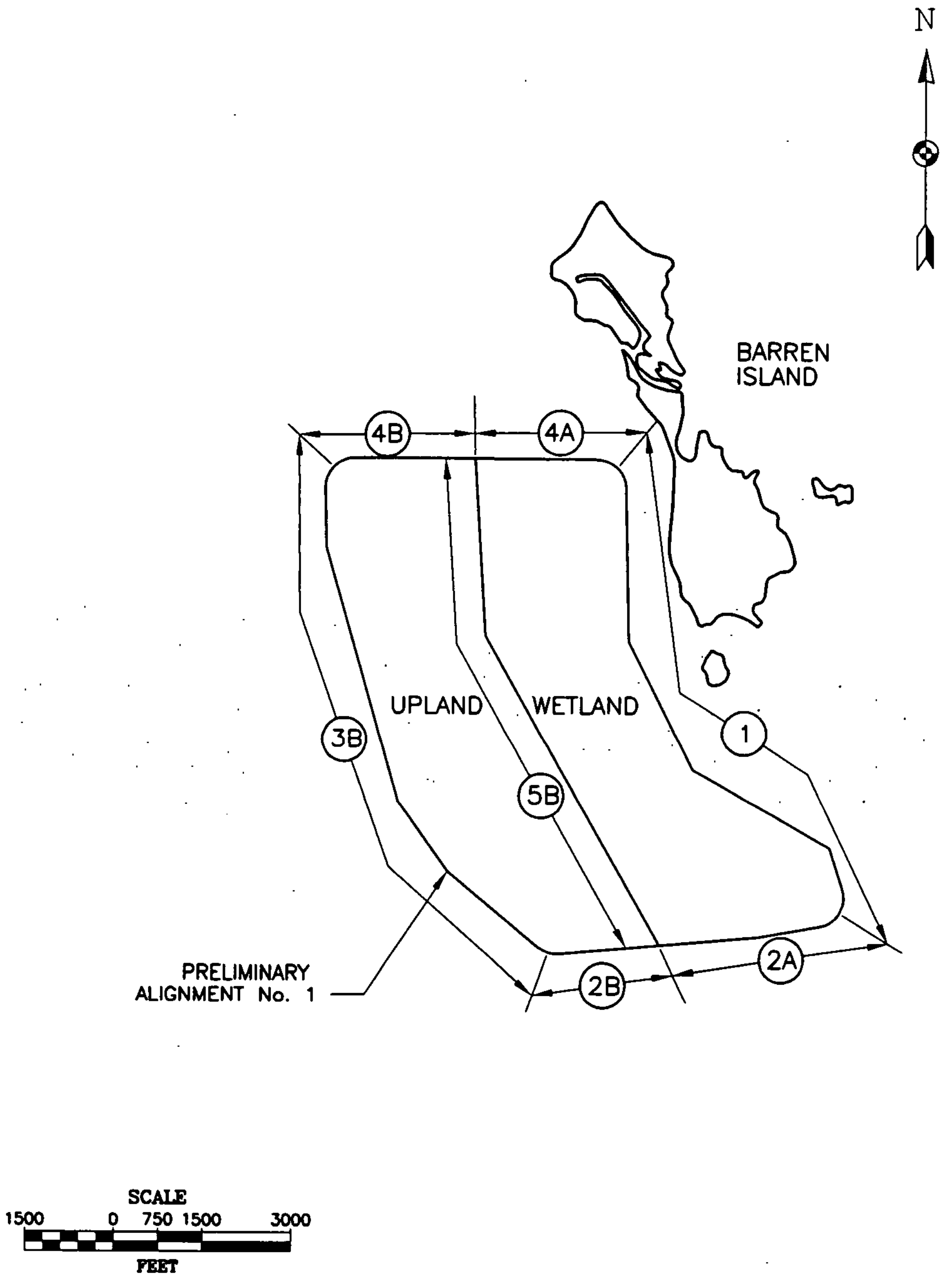


FIGURE 4. PRELIMINARY DIKE ALIGNMENT NO. 1 (20 FT)

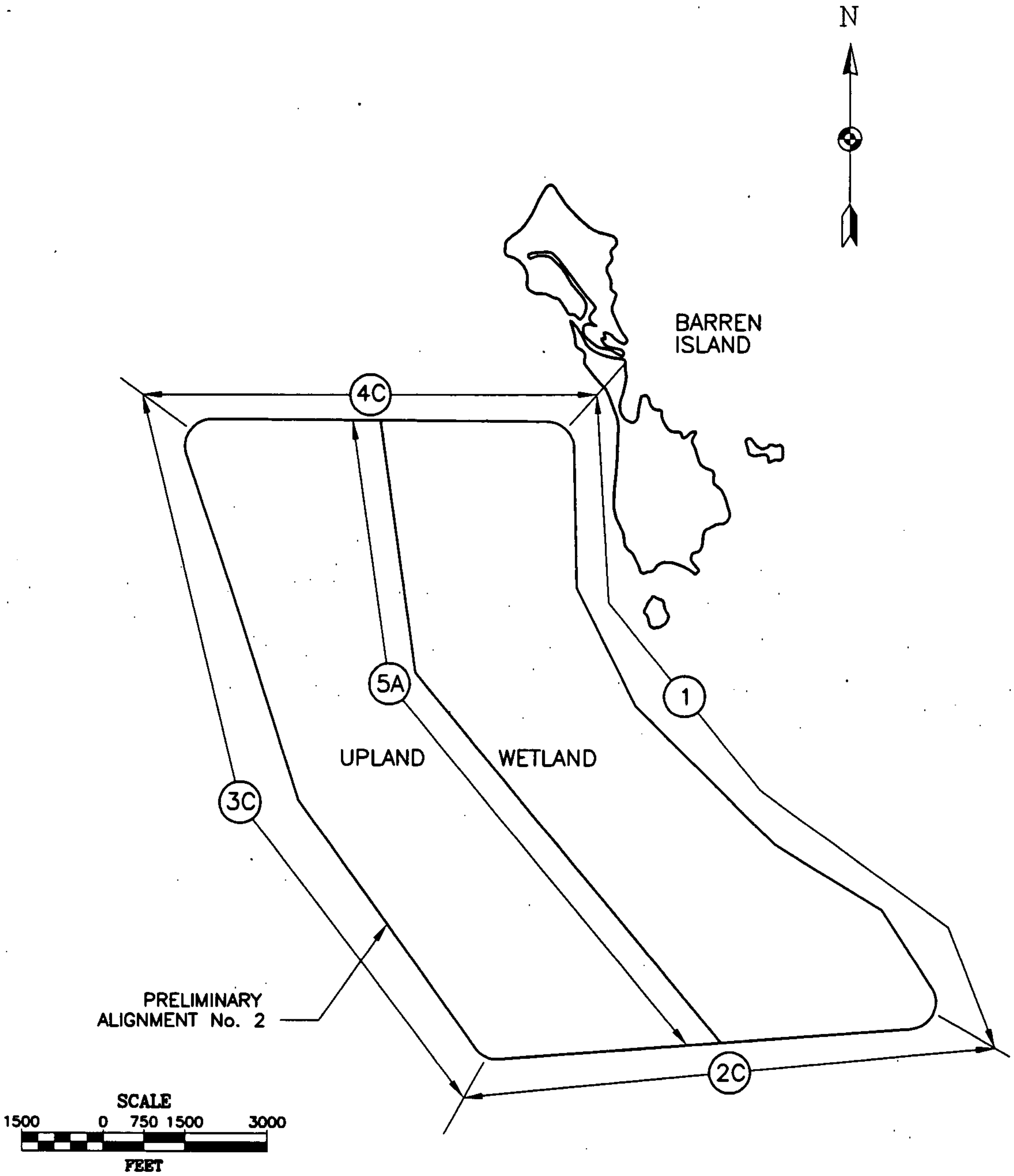


FIGURE 5. PRELIMINARY DIKE ALIGNMENT NO. 2 (10 FT)

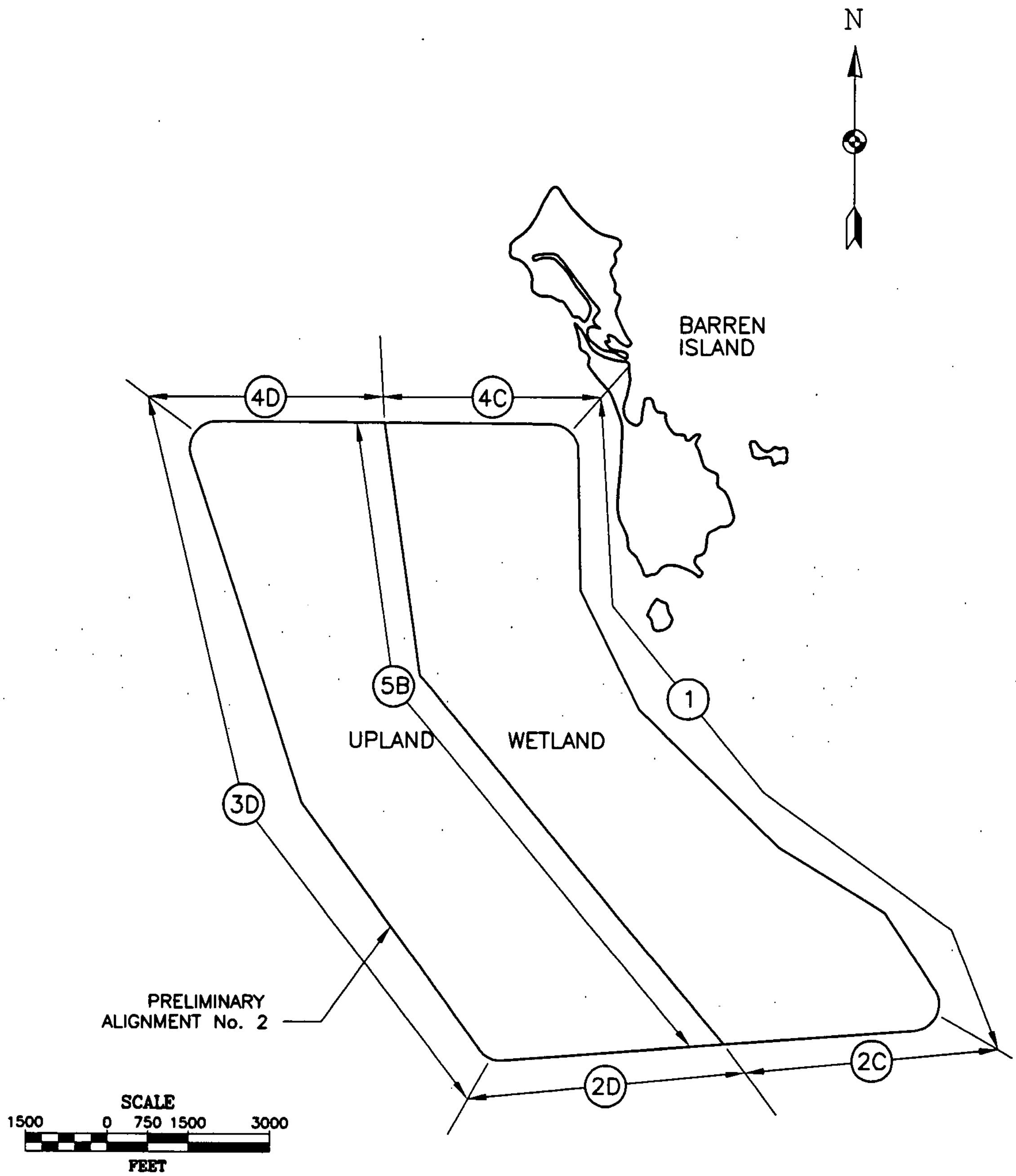


FIGURE 6. PRELIMINARY DIKE ALIGNMENT NO. 2 (20 FT)

Barren Island Habitat Development

Table 1 - Preliminary Site Characteristics and Quantities for Dike Alignment No.1

	Dike Alignment No. 1 (10 ft)			Dike Alignment No. 1 (20 ft)		
SITE CHARACTERISTICS						
Uplend Baseline Area -	500	Acres		500	Acres	
Upland Baseline Perimeter -	22,847	LF		22,847	LF	
Upland Site Volume below sea level -	5.25	MCY		5.25	MCY	
Upland Site Volume above sea level -	6.46	MCY		14.53	MCY	
Upland Volume -	11.70	MCY		19.77	MCY	
Upland Site Capacity -	16.93	MCY		29.34	MCY	
Wetland Baseline Area -	500	Acres		500	Acres	
Wetland Beseline Perimeter -	23,796	LF		23,796	LF	
Wetland Site Volume below sea level -	4.03	MCY		4.03	MCY	
Wetland Site Volume above sea level -	1.21	MCY		1.21	MCY	
Wetlend Volume -	5.24	MCY		5.24	MCY	
Wetland Site Cepacity -	7.24	MCY		7.24	MCY	
Total Baseline Area -	1,000	Acres		1,000	Acres	
Total Baseline Perimeter -	28,655	LF		28,655	LF	
Total Volume -	16.94	MCY		25.01	MCY	
Total Site Capecity -	24.16	MCY		36.58	MCY	
Volume of available sand within diked eree -	8.00	MCY		8.00	MCY	
QUANTITIES	**Dike Alignment No. 1 (10 ft)**			**Dike Alignment No. 1 (20 ft)**		
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Beckfill -			300,000			300,000
Perimeter Dike Section 1 to +8 -	9,207	20.2	186,352	9,207	20.2	186,352
Perimeter Dike Section 2A to +10 -	5,031	39.3	197,731	3,158	39.3	124,126
Perimeter Dike Section 2B to +20 -				1,873	84.6	158,356
Perimeter Dike Section 3A to +10 -	9,525	39.3	374,352			
Perimeter Dike Section 3B to +20 -				9,525	84.6	805,396
Perimeter Dike Section 4A to +10 -	4,891	39.3	192,237	2,436	39.3	95,754
Perimeter Dike Section 4B to +20 -				2,455	84.6	207,577
Interior Dike Section 5A to +10 -	8,994	31.4	282,154			
Interior Dike Section 5B to +20 -				8,994	77.3	695,197
Total -	**37,649**		**1,532,825**	**37,649**		**2,572,758**
Perimeter Dike Section 2 & 2A Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	5,031	1.5	7,672	5,031	1.5	7,672
Toe Armor -	5,031	3.8	19,056	5,031	3.8	19,056
Underlayer Stone -	5,031	4.5	22,488	5,031	4.5	22,488
Slope Dike Armor -	5,031	9.9	49,741	5,031	9.9	49,741
Perimeter Dike Section 3 & 3A Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	9,525	1.5	14,525	9,525	1.5	14,525
Toe Armor -	9,525	3.8	36,078	9,525	3.8	36,078
Underlayer Stone -	9,525	4.5	42,576	9,525	4.5	42,576
Slope Dike Armor -	9,525	9.9	94,172	9,525	9.9	94,172
Perimeter Dike Section 4 & 4A Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	4,891	1.5	7,459	4,891	1.5	7,459
Toe Armor -	4,891	3.8	18,527	4,891	3.8	18,527
Underlayer Stone -	4,891	4.5	21,863	4,891	4.5	21,863
East Slope Dike Armor -	4,891	9.9	48,359	4,891	9.9	48,359
East Perimeter Dike Section 1 Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
East Slope Dike Armor -	9,207	4.2	38,284	9,207	4.2	38,284
Perimeter Dike Totals	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	19,448	N/A	29,656	19,448	N/A	29,656
Toe Armor -	19,448	N/A	73,660	19,448	N/A	73,660
Underlayer Stone -	19,448	N/A	86,928	19,448	N/A	86,928
Slope Dike Armor -	19,448	N/A	192,273	19,448	N/A	192,273
Eest Slope Dike Armor -	9,207	N/A	38,284	9,207	N/A	38,284
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	37,649	1.5	55,594	37,649	1.5	55,594
Geotextile -	28,655	15.5	444,155	28,655	15.5	444,155

Barren Island Habitat Development

Table 2 - Preliminary Site Characteristics and Quantities for Dike Alignment No. 2

	Dike Alignment No. 2 (10 ft)			Dike Alignment No. 2 (20 ft)		
SITE CHARACTERISTICS						
Upland Baseline Area -	1,000	Acres		1,000	Acres	
Upland Baseline Perimeter -	34,383	LF		34,383	LF	
Upland Site Volume below sea level -	14.52	MCY		14.52	MCY	
Upland Site Volume above sea level -	12.91	MCY		29.04	MCY	
Upland Volume -	27.43	MCY		43.56	MCY	
Upland Site Capacity -	39.22	MCY		64.03	MCY	
Wetland Baseline Area -	1,000	Acres		1,000	Acres	
Wetland Baseline Perimeter -	34,462	LF		34,462	LF	
Wetland Site Volume below sea level -	7.26	MCY		7.26	MCY	
Wetland Site Volume above sea level -	2.42	MCY		2.42	MCY	
Wetland Volume -	9.68	MCY		9.68	MCY	
Wetland Site Capacity -	13.40	MCY		13.40	MCY	
Total Baseline Area -	2,000	Acres		2,000	Acres	
Total Baseline Perimeter -	41,854	LF		41,854	LF	
Total Volume -	37.11	MCY		53.24	MCY	
Total Site Capacity -	52.62	MCY		77.44	MCY	
Volume of available sand within diked area -	20.00	MCY		20.00	MCY	
	Dike Alignment No. 2 (10 ft)			**Dike Alignment No. 2 (20 ft)**		
QUANTITIES						
Hydraulic Fill Material	LF	CY/LF	CY	LF	CY/LF	CY
Unsuitable Backfill -			500,000			500,000
Perimeter Dike Section 1 to +8 -	13,451	20.2	272,242	13,451	20.2	272,242
Perimeter Dike Section 2C to +10 -	8,363	39.2	328,040	4,049	39.2	158,833
Perimeter Dike Section 2D to +20 -				4,314	84.5	364,431
Perimeter Dike Section 3C to +10 -	13,030	61.1	795,912			
Perimeter Dike Section 3D to +20 -				13,030	111.8	1,457,159
Perimeter Dike Section 4C to +10 -	7,010	46.0	322,704	3,466	46.0	159,552
Perimeter Dike Section 4D to +20 -				3,544	92.9	329,184
Interior Dike Section 5A to +10 -	13,495	31.4	423,354			
Interior Dike Section 5B to +20 -				13,495	77.3	1,043,100
Total -	**55,350**		**2,642,252**	**55,350**		**4,284,502**
Perimeter Dike Section 2 & 2B Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	8,363	0.9	7,808	8,363	0.9	7,808
Toe Armor -	8,363	4.3	35,749	8,363	4.3	35,749
Underlayer Stone -	8,363	4.7	38,942	8,363	4.7	38,942
Slope Dike Armor -	8,363	9.9	82,681	8,363	9.9	82,681
Perimeter Dike Section 3 & 3B Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	13,030	6.7	87,768	13,030	6.7	87,768
Toe Armor -	13,030	6.3	82,038	13,030	6.3	82,038
Underlayer Stone -	13,030	4.6	59,571	13,030	4.6	59,571
Slope Dike Armor -	13,030	9.9	128,825	13,030	9.9	128,825
Perimeter Dike Section 4 & 4B Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	7,010	2.4	16,803	7,010	2.4	16,803
Toe Armor -	7,010	4.9	34,383	7,010	4.9	34,383
Underlayer Stone -	7,010	4.6	32,049	7,010	4.6	32,049
East Slope Dike Armor -	7,010	9.9	69,308	7,010	9.9	69,308
East Perimeter Dike Section 1 Stone Work	LF	Tons/LF	Tons	LF	Tons/LF	Tons
East Slope Dike Armor -	13,451	4.2	55,930	13,451	4.2	55,930
Perimeter Dike Totals	LF	Tons/LF	Tons	LF	Tons/LF	Tons
Quarry Run -	28,403	N/A	112,379	28,403	N/A	112,379
Toe Armor -	28,403	N/A	152,169	28,403	N/A	152,169
Underlayer Stone -	28,403	N/A	130,563	28,403	N/A	130,563
Slope Dike Armor -	28,403	N/A	280,814	28,403	N/A	280,814
East Slope Dike Armor -	13,451	N/A	55,930	13,451	N/A	55,930
Miscellaneous	LF	SY/LF	SY	LF	SY/LF	SY
Road Stone -	55,350	1.5	81,731	55,350	1.5	81,731
Geotextile -	41,854	15.5	648,745	41,854	15.5	648,745

4.0 ALTERNATE BORROW METHODS

The estimated neat sand fill quantities for construction of perimeter dike Alignment No. 1 at Barren Island are between 1.54 million cubic yards for an upland dike height of 10 ft and 2.58 million cubic yards for an upland dike height of 20 ft. The estimated neat sand fill quantities for perimeter dike Alignment No. 2 are between 2.65 million cubic yards for an upland dike height of 10 ft and 4.29 million cubic yards for an upland dike height of 20 ft. This estimate does not include interior dikes to divide the island into cells.

Two different methods for providing sand borrow were considered to meet the estimated quantities: (1) hydraulically dredge directly from the on-site borrow area (2) dredge and transport the off-site sand by hopper dredge to an underwater placement site and place the sand in the dikes with a hydraulic dredge. These two methods were analyzed in the event that there is not enough sand borrow available onsite to construct the containment dikes.

Borrow method 1 and 2 both use a hydraulic dredge to place the sand in the dikes. In borrow method 1, suitable on-site sand fill is pumped directly to dikes where it is shaped and armored. Borrow method 2 assumes that suitable fill material is not available within two or three miles and must be transported by hopper dredge from about 53 nautical miles away. After transport, the material is bottom dumped in an on-site underwater stockpile and pumped into section by hydraulic dredge.

Borings were taken by E2CR (Figure 2) and from a preliminary analysis, there appears to be a sufficient source of borrow material on the Barren Island site. For Alignment No. 1 there is 8 million cubic yards and for Alignment No. 2 there is 20 million cubic yards of silty sand available for borrow source material (E2CR, 2001).

5.0 COST ANALYSIS

The costs to construct the Barren Island site were estimated based on the configurations and typical dike sections described in Section 3. Quantities for each material type were estimated based on the 9 different typical dike sections, the alignment and average existing bottom elevation. Unit prices were estimated from similar construction projects at Poplar Island. A summary of the estimated construction costs for each borrow method alternative for the two dike alignments is presented in Table 3.

The preliminary construction cost is broken down for materials and borrow area alternatives. Materials listed include: road stone – stone used to cover all axis roads on island; unsuitable excavation – material that is unsuitable to place a dike on, that is removed along dike alignment; geotextile – fabric used for dike protection; dike slope and toe stone – stone used for protection of the dike. Other items such as: spillways, personnel pier and nursery planting are included for initial construction. The study costs are also included in the preliminary costs. The cost range for each alignment and both upland cell elevation options is $42.4 to $81.5 million.

The Total Site Use Cost Analysis for each dike alignment and dike height is comprised of a Study Cost (reconnaissance, pre-feasibility and feasibility), Total Construction Cost, Site Development Cost (dredged material management, site maintenance and site monitoring and reporting), Habitat Development Cost (plans and design, monitoring, implementation, and operation & maintenance), Dredging, Transport and Placement Cost (mob & demob, dredging, transport, and placement) (see Tables 4 thru 7). The total cost range for each alignment and upland dike height is $414 million to $1.29 billion. The total unit costs for both alignments (No. 1 and No. 2) and dike heights (10 and 20 ft) range from $16.57/cy to $17.16/cy.

BARREN ISLAND HABITAT DEVELOPMENT

Table 4 - Total site nse cost analysis for Dike Alignment No. 1 (10 ft)*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	24.2	Site Surface Area (Ac)	1,000
Site Operating Life (Years)	10	Site Perimeter Dike (Ft)	28,655
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	8,994
Average One-Way Haul Distance (NM)	58	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs				**$42,321,688**	
Total Construction Costs				$39,321,688	Refer to Table 3, Borrow Alternative 1**
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs				**$36,579,060**	
Dredged Material Management	10.0	Year	$1,125,029	$11,250,288	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	12.0	Year	$1,379,481	$16,553,772	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	13.0	Year	$675,000	$8,775,000	Environmental monitoring for operating life
					plus 3 years following site placement.
Subtotal Total Annual Cost:			**$3,179,510**		
C. Site Finishing Cost (Habitat Development)				**$17,900,130**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	10.0	Year	$250,000	$2,500,000	
Implementation				$7,400,130	
Channels	500	Acre	$6,000	$3,000,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1000	Acre	$4,400	$4,400,130	$4,400 per acre
Operation & Maintenance	10.0	Year	$500,000	$5,000,000	
D. Dredging, Transportation & Placement Costs				**$262,847,158**	
Mob and Demob	10.0	Year	$2,000,000	$20,000,000	Mob & Demob for operating life of site
Dredging	24.2	Mcy	$2.00	$48,327,793	Clamshell Dredging
Transport	24.2	Mcy	$5.80	$140,150,599	$0.10 Per One-Way Haul in NM (58 NM)
Placement	24.2	Mcy	$2.25	$54,368,767	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$359,648,035**	
Contingency	15.00%			$53,947,205	
TOTAL COST A+B+C+D				**$413,595,240**	
TOTAL UNIT COST				**$17.12**	**per cubic yard**

* Costs are estimated in 2001 dollars.

** Engineering Consultation Construction Remediation, Inc. (E2CR 2001).

BARREN ISLAND HABITAT DEVELOPMENT

Table 5 - Total site use cost analysis for Dike Alignment No. 1 (20 ft)*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	36.6	Site Surface Area (Ac)	1,000
Site Operating Life (Years)	15	Site Perimeter Dike (Ft)	28,655
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	8,994
Average One-Way Haul Distance (NM)	58	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs				**$51,161,118**	
Total Construction Costs				$48,161,118	Refer to Table 3, Borrow Alternative 1**
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs				**$52,476,608**	
Dredged Material Management	15.0	Year	$1,125,029	$16,875,431	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	17.0	Year	$1,379,481	$23,451,177	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	18.0	Year	$675,000	$12,150,000	Environmental monitoring for operating life
					plus 3 years following site placement.
Subtotal Total Annual Cost:			**$3,179,510**		
C. Site Finishing Cost (Habitat Development)				**$21,650,130**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	15.0	Year	$250,000	$3,750,000	
Implementation				$7,400,130	
Channels	500	Acre	$6,000	$3,000,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	1000	Acre	$4,400	$4,400,130	$4,400 per acre
Operation & Maintenance	15.0	Year	$500,000	$7,500,000	
D. Dredging, Transportation & Placement Costs				**$397,632,555**	
Mob and Demob	15.0	Year	$2,000,000	$30,000,000	Mob & Demob for operating life of site
Dredging	36.6	Mcy	$2.00	$73,160,708	Clamshell Dredging
Transport	36.6	Mcy	$5.80	$212,166,052	$0.10 Per One-Way Haul in NM (58 NM)
Placement	36.6	Mcy	$2.25	$82,305,796	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$522,920,412**	
Contingency	15.00%			$78,438,062	
TOTAL COST A+B+C+D				**$601,358,473**	
TOTAL UNIT COST				**$16.44**	**per cubic yard**

* Costs are estimated in 2001 dollars.

** Engineering Consultation Construction Remediation, Inc. (E2CR 2001).

BARREN ISLAND HABITAT DEVELOPMENT

Table 6 - Total site nse cost analysis for Dike Alignment No. 2 (10 ft)*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	52.6	Site Surface Area (Ac)	2,000
Site Operating Life (Years)	22	Site Perimeter Dike (Ft)	41,854
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,495
Average One-Way Haul Distance (NM)	58	Final Dike Elev. (Ft)	10.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs				**$67,502,690**	
Total Construction Costs				$64,502,690	Refer to Table 3, Borrow Alternative 1**
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs				**$110,438,325**	
Dredged Material Management	22.0	Year	$2,100,022	$46,200,480	Placement, dewatering and crust management costs for the operating life. $150,000+ ($975 per Acre)
Site Maintenance	24.0	Year	$1,973,452	$47,362,845	Site Maintenance for operating life plus 2 years following site placement. $90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	25.0	Year	$675,000	$16,875,000	Environmental monitoring for operating life plus 3 years following site placement.
Subtotal Total Annual Cost:			**$4,748,474**		
C. Site Finishing Cost (Habitat Development)				**$34,300,099**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	22.0	Year	$250,000	$5,500,000	
Implementation				$14,800,099	
Channels	1000	Acre	$6,000	$6,000,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2000	Acre	$4,400	$8,800,099	$4,400 per acre
Operation & Maintenance	22.0	Year	$500,000	$11,000,000	
D. Dredging, Transportation & Placement Costs				**$572,820,675**	
Mob and Demob	22.0	Year	$2,000,000	$44,000,000	Mob & Demob for operating life of site
Dredging	52.6	Mcy	$2.00	$105,237,945	Clamshell Dredging
Transport	52.6	Mcy	$5.80	$305,190,041	$0.10 Per One-Way Haul in NM (58 NM)
Placement	52.6	Mcy	$2.25	$118,392,688	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$785,061,788**	
Contingency	15.00%			$117,759,268	
TOTAL COST A+B+C+D				**$902,821,057**	
TOTAL UNIT COST				**$17.16**	**per cubic yard**

* Costs are estimated in 2001 dollars.

** Engineering Consultation Construction Remediation, Inc. (E2CR 2001).

BARREN ISLAND HABITAT DEVELOPMENT

Table 7 - Total site use cost analysis for Dike Alignment No. 2 (20 ft)*

BASIS FOR ESTIMATE:

Site Capacity (Mcy)	77.4	Site Surface Area (Ac)	2,000
Site Operating Life (Years)	31	Site Perimeter Dike (Ft)	41,854
Annual Channel (Cut) Volume (Mcy)	2.50	Site Interior Dikes (Ft)	13,495
Average One-Way Haul Distance (NM)	58	Final Dike Elev. (Ft)	20.0

Item	*Quantity*	*Unit*	*Unit Cost*	*Item Cost*	*Comments*
A. Initial Construction Costs				**$81,461,812**	
Total Construction Costs				$78,461,812	Refer to Table 3, Borrow Alternative 1**
Study Costs				$3,000,000	Conceptual, pre-feasibility and feasibility costs.
B. Site Development Costs				**$153,174,588**	
Dredged Material Management	31.0	Year	$2,100,022	$65,100,677	Placement, dewatering and crust
					management costs for the operating life.
					$150,000+ ($975 per Acre)
Site Maintenance	33.0	Year	$1,973,452	$65,123,911	Site Maintenance for operating life plus
					2 years following site placement.
					$90,000+ ($45 per Perimeter Ft.)
Site Monitoring and Reporting	34.0	Year	$675,000	$22,950,000	Environmental monitoring for operating life
					plus 3 years following site placement.
Subtotal Total Annual Cost:			**$4,748,474**		
C. Site Finishing Cost (Habitat Development)				**$41,050,099**	
Plan and Design	3.0	Year	$1,000,000	$3,000,000	
Monitoring	31.0	Year	$250,000	$7,750,000	
Implementation				$14,800,099	
Channels	1000	Acre	$6,000	$6,000,000	$8/cy x 3 cy/LF x 250 LF/acre
Planting/Seeding	2000	Acre	$4,400	$8,800,099	$4,400 per acre
Operation & Maintenance	31.0	Year	$500,000	$15,500,000	
D. Dredging, Transportation & Placement Costs				**$840,258,956**	
Mob and Demob	31.0	Year	$2,000,000	$62,000,000	Mob & Demob for operating life of site
Dredging	77.4	Mcy	$2.00	$154,877,404	Clamshell Dredging
Transport	77.4	Mcy	$5.80	$449,144,472	$0.10 Per One-Way Haul in NM (58 NM)
Placement	77.4	Mcy	$2.25	$174,237,080	Hydraulic Unloader
SUBTOTAL COST A+B+C+D				**$1,115,945,455**	
Contingency	15.00%			$167,391,818	
TOTAL COST A+B+C+D				**$1,283,337,273**	
TOTAL UNIT COST				**$16.57**	**per cubic yard**

* Costs are estimated in 2001 dollars.

** Engineering Consultation Construction Remediation, Inc. (E2CR 2001).

6.0 SUMMARY & CONCLUSIONS

Based on the available data collected during this dredging engineering assessment, the construction of the Barren Island Restoration Project appears to be technically feasible. The estimated range of Initial Cost for construction is about $43 to $82 million and the projected schedule for construction is about 2 to 4 years. The estimated range of Total Site Use Cost is about $414 million to $1.29 billion. The estimated total unit cost ranges from $16.57/cy to $17.16/cy dependent on alignment and dike height chosen.

Note that the analysis in this study was conducted at a pre-feasibility level and therefore, the results should be considered preliminary. A feasibility study and engineering design would be needed to implement the proposed project. The analysis and findings in this report would still generally apply if the northern and southern dikes were reoriented to the historic shoreline, but additional studies would be needed.

7.0 REFERENCES

E2CR (2001). Geotechnical Reconnaissance Study for Barren Island Chesapeake, MD. Engineering Construction Consulting Remediation, Baltimore, MD.

Applied Coastal (2001). Coastal Engineering Reconnaissance Study for Barren Island, Maryland. Applied Coastal Research and Engineering, Inc., Mashpee, MA

GBA (2001). Conceptual/Pre-feasibility Study for Dredged Material Placement Site Construction at Parsons Island. Gahagan & Bryant Associates, Inc., Baltimore, MD

APPENDIX C

GEOTECHNICAL RECONNAISSANCE STUDY

Geotechnical Reconnaissance Study for Barren Island, Chesapeake Bay, Maryland
Gahagan & Bryant Associates, Inc.
February 2002

APPENDIX C

ENGINEERING · CONSTRUCTION · CONSULTING · REMEDIATION

GEOTECHNICAL RECONNAISSANCE STUDY

FOR:

BARREN ISLAND

CHESAPEAKE BAY, MARYLAND

PREPARED FOR:

ROY F. WESTON, INC.

1400 WESTON WAY, P.O. BOX 2653

WEST CHESTER, PA 19380

BY:

E2CR, INC.

9004 YELLOW BRICK ROAD, SUITE-E

BALTIMORE, MARYLAND 21237

PHONE: 410-574-4393

FAX: 410-574-7970

FEBRUARY 2002

ENGINEERING • CONSULTATION •
E2CR inc.
CONSTRUCTION • REMEDIATION •

9004 Yellow Brick Road, Suite E
Baltimore, Maryland 21237
Phone: 410-574-4393
Fax: 410-574-7970
e-mail: e2cr@erols.com

February 8, 2002

Ms. Corinne L. Murphy, P.E.
Roy F. Weston, Inc.
1400 Weston Way
P.O. Box 2653
West Chester, PA 19380

Re: Preliminary Reconnaissance Study – Geotechnical
Barren Island
Chesapeake Bay, Maryland
E2CR Project No.: 01556-04

Dear Ms. Murphy:

We have completed the necessary amendments to the previous report dated December 3, 2001. Transmitted herewith are five copies of our Geotechnical Report dated February 8, 2002.

Should you have any questions, or need any additional information, please give us a call.

Very Truly Yours,
E2CR, INC.

G.V. Kumar, Ph.D.
Project Engineer

Siva Balu, P.E
Chief Executive Officer

ENGINEERING • CONSULTATION •

E2 C/R inc.

CONSTRUCTION • REMEDIATION •

TABLE OF CONTENTS

ENGINEERING • CONSULTATION •
E/2 C/R inc.
CONSTRUCTION • REMEDIATION •

LIST OF FIGURES

ENGINEERING • CONSULTATION •
E/2 C/R inc.
CONSTRUCTION • REMEDIATION •

LIST OF TABLES

ENGINEERING • CONSULTATION •

E2 C R inc.

CONSTRUCTION • REMEDIATION •

BARREN ISLAND
PRELIMINARY RECONNAISSANCE STUDY – GEOTECHNICAL

EXECUTIVE SUMMARY

This report presents the results of the preliminary geotechnical reconnaissance study conducted for the proposed beneficial use of dredged material project at the west side of Barren Island. Two potential beneficial use areas were evaluated. Alignment Option 1 for the perimeter dike would enclose an area of approximately 1000 acres and Alignment Option 2 would enclose an area of about 2000 acres.

The study focused on the subsurface conditions along the proposed alignments, the suitability of the foundation soils for supporting the dike, the availability of suitable borrow to construct the dike, and developing a preliminary dike section. A total of 18 soil borings were drilled to depths of 35 to 70 feet and laboratory testing was performed to evaluate the classification, shear strength, and compressibility of selected soil samples.

The borings drilled along the proposed dike alignments indicate that the foundation soils in most areas will consists of silty sand which will be suitable for supporting the dike. Some of the borings, however, encountered soft silty clays at the mud line that will need to be undercut and backfilled with sand. For these areas, the depth required undercut is anticipated to range from 5 to 18 feet and average about 10 feet.

The site was found to contain a sufficient quantity of suitable borrow for constructing the perimeter dike to Elevation +20 feet. Suitable borrow was defined as sand with less than 30% fines. It is estimated that the total volume of suitable silty sand within the areas of Alignments Options 1 and 2 is about 10 million cubic yards and 25+ million cubic yards, respectively. The net quantity of sand available (assuming a 15% loss of fines during construction) will be about 8 million cubic yards and 20+ million cubic yards, respectively.

A slope stability analysis was performed to develop a preliminary design section for the perimeter dike. For a dike constructed to Elevation + 20 feet, it was determined that the side slopes should have an inclination of 3H: 1V or flatter and that sand borrow containing less than about 30% non-plastic fines should be used.

I INTRODUCTION

This report presents the results of the preliminary geotechnical reconnaissance study conducted in association with the conceptual development of a proposed beneficial use of dredged material project at the Western side of Barren Island, in Dorchester County, Maryland. The overall study is being performed by E2CR, Inc. under contract to the Maryland Environmental Services (MES) and is sponsored by the Maryland Port Administration through MES. The investigation was conducted for Roy F. Weston, Inc., in general accordance with E2CR's revised proposal dated August 29, 2001, and was authorized by Roy F. Weston, Inc.

II SITE LOCATION / DESCRIPTION

Barren Island is located at the central portion of Chesapeake Bay in Dorchester County, Maryland, about 27 miles northeast of the mouth of the Potomac River. The island is located at the west side of Tar Bay, 1.5 miles west of Upper Hooper Island, as shown on Figure 1 and Figure 2. The depth of water within the proposed dike area varies from about 3 feet to 10 feet. The shoreline change at the island from 1848 to 1993 is shown on Figure 3. The predominantly north to south littoral drift has caused severe erosion of the shoreline on the west side of the island due to high wave energies from Chesapeake Bay. Since 1848, an estimated 78% of the Barren Island has been lost to erosion with most of the erosion occurring on the western, as shown on Figure 3.

III PROJECT DESCRIPTION

It is proposed to construct a beneficial use of dredged material project protected by a dike system immediately west of Barren Island. Two dike alignments are being evaluated. (Figure 4). Option 1 would envelope an area of about 1,000 acres. Option 2 would enclose an area of about 2000 acres. The dike system would be separated from the existing island by about 500 feet wide tidal gut.

The dike will be constructed by hydraulically or mechanically dredging the sand from the borrow area, stockpiling the sand if necessary, and then hydraulically or mechanically depositing the sand along the dike alignment. Hydraulic placement offers certain construction advantages and was used for analytical purposes in this report. It should be noted that if dike is constructed using only mechanical dredging, the properties of the sand in the dike would change. This could affect the stability of the dike, especially shallow failures. The outside face of the dike will be protected from wave action by armor stones.

The wetlands and uplands within the diked area will be created using sediments dredged from approach channels to the upper bay. The top of the dike enclosure, where needed, is expected to vary from Elevation (El.) +10 feet to El. +20 feet. For design purposes, the highest dike height was assumed. Hence, the top of the dike was assumed to be at El. +20 feet for this feasibility study.

IV PURPOSE AND SCOPE

The purpose of this preliminary geotechnical reconnaissance investigation was to:

i) Evaluate the geotechnical conditions at the site, especially along the proposed dike alignments;

ii) Design a stable dike section for the site in order to establish a preliminary cost estimate for construction;

iii) Evaluate the availability of suitable borrow material (sand) at the site, for the construction of the dike.

It should be understood that this investigation was a preliminary reconnaissance study and not a design investigation. The design phases may be conducted at a later date.

The scope of the study included reviewing the available data such as Maryland Geological Survey (MGS) and Soil Conservation Service (SCS) data, drilling 18 borings; obtaining Shelby tube samples; conducting laboratory tests to determine the stress history, strength characteristics and index properties of various strata; evaluating the data; conducting slope stability analysis for the proposed dike system; evaluating the soils at the site for possible use in constructing the dike; and preparing a geotechnical report, including developing a dike section for use in preparing a cost estimate. The evaluation of off-site borrow areas was outside of the scope of this study.

V FIELD INVESTIGATION

The field investigations were conducted during September and October 2001. A total of 18 borings (G-1 through G-18) were drilled at the approximate locations shown on Figure 4. All borings were drilled using a truck mounted drill rig placed on a barge. Standard penetration tests were conducted and split-spoon samples were obtained in every boring at depth intervals of 2.5 feet to 5 feet. A representative portion of each sample was placed in a glass jar and was appropriately marked. Three inch diameter Shelby tube samples were obtained in borings G-4, G-10 & G-11 in the cohesive soils. All samples were sent to our laboratory for further testing.

Generally the following criteria was used to drill the borings:

- Borrow Area Borings: These borings were drilled to a depth of 20 feet into the clay or to the bottom of sand layers or to a maximum depth of 70 feet, whichever occurred first.
- Foundation Borings: These were drilled to a minimum of 30 feet or to depths of 10+ feet into dense/hard stratum. The foundation borings were drilled to a maximum depth of 70 feet or to the bottom of the sand layer, whichever occurred first.

The individual boring depths hand wide variation because of the variability in the depth of the sand stratum and firmness in the underlying clay stratum. The depth of the borings varied from about 35 feet to 70 feet, as tabulated below.

Boring	Depth (ft.) Water	Bottom of the Boring below water surface
G-1	10	40
G-2	8	40
G-3	9	50
G-4	6	45
G-5	10	45
G-6	9.8	55
G-7	12	45
G-8	10	35
G-9	18	65
G-10	11	35
G-11	12.2	40
G-12	12.6	40
G-13	11	50
G-14	10	50
G-15	3.5	40
G-16	12	70
G-17	12	45
G-18	6	50

All borings were inspected while drilling was in progress and the samples were logged and classified in the field by a Geologist. The edited logs of the borings are included in the Appendix.

VI LABORATORY TESTING

All samples were visually classified in the laboratory by a Geotechnical Engineer to corroborate and/or modify the field classifications. Selected samples were tested for their natural water content, Atterberg limits, grain size, percent fines, shear strength (unconfined compression tests and consolidated undrained (CU) triaxial tests) and consolidation characteristics. In addition, torvane and pocket penetrometer readings were recorded for cohesive soil samples and are summarized on Table 1. A total of 90 water contents, 14 Atterberg limits, 26 sieve analyses, 56 percent fines, 2 consolidation tests, 3 consolidated undrained triaxial tests and 5 unconfined compression tests were conducted. All tests were conducted in accordance with American Society for Testing Materials (ASTM) procedures. The results of the laboratory tests are included in Table 1 and in the Appendix.

VII PUBLISHED DATA

The available data that was reviewed included:

- Maryland Geologic Survey (MGS) Reports and Maps (Figure 5)
- Soil Conservation Service Publications for Dorchester County
- MGS's side scan sonar profiles (Figure 6). The survey was conducted by MGS on August 7, 2001.

  The side scan sonar profiles were used to locate some borings.

A. Area Geology

The site lies in the Coastal Plain Physiographic Province. According to the Maryland Geologic Survey map (Figure 5), the surface soils of Barren Island consists of Tidal Marsh Deposits (Qtm) and soils of the Kent Island Formation (Qk). The Tidal Marsh Deposits consists of soft silt and clay sediments containing thin beds of sand. The stratum is relatively thin (typically less than 10 feet) and is underlain by the Kent Island Formation. This formation consists of Interbedded layers of sand, silt and clay and ranges from approximately 10 to 25 feet in thickness. The soils underlying the Kent Island Formation are known as the Chesapeake Group, which consists of loose micaceous sand interbedded with dark silt and clay.

VIII SUBSURFACE CONDITIONS

The subsurface conditions along the perimeter and in the potential borrow area (within the diked area) are significantly different and are therefore, discussed separately.

A. Foundations

The borings indicate that the subsurface stratigraphy along the perimeter of Alignment Option 1 and 2 generally consist of three major strata, as shown on Figure 7 and 8 – Generalized Subsurface Profile.

Stratum I: This stratum was encountered in borings G-2, G-4, G-14 and G-18 at the mud line. It is about 5 feet to 15 feet thick, and predominantly consists of gray silty clay (CL) with Interbedded silt (ML) and sand (SM-SC) layers. Standard penetration resistance varies from WOH (weight of hammer) to 14 blows/feet. Laboratory test data indicates that the geotechnical properties of silty clay (CL) are as follows.

Liquid limit (LL)	19% to 40%
Plastic Limit (PL)	16% to 20%
Plasticity Index (PI)	3% to 20%
Water Content	18% to 67%
Preconsolidation Pressure (psf)	800 to 3500

In some areas, it is believed that this stratum has been preconsolidated by overburden with surface elevations in excess of 20 feet which has since been eroded.

Stratum II: This stratum consists of very loose to dense, gray to brown silty sand (SM) with pockets of silty clay. Standard penetration resistance varies from about WOH to 50 blows/4 inches. Fines content (i.e. percent passing U.S. standard sieve No. 200) vary from 3% to 48%, but is generally less 30%. The stratum occurs beneath Stratum I and is generally about

10 feet to 30 feet thick, except in the vicinity of borings G-9 and G-16. The stratum extends below El. –60 near G-9 and G-16. The sands are medium to fine and have angular to semi-angular grains.

It should be noted that this stratum contains localized pockets of clayey sand and silty clay.

Stratum III: This stratum underlies the entire site (except at boring G-9), and consists of soft to very stiff green gray silty clay with pockets of silty sand. The top of the stratum varies from about El. -26 to El. –47 feet. Standard penetration resistance varies from 2 to 18 blows/feet. Laboratory tests indicate that the index properties of this stratum are as follows.

Liquid Limit	Non-plastic to 63%
Plastic Limit	Non-plastic to 32%
Plasticity Index	Non-plastic to 31%
Water Content	18% to 77%

This stratum extends to the bottom of the borings, except in boring G-9.

B. Borrow Area

The subsurface conditions in the borrow area, especially close to the shore, are highly variable, compared to those along or close to the proposed alignment of the dike. Near the shore, the soils consist of discontinuous layers of gray brown silty clay, sandy clay, clayey sand and silty sand. The thickness of the layer varies from 0 to 18 feet, and there appears to be a lack of continuity in the sand layers.

Along or close to the dike alignment, the silty sand Stratum appears to be up to about 30 feet thick, with zero clay cover. The thicknesses of the clay cover and sand layers at each of the borings locations are shown on Figure 9.

Laboratory tests indicate that the percent fines content in the silty sands vary from 4% to 48%, but is generally less than 30%, as shown in Table 1 and on Figures 7 and 8.

The borrow area soils data, including thickness of clay to be stripped and the thickness of the sand available, are summarized in Table 2 and on Figure 9.

IX EVALUATION AND ANALYSIS

A. General

Two major issues concerning the geotechnical evaluation of a dredged material placement site are:

- Borrow: Availability of suitable borrow material within the contained area:

The borrow should ideally be a sand, with as little fines (i.e. percent passing U.S. Standard Sieve No. 200) as possible. If sand is not available locally, it will either have to be imported or the dike would have to be constructed from on-site clay (usually not practical due to the low strength of the clay placed in the dike), or another type of containment structure would need to be used.

- Foundation: Foundation conditions under the containment (perimeter) dike:

Soft clays in the foundation soils would require flatter slopes for the dike, or steeper slopes with stabilizing berms. Stiff clays and sands are the preferred conditions. Additionally, areas that have very soft clays may require the total or partial removal (either by displacement or by undercutting) of the very soft clay. The undercut soil has to be disposed of, either on-site or off-site, and the undercut area has to be backfilled with sand.

In evaluating the stability of a slope, four variables have to be considered:

i) Analytical Method.
ii) Shear strength of the foundation soil and the embankment soil.
iii) The slope of the dike.
iv) The acceptable factor of safety.

Each of the major issues is discussed below.

B. Borrow Area Sand

In evaluating the borrow area, two variables have to be evaluated: i) quality of sand and ii) quantity (volume) of sand.

i) Quality of Sand:

The borings indicate that the sand, in generally, is semi-angular to angular. Sand containing fines in excess of 30% is not considered to be suitable, though about 15% of fines will be lost in hydraulic dredging and placement operations. The fines content of the borings vary from about 3% to 48%, and is generally less than 30%. Based on the boring data, the majority of the available sand is considered to be suitable for building the dike.

ii) Quantity of Sand

The extent of the potential borrow areas are shown on Figure 10.

The quantity of sand available was estimated based on the limited available data. It was assumed that no dredging will be done within 300 feet of the toe of the dike. The thickness of clay that will need to be stripped and the thickness of sand available at each boring are summarized in Table 2, and are also shown on Figure 9.

For Alignment Option 1, the volume of total sand available is estimated to be about 10 million cubic yards. During construction, the bulking will be minimal, since the sand is loose. In addition, about 15% of the fines will be lost. Therefore, the net quantity of sand available for dike construction is estimated to be about 8 million cubic yards. Additional sand will also be available outside the dike area.

For Alignment Option 2, the total volume of sand available within the dike area is about 25+ million cubic yards, and the net volume available is about 20+ million cubic yards. Additional sand will be available outside the dike area.

It appears that adequate sand is available to build the dike to Elevation +20 feet.

C. Foundation / Slope Stability

i) Analytical Method

Slope stability analyses were conducted using one typical case for the subsurface profile. Purdue University PC STABL-V program was used to analyze the stability of the slopes. This program incorporates many different analytical methods, such as circular failure and wedge failure. Also, the failures can be analyzed using different analytical approaches, such as the Modified Bishop Method, the Modified Janbu Method and the Spencer Method. For this study, the Modified Bishop method was used. The Janbu Method results in a lower factor of safety (ratio of resisting and driving forces along a potential failure plane), which is generally considered to be too conservative, and is typically about 15% less than the Bishop's Method.

ii) Design Parameters (Shear strength of foundation and embankment)

For Alignment Option 1 and Alignment Option 2, shear strength of the foundation soils was based on the evaluation of standard penetration tests (SPT) blow counts, since the soils at the foundation level are mostly silty sands.

At Alignment Option 1, soft clay with interbedded sand layers (Stratum I) was encountered in boring G-2, G-4 and G-14. At Alignment Option 2, soft clay with interbedded layers (Stratum I) was encountered in Boring G-2, G-4, G-14 and G-18. The majority of this Stratum I layer is soft and unsuitable and will have to be undercut. The depth of undercutting will vary from 5± feet to 10± feet. Though the shear strength of the bottom portion of this stratum is reasonably good, the entire portion may have to be undercut because the layers are relatively thin and are very localized, based on the limited data obtained during this preliminary reconnaissance study. The extent of the soft stratum, and its depth and shear strength will have to be further investigated in the design phase to further evaluate the depth of undercutting that will be required.

The following design parameters were used for the foundation soils.

Stratum	N	γ pcf	C psf	ϕ Degrees
I*	WOH-14	-	-	-
II	WOH-50	120	0	28
III	2-18	120	750	0

* Will be undercut

N = Standard Penetration Resistance in blows/foot

γ = Density of soil in pcf

C = Cohesion in psf

ϕ = Angle of internal friction

The dike will be constructed from the on-site sands. For other similar projects, the friction angle (ϕ) of the dike soils has been assumed to be 30° above the water and 28° below the water, since the dike soils were assumed to be non-plastic silty sands. However, it is conceivable and likely that the fines in the dike at this site could be plastic, especially since the borrow area inside Alignment Options 1 and 2 may consist of pockets of clayey sands and silty cays near the shore. Therefore, two cases were analyzed: one for non-plastic fines in the dike fill and the other for plastic fines in the dike fill. The following design parameters were used for design:

Case A – Non-Plastic Fines

	γ pcf	C psf	ϕ Degrees
• Above Water	120	-	30
• Below Water	120	-	28

Case B – Plastic Fines

	γ pcf	C psf	ϕ Degrees
• Above Water	115	100	20
• Below Water	110	0	20

The subsurface profiles did not warrant the use of a wedge type of failure, since there are no thin, soft layers. Therefore, only circular failures were analyzed.

iii) Slope of Embankment (dike)

During construction, the slope of the dike can vary considerably, depending upon the type of soil, placement methodology, and whether the soil is placed above or below the water. Past experience has indicated that dikes constructed from silty sands (non-plastic) can achieve slopes as steep as 2H:1V below the water. However, 3H:1V is a more realistically obtainable slope. Also, during dredging, pumping and placement, about 15% of the fines can wash out for hydraulically dredged and placed sand. Thus, if a borrow area has 30% non-plastic fines, the dike will tend to have about 10% to 15% fines. For mechanically dredged and placed sands, the loss of fines would be much smaller. For this preliminary reconnaissance it was assumed that the dike would be constructed by hydraulic dredging, and the slopes achievable would be 3H:1V below the water table.

iv) Acceptable Factor of Safety

The acceptable factor of safety for stability of the dike slopes was assumed to be 1.3, at the end of the dike construction phase. This was also based on the experience at the Hart-Miller Island and Poplar Island projects, and was considered to be acceptable to the U.S. Army Corps of Engineers. USACE will be involved in the permit process, and will review and approve the final design for this project, if this project is implemented.

The design sections for slope stability analysis are shown on Figure 11 and Figure 12. The results of the analyses are shown on Table 3 (for non-plastic fill) and Table 4 (for plastic silty sand).

The analysis indicates that the factor of safety for the assumed design section is in excess of 1.3 for both deep and shallow failures surfaces for non-plastic dike fill (see Table 3). The analysis shows that the factor of safety for a plastic fill dike is less than 1.3 (see Table 4) for shallow failure surfaces. Therefore, it is recommended that the dike should be constructed with non-plastic fill, especially below the water level. It is recommended that the slopes of the dike be no steeper than 3H:1V, as shown on the design section.

D. Undercutting

The borings indicate that along Alignment Option 1, soft soils should be anticipated at the surface (mud line) near borings G-2, G-4 and G-14. Similarly, soft soils are anticipated in borings G-2, G-4, G-14 and G-18, along Alignment Option 2. These soft soils (Stratum I) will need to be undercut. As a preliminary estimate, the depth of undercut will vary from about 5± feet to 18+ feet with an average of about 10 feet. Other areas of soft soils that will need to be undercut should also be anticipated.

X CONCLUSIONS

Based on the limited boring data, our conclusions are as follows:

A. Alignment Option 1

i) The foundation soils for Alignment Option 1 are anticipated to be mostly loose silty sands, except near G-2, G-4 and G-14, where the soils are predominantly layers of soft silty clay.

ii) The dike along Alignment No. 1 can be founded on the silty sand foundation soils, using a slope of 3H:1V. However, the soft clays near borings G-2, G-4 and G-14 will have to be undercut. As a preliminary estimate, an average undercut depth of 10 feet should be used.

iii) A total of about 10 million cubic yards of silty sand and a net (i.e. assuming 15% loss of during hydraulic dredging and placement) of about 8 million cubic yards of silty sand is available within the diked area.

B. <u>Alignment Option 2</u>

i) The foundation soils for Alignment Option 2 are anticipated to be mostly loose silty sands, except near G-2, G-4 , G-14 and G-18, where the soils are predominantly layers of soft silty clay.

ii) The sands are considered to be suitable for supporting the dike on a 3H:1V slope. However, the interbedded soft clays and silty sand will need to be undercut. The soft soil near boring G-2, G-4, G-14 and G-18 will have to be undercut to an estimated average depth of 10 feet.

iii) The total volume of silty sand available within the diked area is estimated to be about 25+ million cubic yards and the net (i.e. assuming 15% loss of during hydraulic dredging and placement) volume is estimated to be about 20+ million cubic yards.

REFERENCES

Achilleos, E (1988), *User Guide For PC STABL 5M*, School Of Civil Engineering, Purdue University, West Lafayette, Indiana.

Terzaghi, K. and Peck, R.B. (1948), *Soil Mechanics in Engineering Practice*, 1st edn., Wiley, New York.

U.S. Navy, Naval Facilities Engineering Command, *Soil Mechanics – Design Manual 7.01*, Alexandria, Virginia, 1986.

U.S. Navy, Naval Facilities Engineering Command, *Foundations & Earth Structures – Design Manual 7.02*, Alexandria, Virginia, 1986.

Appendix

Figures

ENGINEERING · CONSULTATION ·

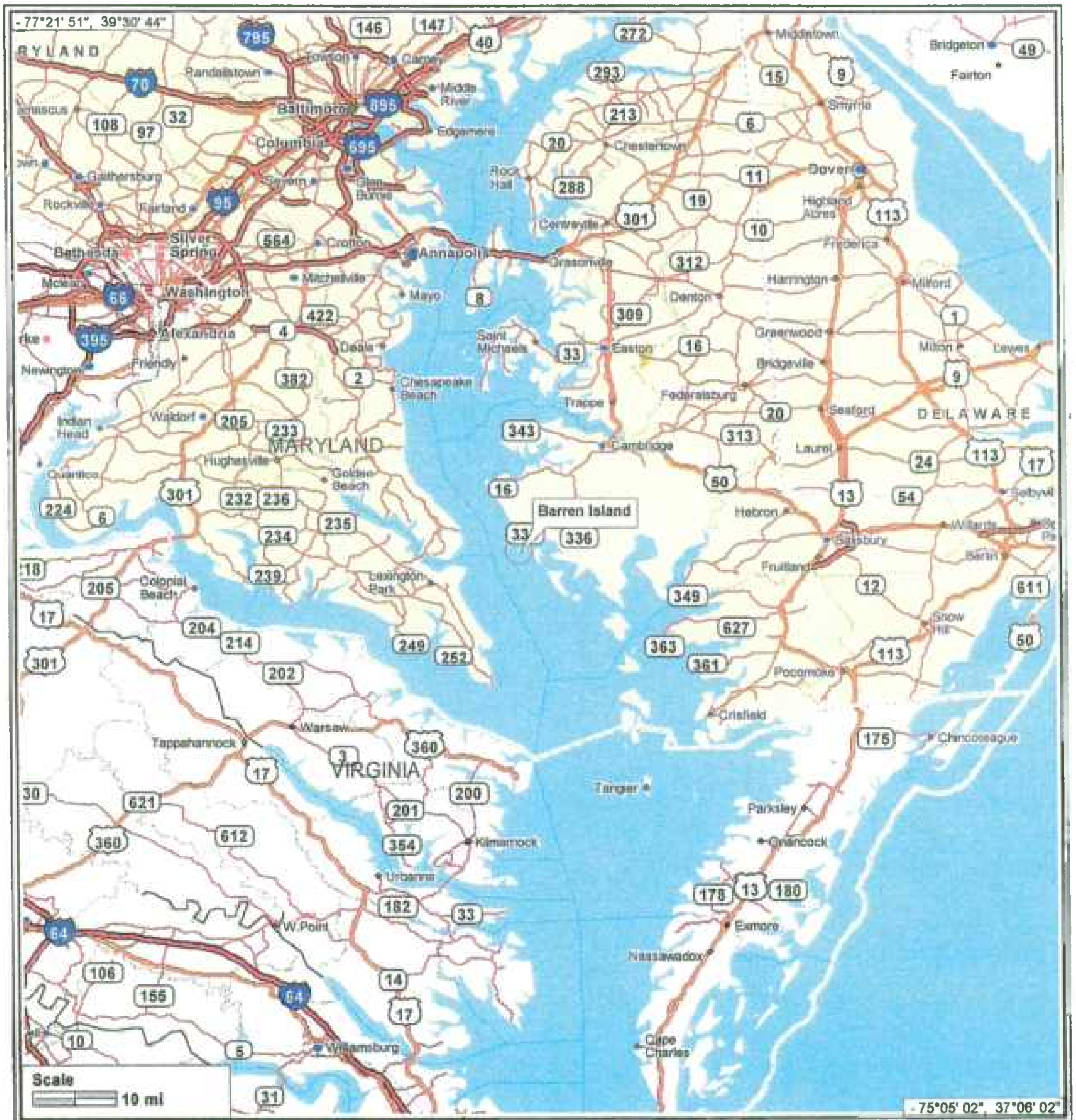
E2CR inc.

CONSTRUCTION · REMEDIATION ·

SITE VICINITY MAP
BARREN ISLAND
CHESAPEAKE BAY, MARYLAND

FIGURE: 1	DRAWN BY: NS	CHECKED BY:
DATE: NOV., 01	JOB NO: 01556-04	SCALE:

BARREN ISLAND



Map Image Created Using Precision Mapping Streets 4.0

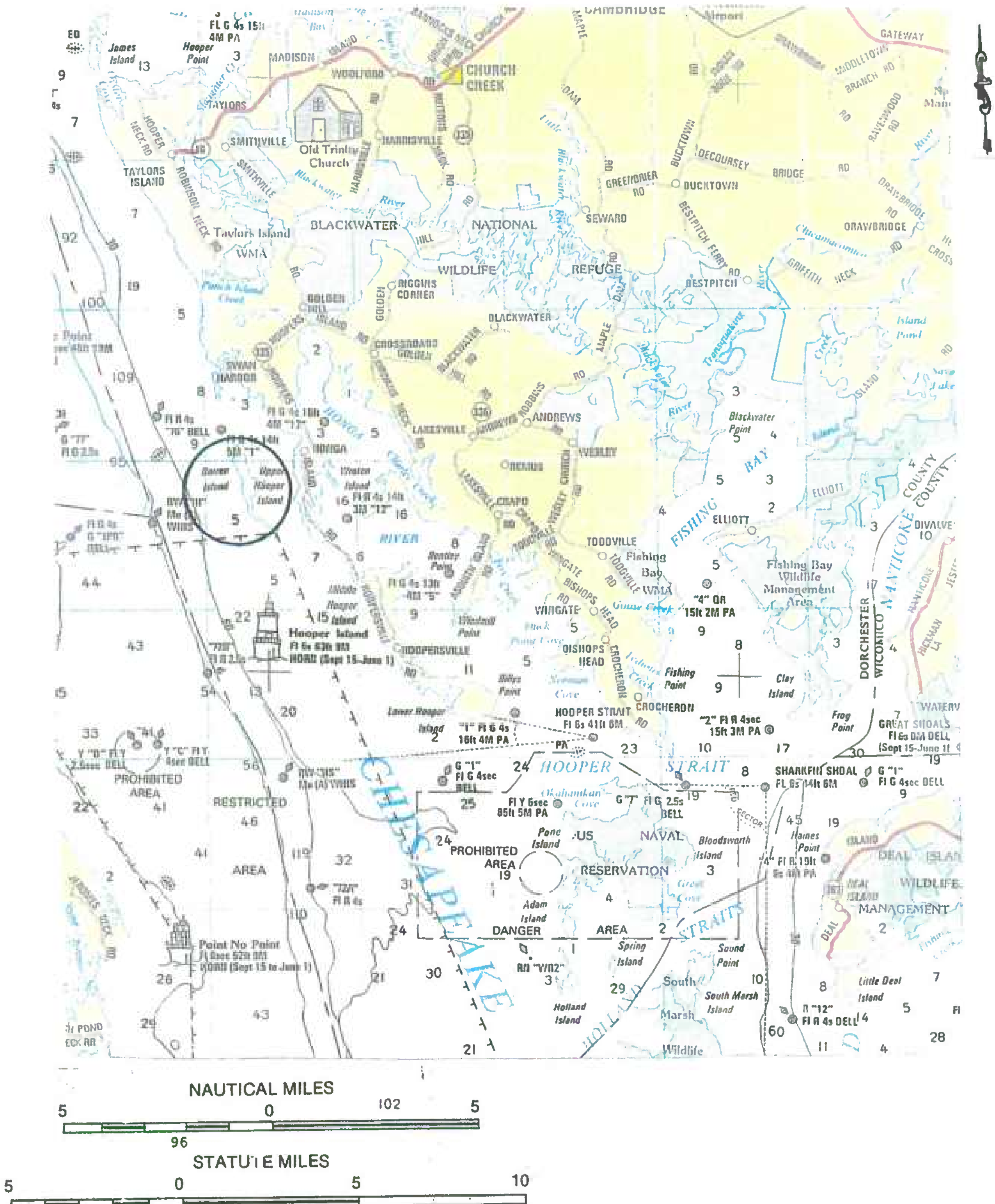
ENGINEERING · CONSULTATION ·

E2CR inc.

CONSTRUCTION · REMEDIATION ·

SITE LOCATION
BARREN ISLAND
CHESAPEAKE BAY, MARYLAND

FIGURE: 2	DRAWN BY: NS	CHECKED BY:
DATE: NOV., 01	JOB NO: 01556-04	SCALE:



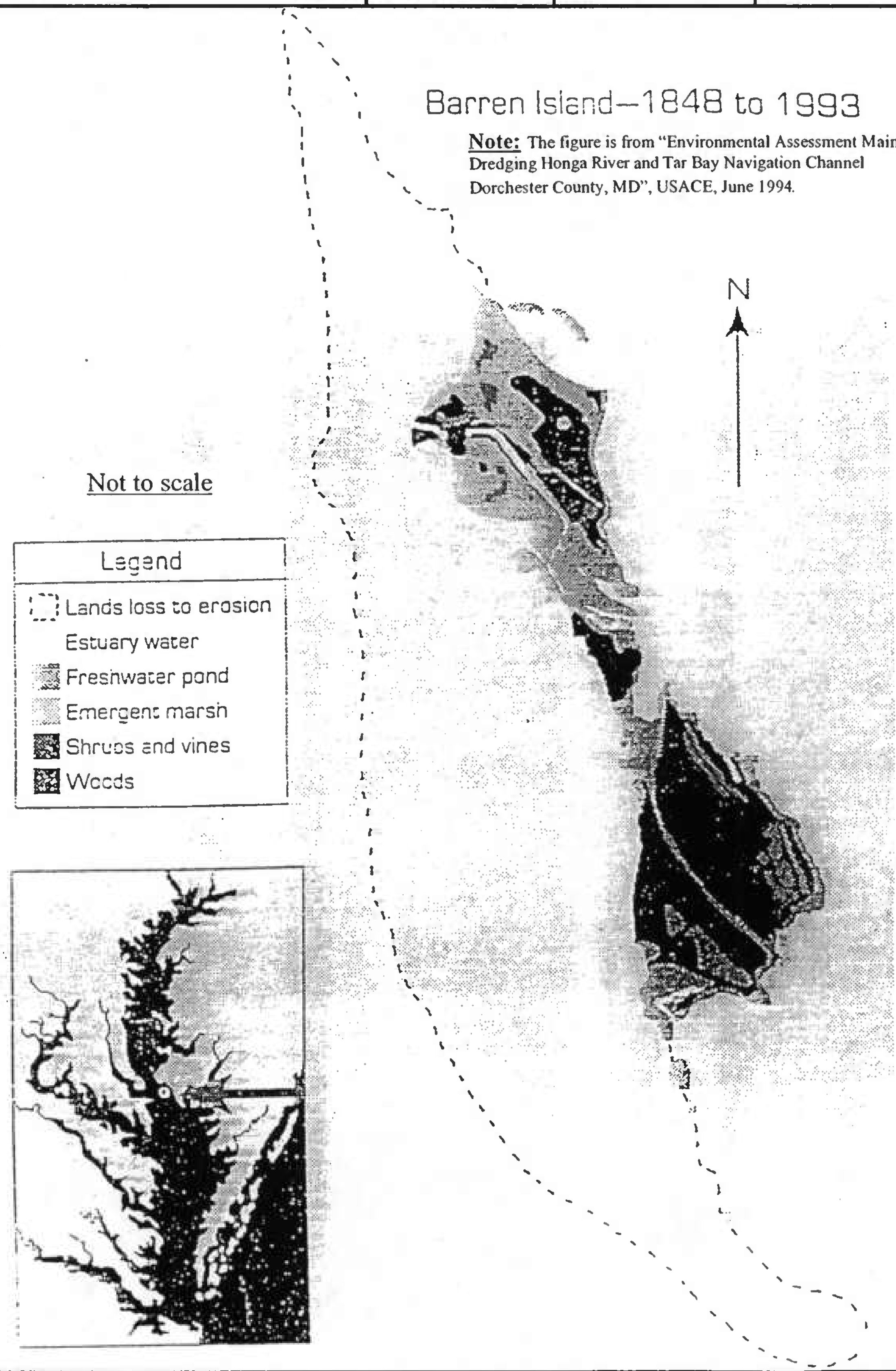
ENGINEERING · CONSULTATION ·
E2CR inc.
CONSTRUCTION · REMEDIATION ·

SHORELINE CHANGES/ EXISTING CONDITIONS
BARREN ISLAND, CHESAPEAKE BAY, MARYLAND

FIGURE: 3	DRAWN BY: NS	CHECKED BY:
DATE: NOV., 01	JOB NO: 01556-04	SCALE: NTS

Barren Island—1848 to 1993

Note: The figure is from "Environmental Assessment Maintenance Dredging Honga River and Tar Bay Navigation Channel Dorchester County, MD", USACE, June 1994.

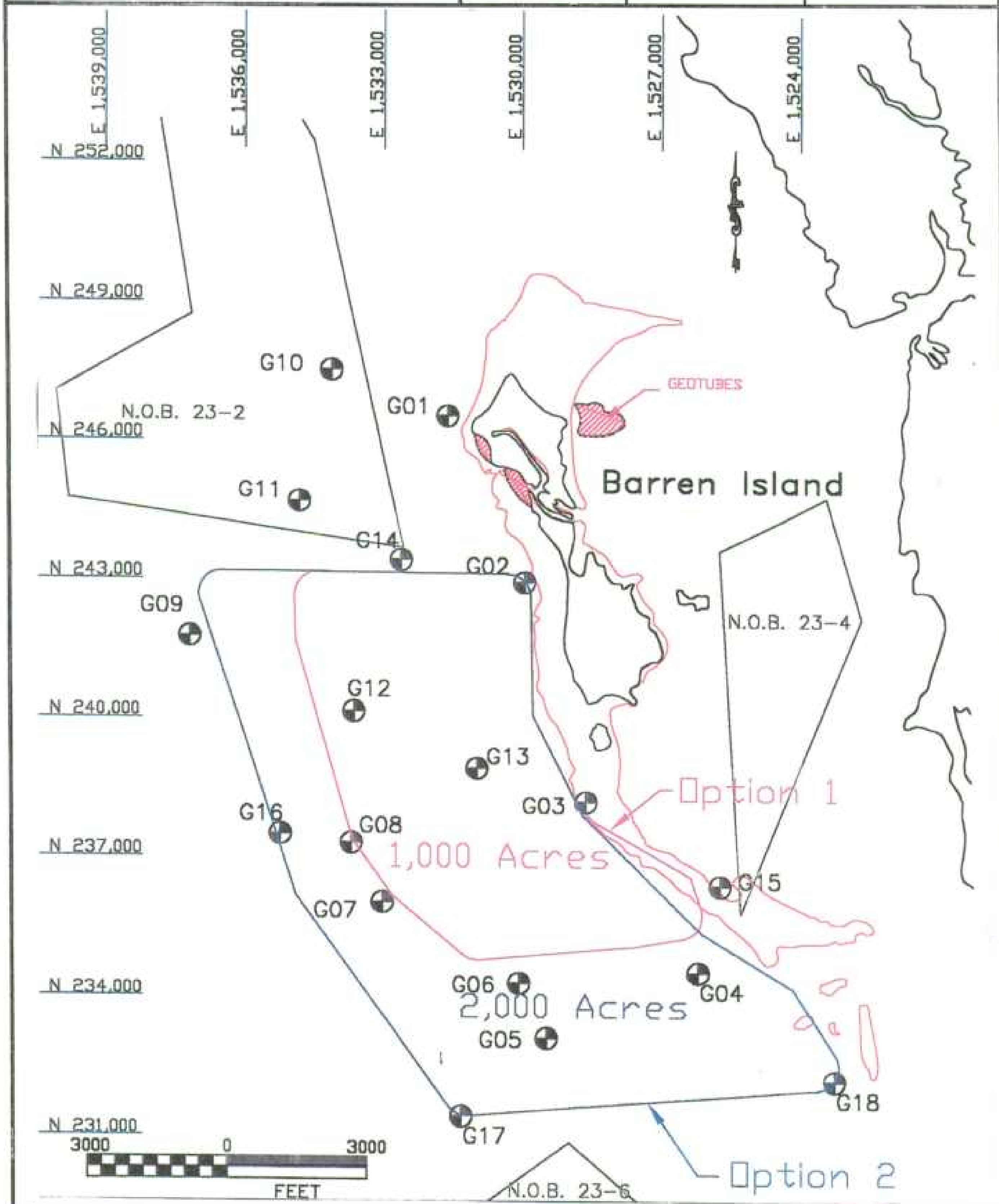


Not to scale

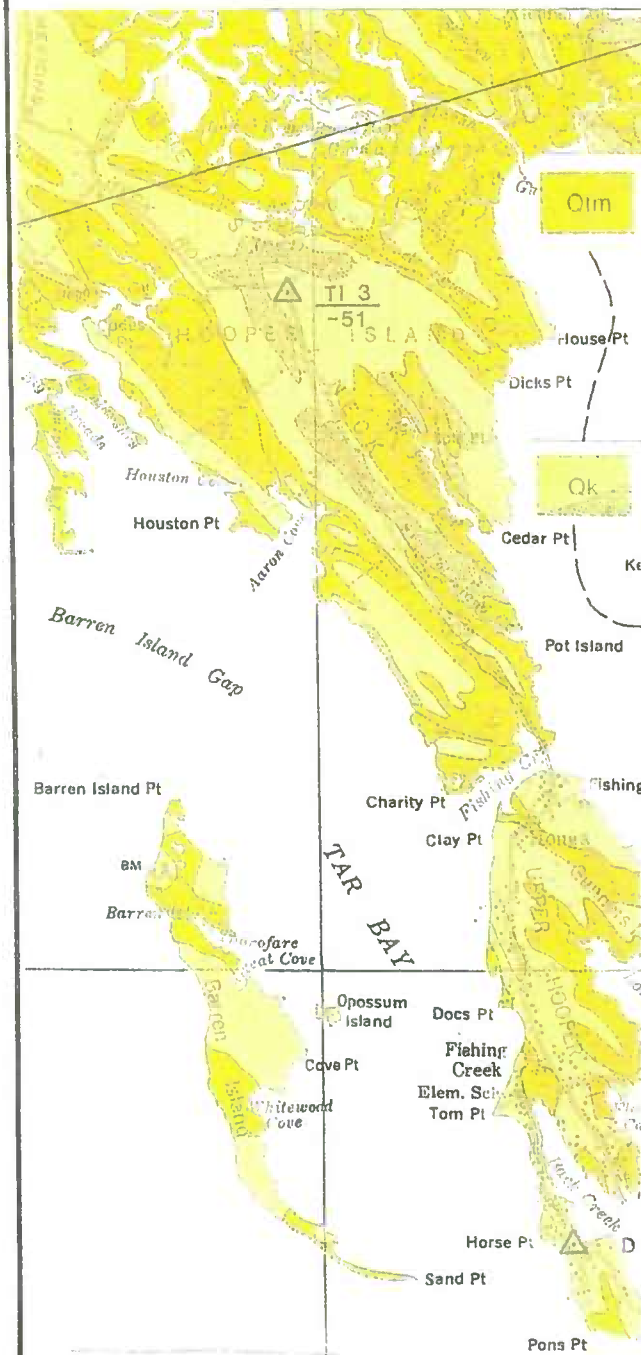
ENGINEERING · CONSULTATION ·
E2CR inc.
CONSTRUCTION · REMEDIATION ·

ALTERNATE ALIGNMENTS/
TEST BORING LOCATION PLAN
BARREN ISLAND, CHESAPEAKE BAY, MARYLAND

FIGURE: 4	DRAWN BY: NS	CHECKED BY:
DATE: NOV., 01	JOB NO: 01556-04	SCALE:



ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	GEOLOGICAL MAP BARREN ISLAND CHESAPEAKE BAY, MARYLAND		
	FIGURE: 5	DRAWN BY: NS	CHECKED BY:
	DATE: NOV., 01	JOB NO: 01556-04	SCALE:



From Geologic Map of Dorchester County, MGS, 1986

EXPLANATION OF MAP UNITS

TIDAL MARSH DEPOSITS (HOLOCENE) — Silt or clay, locally mixed with thin beds of sand, particularly near river mouths. Sediment is dark gray to gray brown due to abundant, finely comminuted, decayed organic matter, and is unconsolidated "soupy". Tidal marsh deposits are widespread in the southern part of the County. The largest area extends from the Blackwater National Wildlife Refuge eastward for about 22 km (14 mi) to the Nanticoke River and ranges in width from about 3 to 13 km (2 to 8 mi). Sediment thickness is unknown. In nearby areas, thicknesses up to about 6 m (20 ft) have been reported (Owens and Denny, 1978, 1979a).

KENT ISLAND FORMATION (MIDDLE WISCONSIN OR UPPER SANGAMON) — Interbedded silt, clay, and sand, with abundant organic matter in places. Clayey and silty sediments underlie most of Dorchester County except the northeastern part where sandy and, in places, gravelly materials overlie the Beaverdam Sand or the Pensauken Formation. In the central County, the Kent Island Formation forms an essentially featureless plain that slopes southward from a low drainage divide just south of the Choptank River and the uplands to the east. The Kent Island plain is traversed by several south-flowing streams, such as the headwaters of the Blackwater River, the Transquaking River, and the Chicamacomico River, which are separated by broad flat areas with poorly-drained soils. The Formation underlies a broad lowland (maximum width 45 km or 38 mi) that is part of a plain extending for nearly 200 km (125 mi) along the east side of Chesapeake Bay. A west-facing scarp with a toe at an altitude of about 7 m (25 ft) separates this lowland from higher land to the east. In Dorchester County, this scarp is not as prominent a topographic feature as it is to the north of the Choptank River.

Adjacent to Chesapeake Bay, in the southwestern County, the Kent Island Fm. underlies long, narrow areas separated by tidal marsh. The nature of the sediments composing the Kent Island in this coastal belt is largely unknown, but the striped appearance of the belt suggests that it is part of a barrier-back barrier system. The broad area of tidal marsh farther northeast, including the Blackwater National Wildlife Refuge, appears to occupy the back-barrier part of the same system. The inner edge of the tidal marsh to the northeast of the Blackwater Refuge trends in a west-northwest direction, whereas the coastal belt trends in a northwest direction. This change in trend suggests that the emplacement of the northwest trending deposits in the coastal belt took place after deposition of the west-northwest trending Kent Island Fm. in the rest of the County.

In the belt bordering the Bay and the Honga River in the southwest County, the stipple pattern indicates areas of well-drained to moderately well-drained soils (Mathews, 1963) that are as much as 1 m (3 ft) above adjoining areas of poorly to very poorly-drained soils.

Scale 1:62500

1 1/2 0 1 2 3 4 Miles

1 1/2 0 1 2 3 4 5 Kilometers

ENGINEERING · CONSULTATION ·

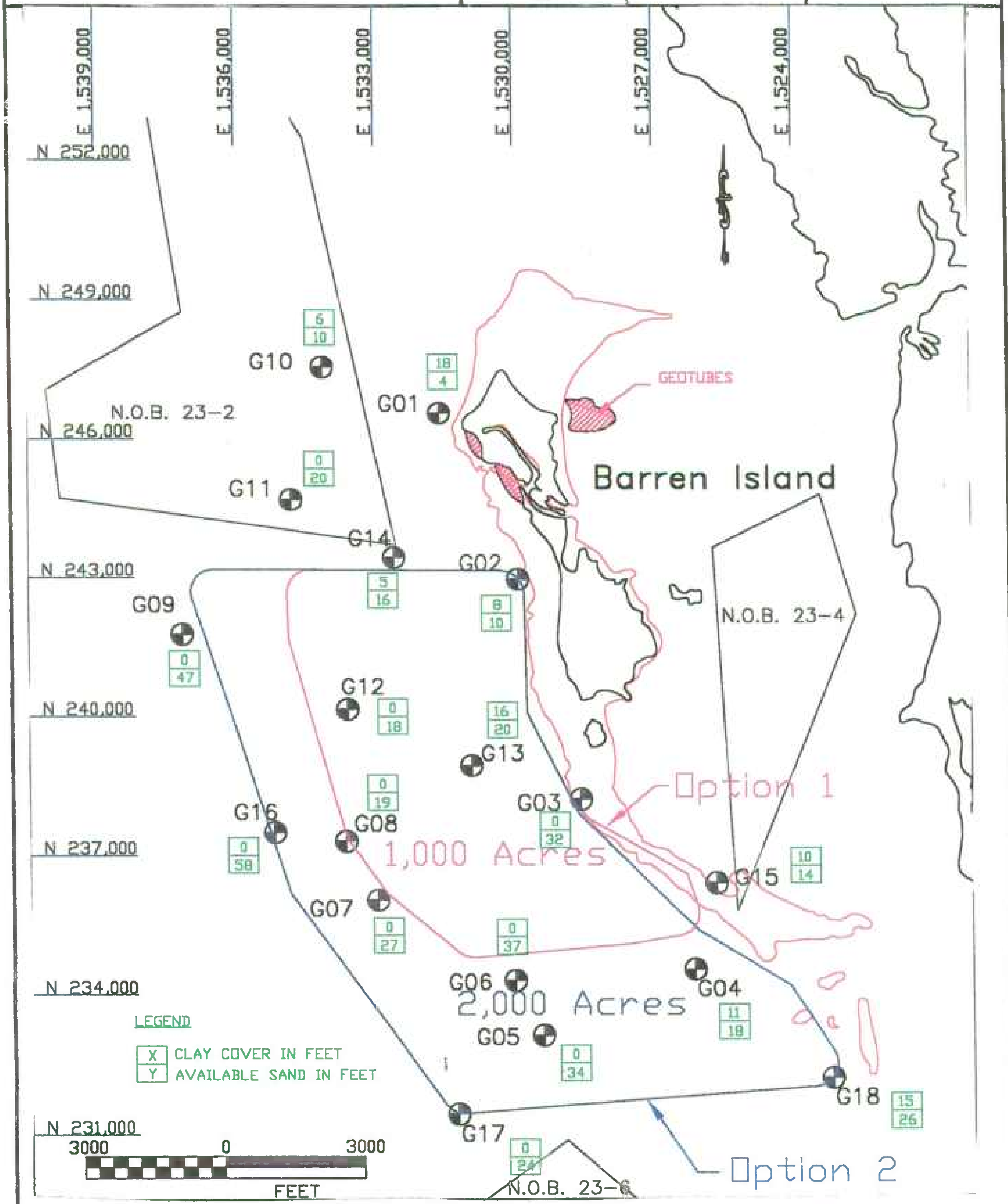
E2CR inc.

CONSTRUCTION · REMEDIATION ·

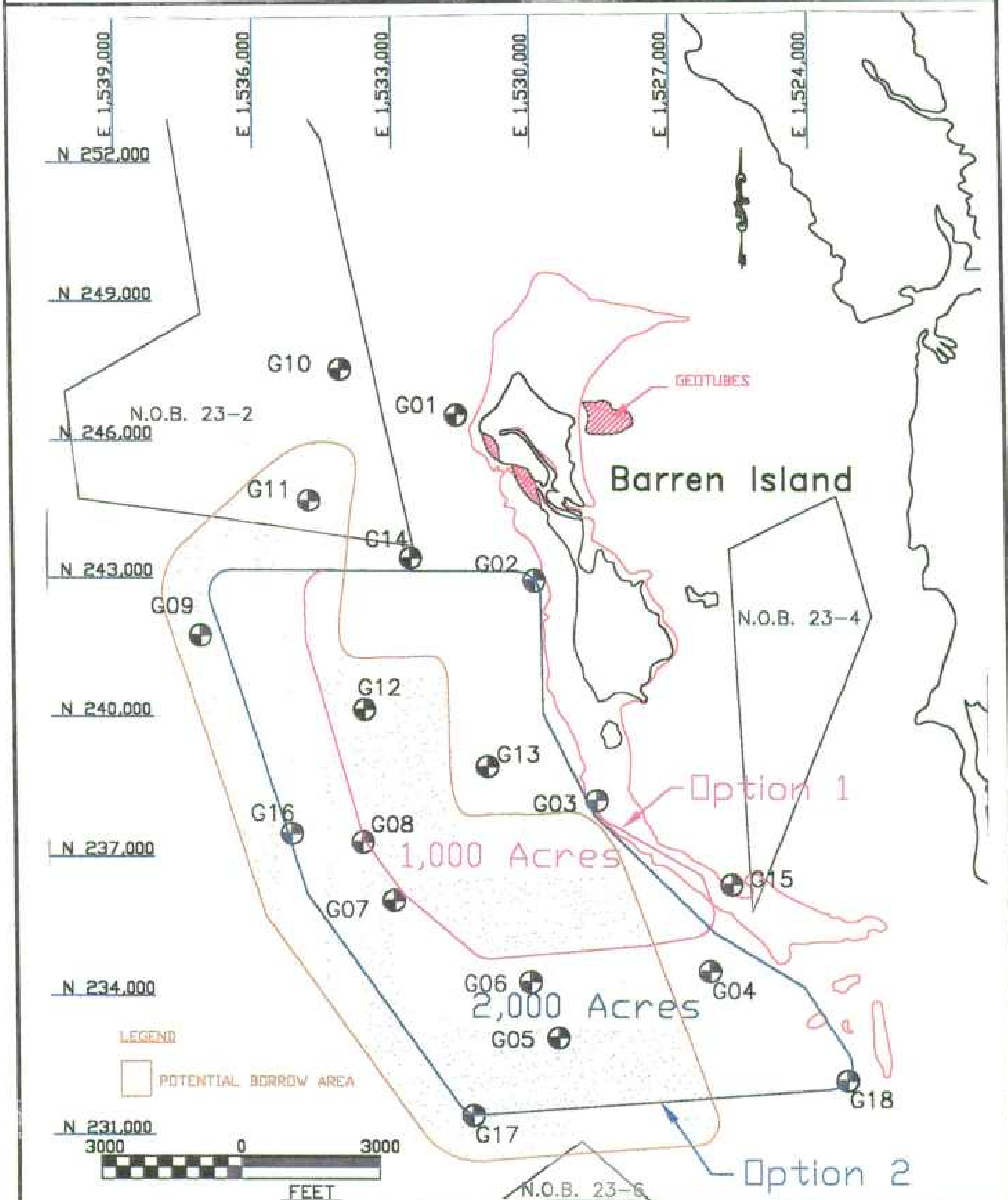
THICKNESS OF CLAY AND SAND - BORROW AREA

BARREN ISLAND, CHESAPEAKE BAY, MARYLAND

FIGURE: 9	DRAWN BY: NS	CHECKED BY:
DATE: DEC. 01	JOB NO: 01556-04	SCALE: 1"=3000'



ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·	LOCATION OF POTENTIAL BORROW AREAS BARREN ISLAND CHESAPEAKE BAY, MARYLAND	
FIGURE: 10	DRAWN BY: NS	CHECKED BY:
DATE: DEC. 01	JOB NO: 01556-04	SCALE: 1"=3000'



Tables

TABLE-2

Summary of Borrow Area Soils Data

Barren Island
E2CR Project No. 01556-04

Boring No.	Depth of Water (feet)	Strip* Thickness (feet)	Thickness Sand (feet)	Remarks
G-1	10	18	4	No Good**
G-2	8	8	10	No Good**
G-3	9	0	32	Good
G-4	6	11	18	No Good**
G-5	10	0	34	Good
G-6	9.8	0	37	Good
G-7	12	0	27	Good
G-8	10	0	19	Good
G-9	18	0	47	Good
G-10	11	6	10	Good
G-11	12.2	0	20	Good
G-12	12.6	0	18	Good
G-13	11	16	20	No Good**
G-14	10	5	16	No Good**
G-15	3.5	10	14	No Good**
G-16	12	0	58	Good
G-17	12	0	24	Good

Note:
* Includes clay, clayey sand and sand containing too much fines.
**Not economical to mine the sand when the strip thickness (es) exceeds 5 ft. or when the quantity of sand is less than 5 ft.

ENGINEERING • CONSULTATION •
E/2 C/R inc.
CONSTRUCTION • REMEDIATION •

TABLE-3: SUMMARY OF SLOPE STABILITY ANALYSIS CASE –A

(Non Plastic Fill)
Barren Island
E2CR Project No. 01556-04

Dike Height, H, Feet	Factor of Safety Through	
	Dike	Foundation
+10	1.50	2.03
+15	1.49	1.79
+20	1.46	1.46

ENGINEERING • CONSULTATION •
E/2 C/R inc.
CONSTRUCTION • REMEDIATION •

TABLE-4 : SUMMARY OF SLOPE STABILITY ANALYSIS CASE –B
(Plastic Silty Sand)
Barren Island
E2CR Project No. 01556-04

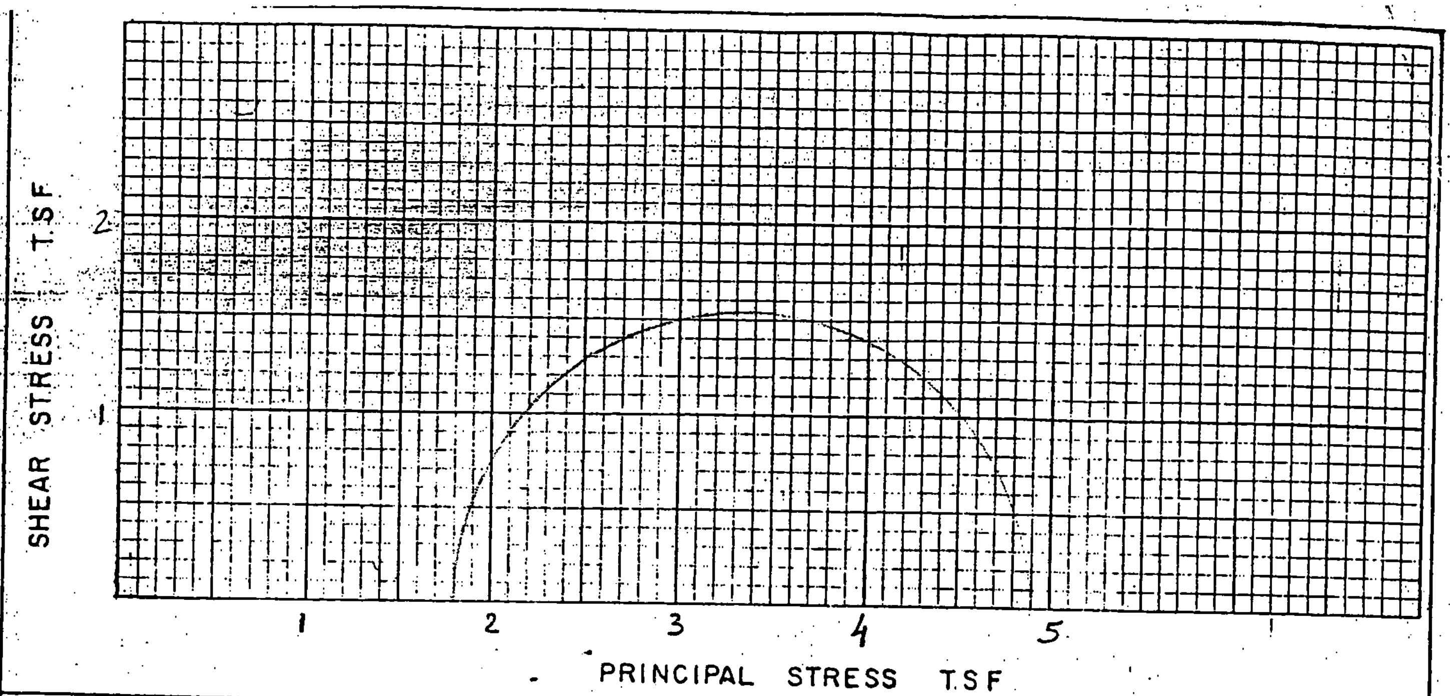
Dike Height, H, Feet	Factor of Safety Through	
	Dike	Foundation
+10	1.27	2.01
+15	1.22	1.78
+20	1.21	1.50

Slope Stability Analysis

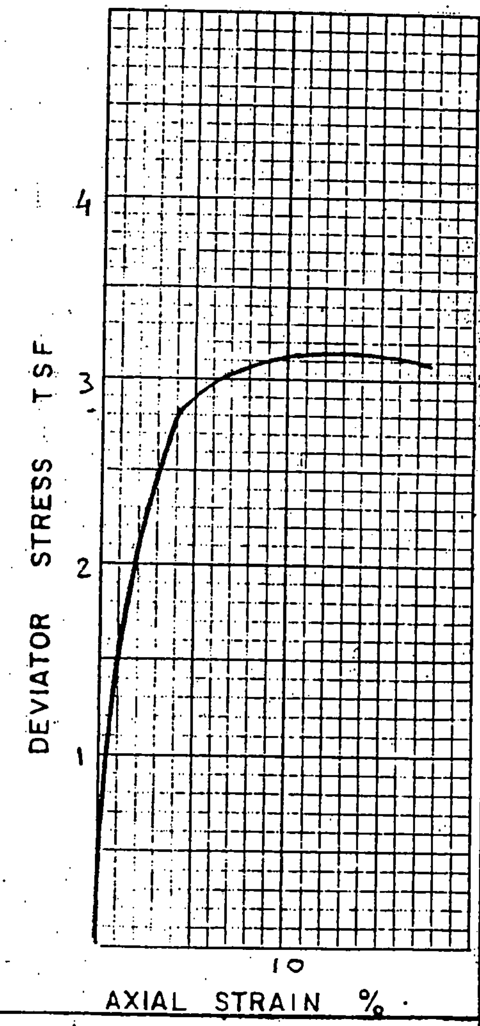
Case A: Non Plastic Fill

Case B: Plastic Silty Sand

Laboratory Testing Data



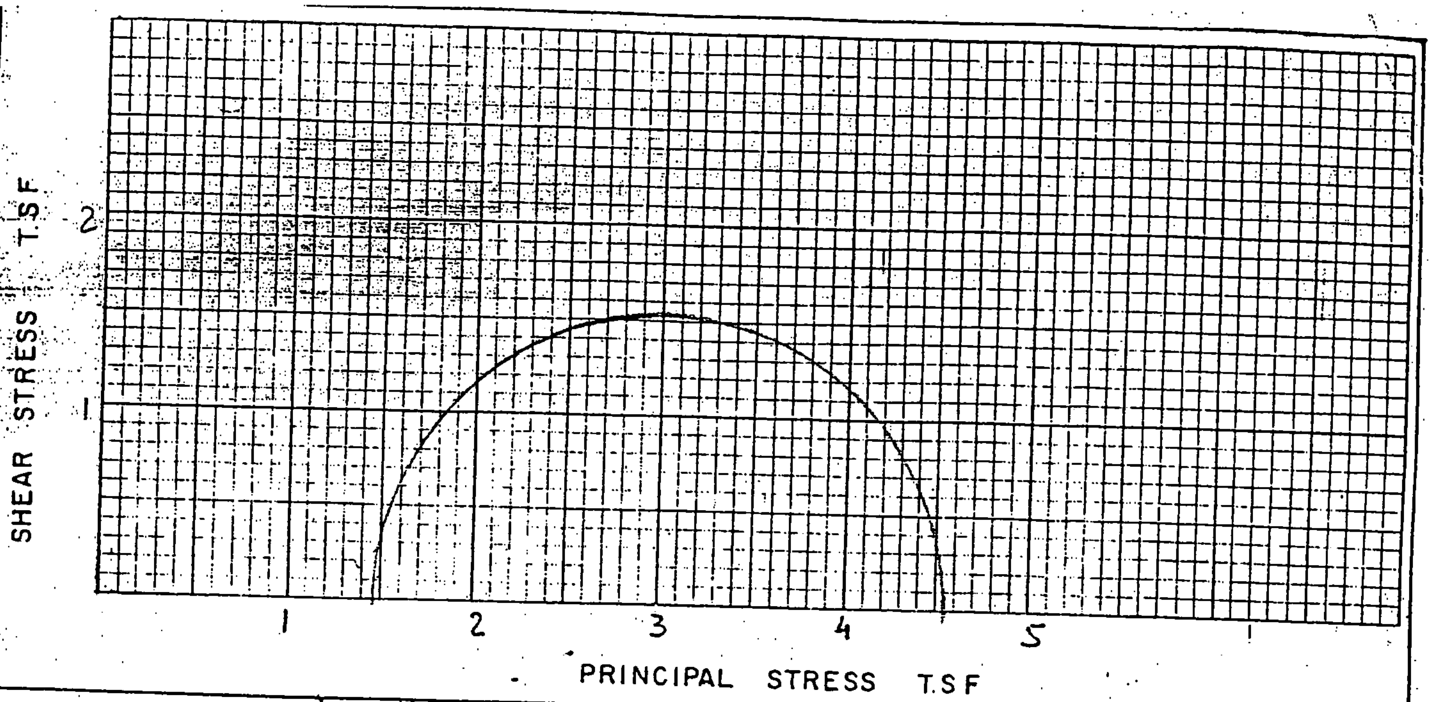
Test No.		1	2	3
Initial	W.C. Wo %	18.2		
	Dry Density PCF	102.4		
	Void Ratio e_o	.584		
	Saturation So%	93.4		
Before Test	W.C. after Sat. W_s%	22.5		
	Saturation S%	100		
	Consol. Press. TSF	1.8		
	W.C. after Con. W_c %			
	Void Ratio after e_c			
At Failure	σ_I TSF	4.9		
	σ_{III} TSF	1.8		
	W.C. W_f %			
	Void Ratio e_f			
Pore Press. at Fail. TSF		.45		
Strain Rate %		.08		
Specimen Dia. In.		2.8		
Initial Height In.		5.6		



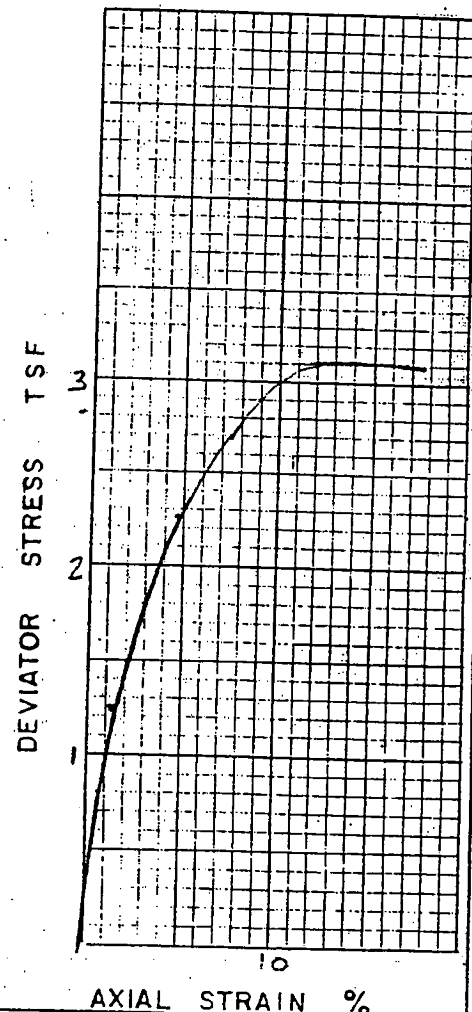
Type of Test CU		
Type of Specimen Shelby Tube		
Ø °	Tan Ø	C= TSF
Description: Light Brown to Yellow Clayey Sand		
LL 40	PI 20	Sp. Gr.

Project: Barren Island		
Client: Roy F. Weston		
Boring No. G-04	Samp. No.	Depth 11'-13'

TRIAXIAL COMPRESSION Date 11/14/01

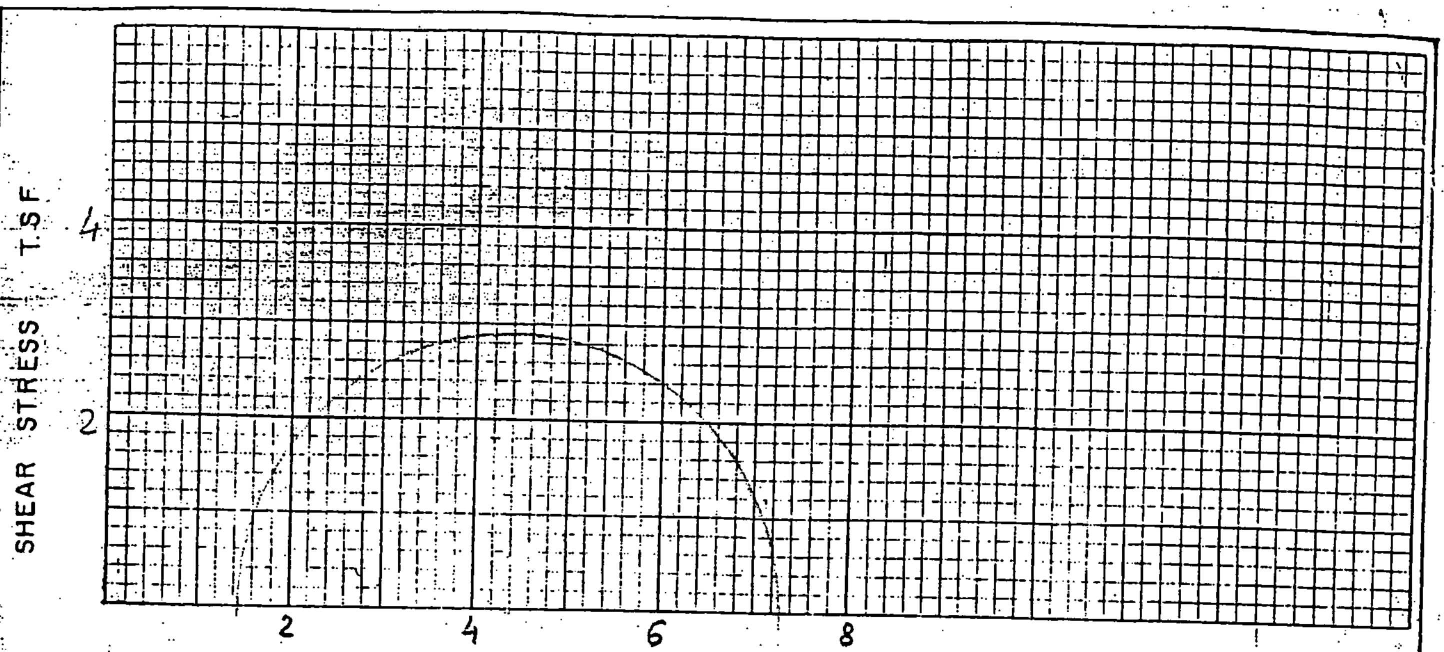


Test No.		1	2	3
Initial	W.C. W_o %	25.4		
	Dry Density PCF	96.7		
	Void Ratio e_o	.678		
	Saturation S_o%	97.3		
Before Test	W.C. after Sat. W_s%	25.6		
	Saturation S%	100		
	Consol. Press. TSF	1.44		
	W.C. after Con. W_c %			
	Void Ratio after e_c			
At Failure	σ_I TSF	4.55		
	σ_{III} TSF	1.44		
	W.C. W_f %			
	Void Ratio e_f			
Pore Press. at Fail. TSF		.92		
Strain Rate %		.08		
Specimen Dia. In.		2.8		
Initial Height In.		5.6		

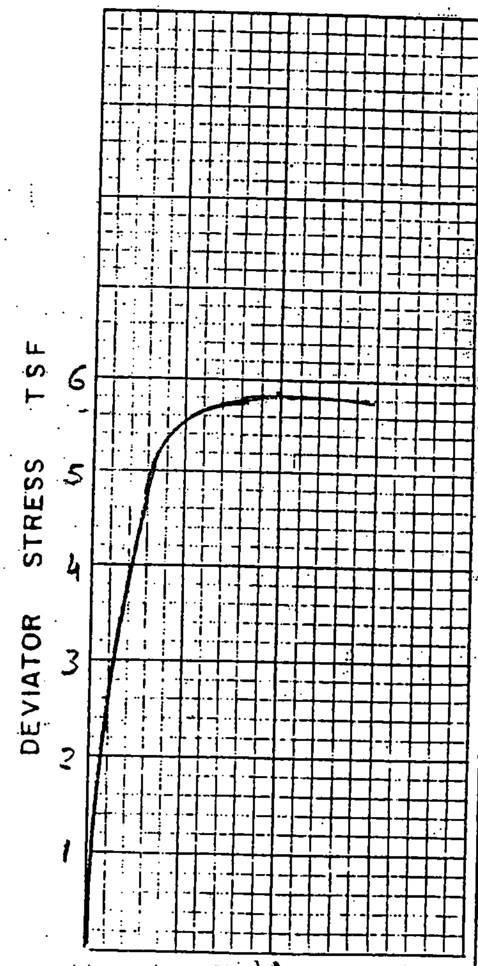


Type of Test CU		
Type of Specimen		
Ø °	Tan Ø	C = TSF
Description: Tan Silty Clay with Sand		
LL 23	PI 5	Sp.Gr.

Project: Barren Island		
Client: Roy F. Weston		
Boring No. G-10	Samp. No.	Depth 15'-17'
TRIAXIAL COMPRESSION		Date 11/14/01



Test No.		1	2	3
Initial	W.C. Wo %	21.5		
	Dry Density PCF	106.5		
	Void Ratio e_o	.523		
	Saturation So %	100		
Before Test	W.C. after Sat. W_s %			
	Saturation S %	100		
	Consol. Press. TSF	1.44		
	W.C. after Con. W_c %			
	Void Ratio after e_c			
At Failure	σ_I TSF	7.35		
	σ_{III} TSF	1.44		
	W.C. W_f %			
	Void Ratio e_f			
Pore Press. at Fail. TSF		-.65		
Strain Rate %		.08		
Specimen Dia. In.		2.8		
Initial Height In.		5.6		

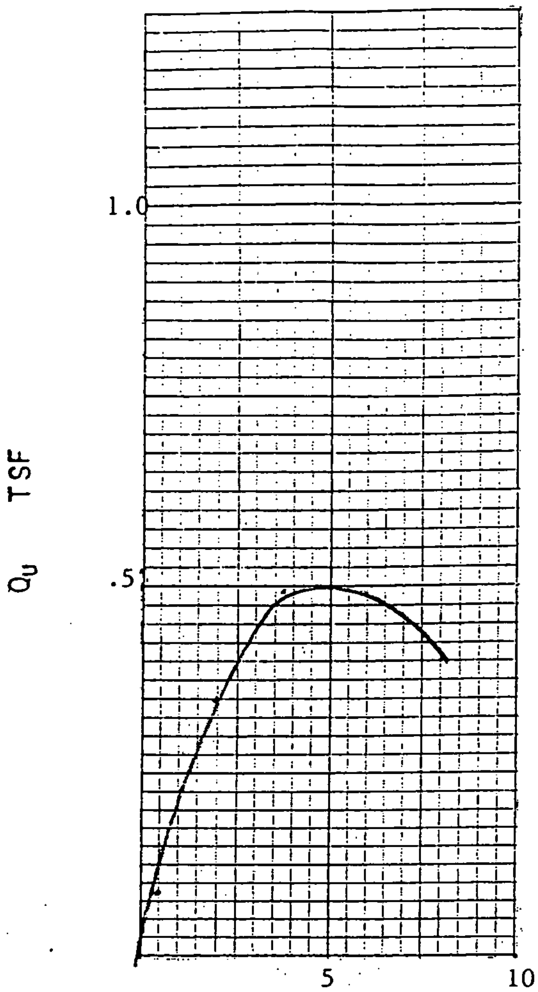


Type of Test CU		
Type of Specimen Shelby Tube		
Ø °	Tan Ø	C = TSF
Description: Gray Silty Sand		
LL	PI NP	Sp. Gr.

Project: Barren Island		
Client: Roy F. Weston.		
Boring No. G-11	Samp. No. "	Depth 28.5-29.5

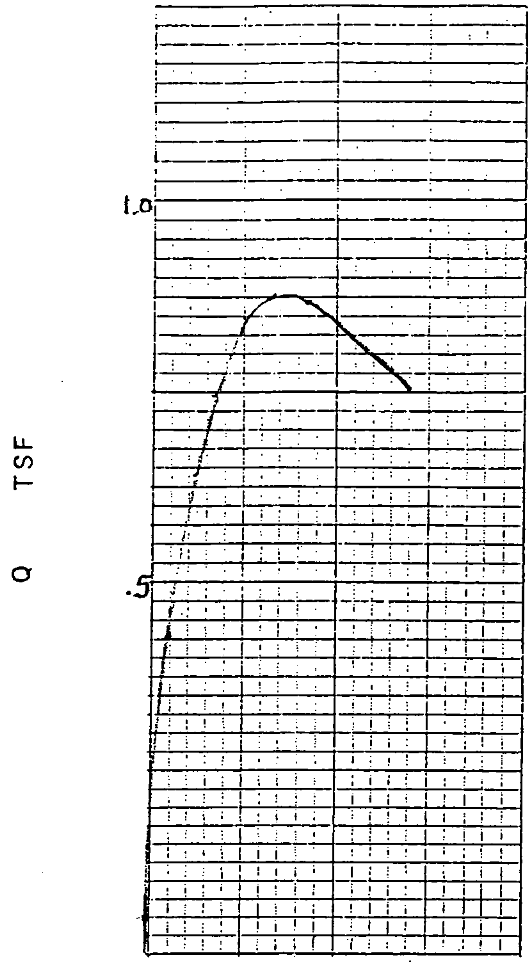
TRIAXIAL COMPRESSION

Date 11/14/01



Boring	G - 04
Depth	11'-13'
Q_u	0.5 TSF
W.C. %	19.5
Dry Wt.	102.4 PCF
Void Ratio	0.584
Q_{ur}	TSF
Sensitivity	
LL 19 PI 3	
Description	GRAY SILT

Sketch at Failure



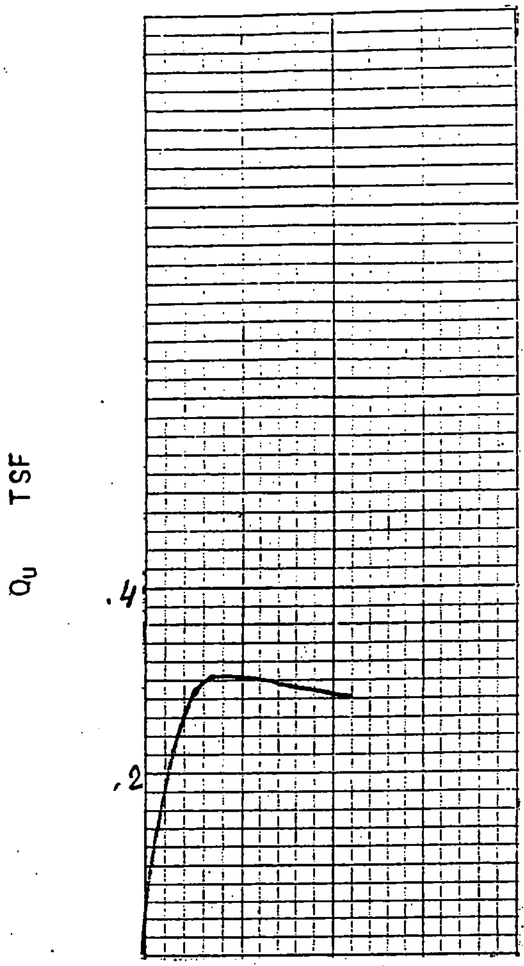
Boring	G-04
Depth	11' - 13'
Q_u	0.9 TSF
W.C. %	18.2
Dry Wt	102.4 PCF
Void Ratio	0.584
Q_{ur}	TSF
Sensitivity	
LL 40 PI 20	
Description	LIGHT BROWN TO YELLOW CLAYEY SAND

Sketch at Failure

Project: Barren Island

Client: Roy F. Weston Date: 11/5/01

UNCONFINED COMPRESSION



Boring G-10

Depth 15' - 17'

Q_u 0.35 TSF

W.C. % 25.4

Dry Wt. 96.7 PCF

Void Ratio 0.678

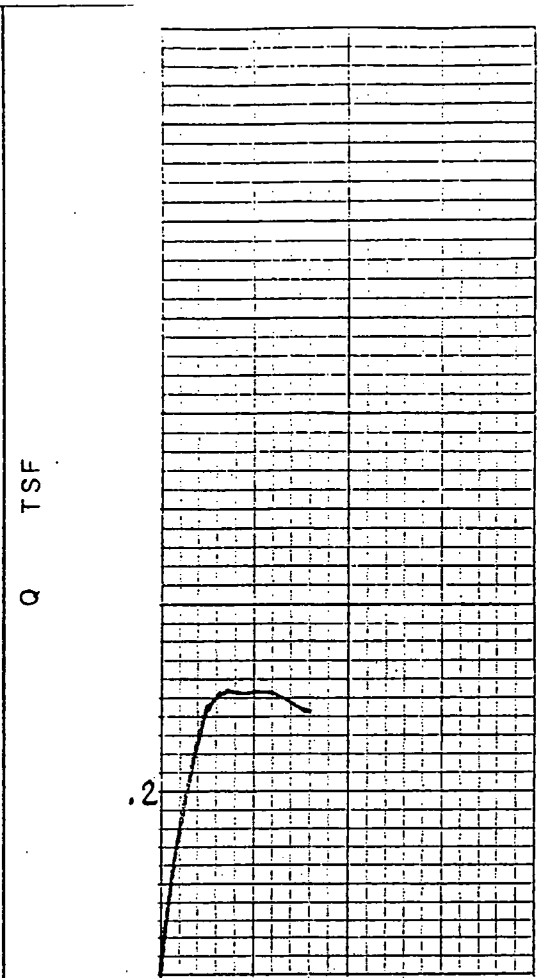
Q_{ur} ______ TSF

Sensitivity ______

LL 23 PI 5

Description Tan Silty Clay and Silt

Sketch at Failure



Boring G-10

Depth 15' - 17'

Q_u 0.31 TSF

W.C. % ______

Dry Wt 96.7 PCF

Void Ratio 0.678

Q_{ur} ______ TSF

Sensitivity ______

LL 17 PI 2

Description Gray Silty Sand

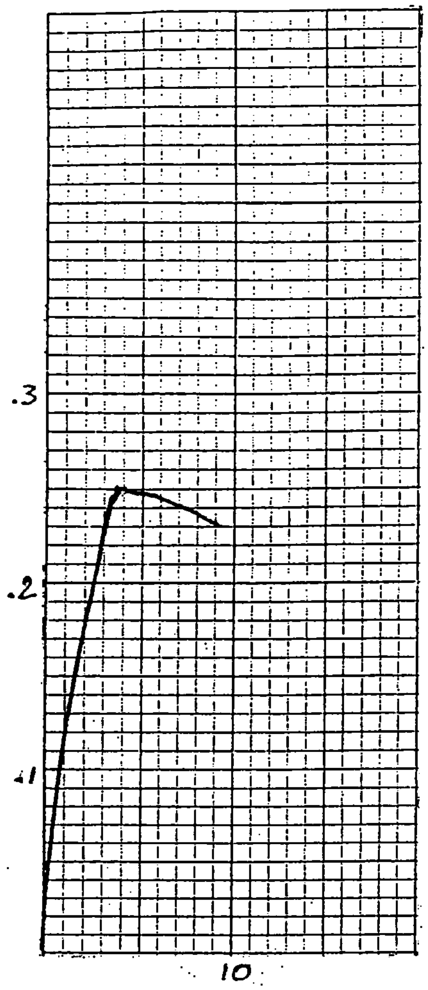
Sketch at Failure

Project: Barren Island

Client: Roy F. Weston

Date: 11/5/01

UNCONFINED COMPRESSION



Boring G-11

Depth 28.5'-29.5'

Q_u 0.25 TSF

W.C. % 15.3

Dry Wt. 106.5 PCF

Void Ratio ____

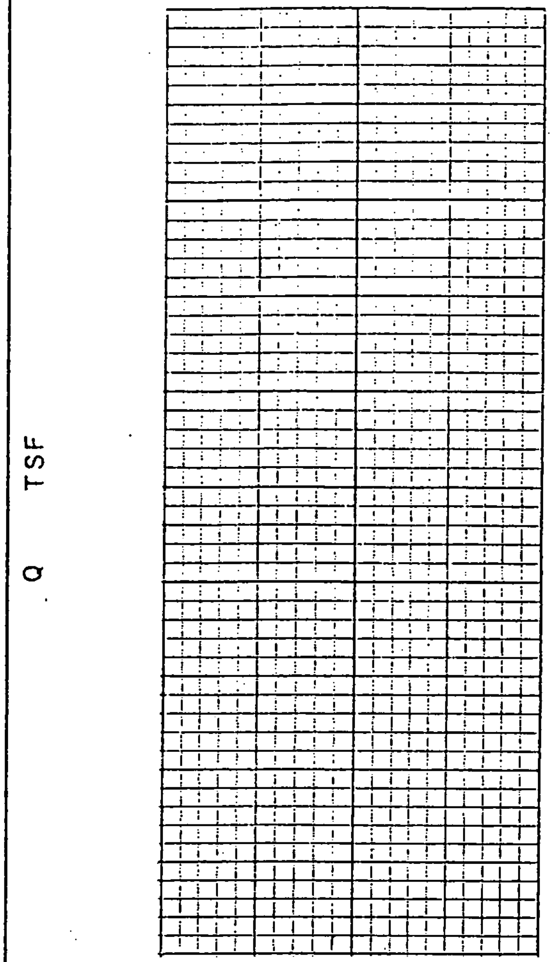
Q_{ur} ____ TSF

Sensitivity ____

LL ____ PI ____

Description Gray Silty Sand

Sketch at Failure



Boring ____

Depth ____

Q_u ____ TSF

W.C. % ____

Dry Wt ____ PCF

Void Ratio ____

Q_{ur} ____ TSF

Sensitivity ____

LL ____ PI ____

Description ____

Sketch at Failure

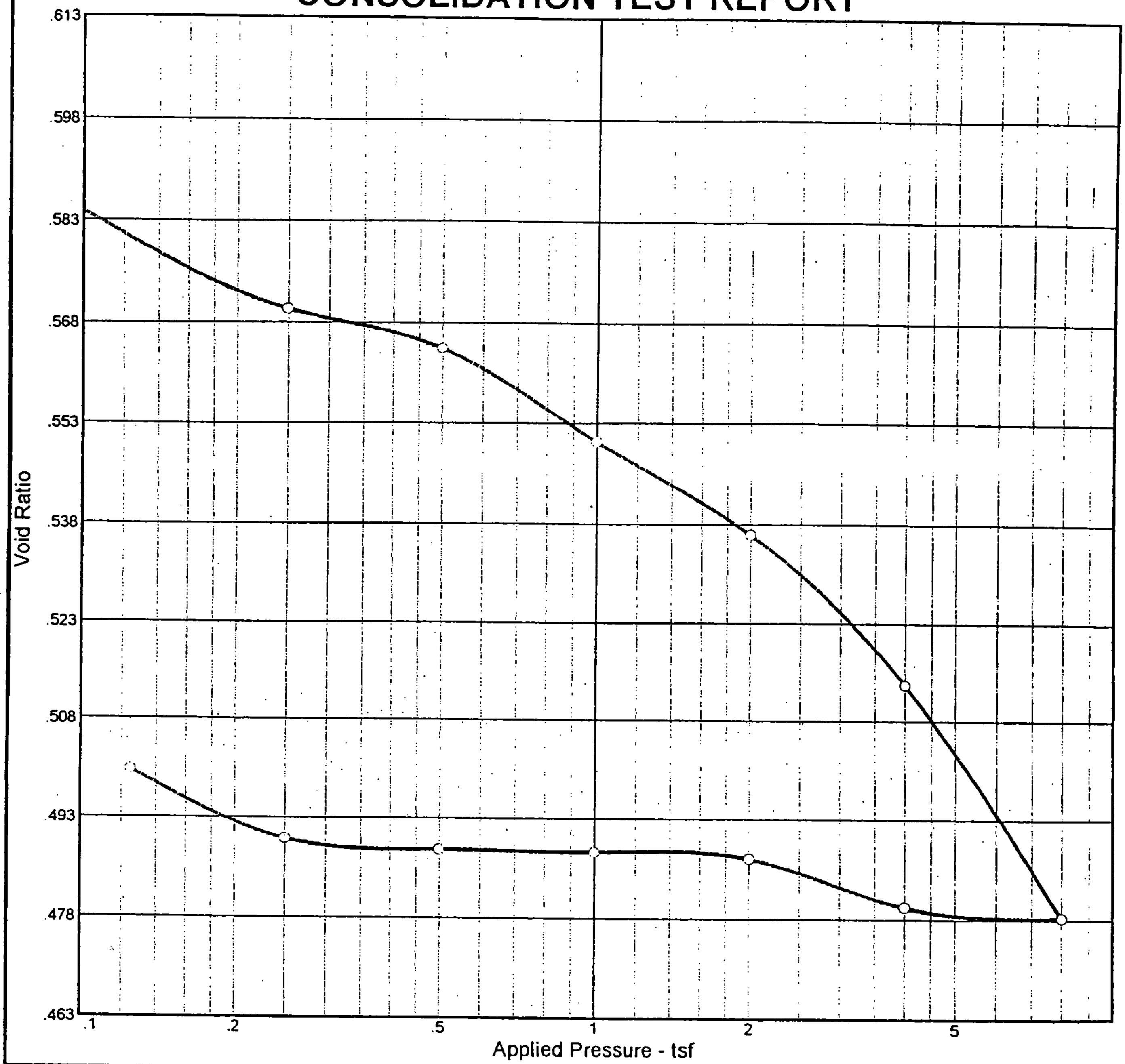
Project: Barren Island

Client: Roy F. Weston

Date: 11-06-01

UNCONFINED COMPRESSION

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
93.4 %	21.0 %	102.4	19	16	2.6	0.60	1.88	0.12	0.01			0.584

MATERIAL DESCRIPTION	USCS	AASHTO
GRAY SILT	ML	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

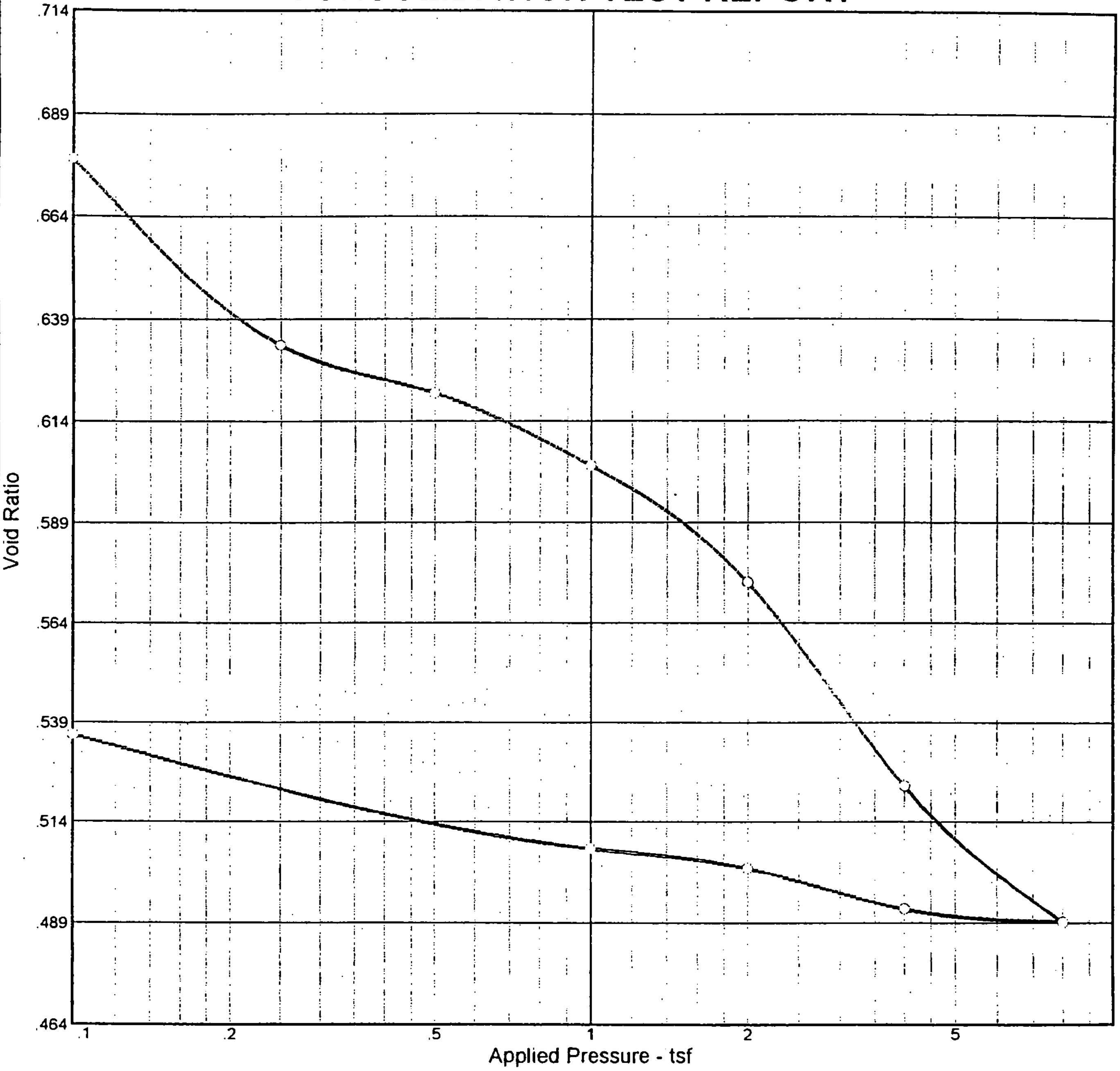
Source: BARREN ISLAND **Sample No.:** G-04 **Elev./Depth:** 11'-13'

Remarks:

CONSOLIDATION TEST REPORT

E2CR, INC.

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (tsf)	P_c (tsf)	C_c	C_r	Swell Press. (tsf)	Swell %	e_o
Sat.	Moist.											
97.3 %	25.4 %	96.7	23	18	2.6	0.90	0.41	0.11	0.02			0.678

MATERIAL DESCRIPTION	USCS	AASHTO
GRAY AND TAN SILTY CLAY	CL-ML	

Project No. 01556-04 Client: Roy F. Weston
Project: Barren Island

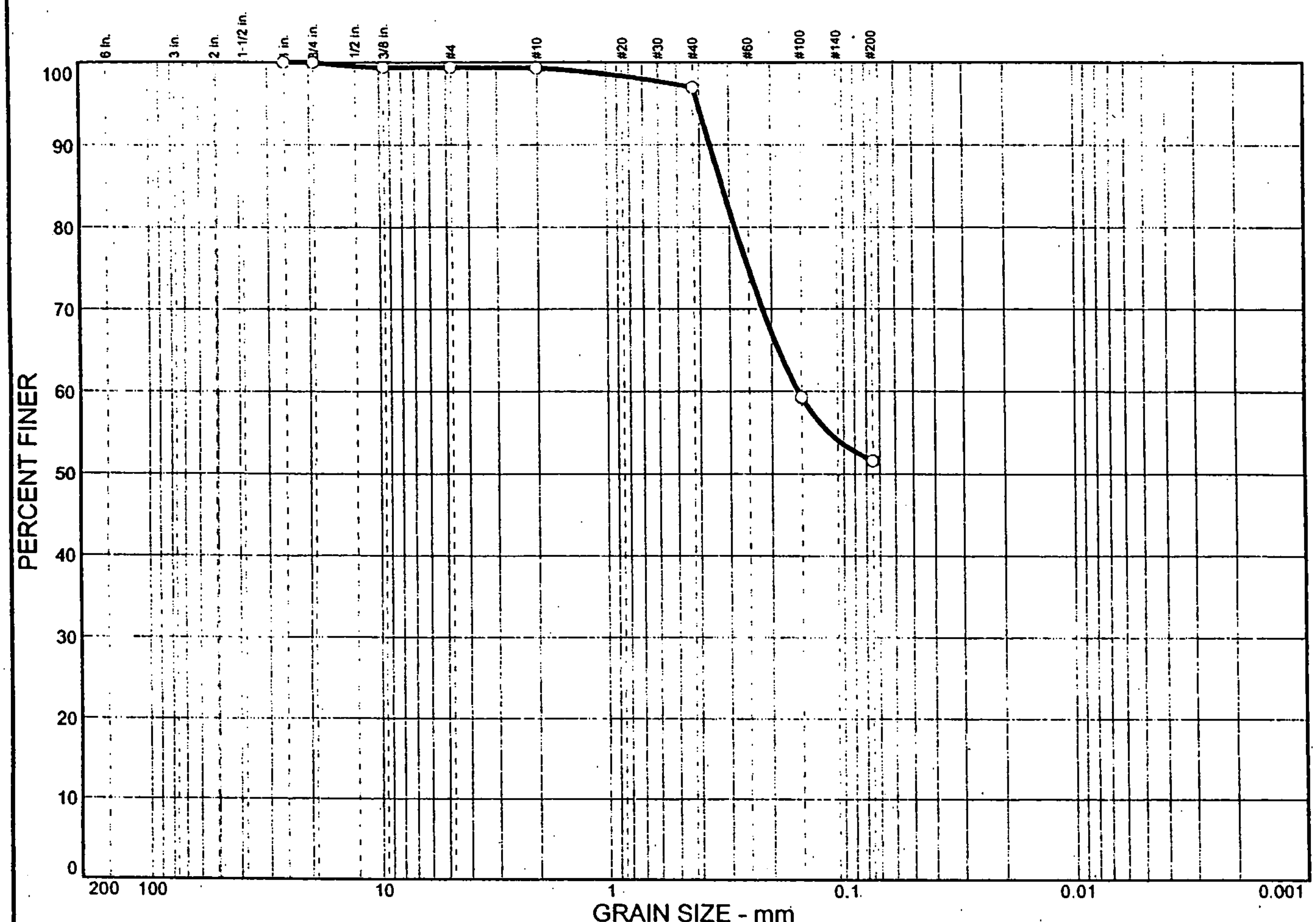
Source: BARREN ISLAND Sample No.: G-10 Elev./Depth: 15'-17'

CONSOLIDATION TEST REPORT

E2CR, INC.

Remarks:

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.6	0.1	2.3	45.4	51.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.321	0.155						

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Silty Fine SAND	ML	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 1 **Sample No.:** S-5 **Elev./Depth:** 23.5'-25.0'

Remarks:

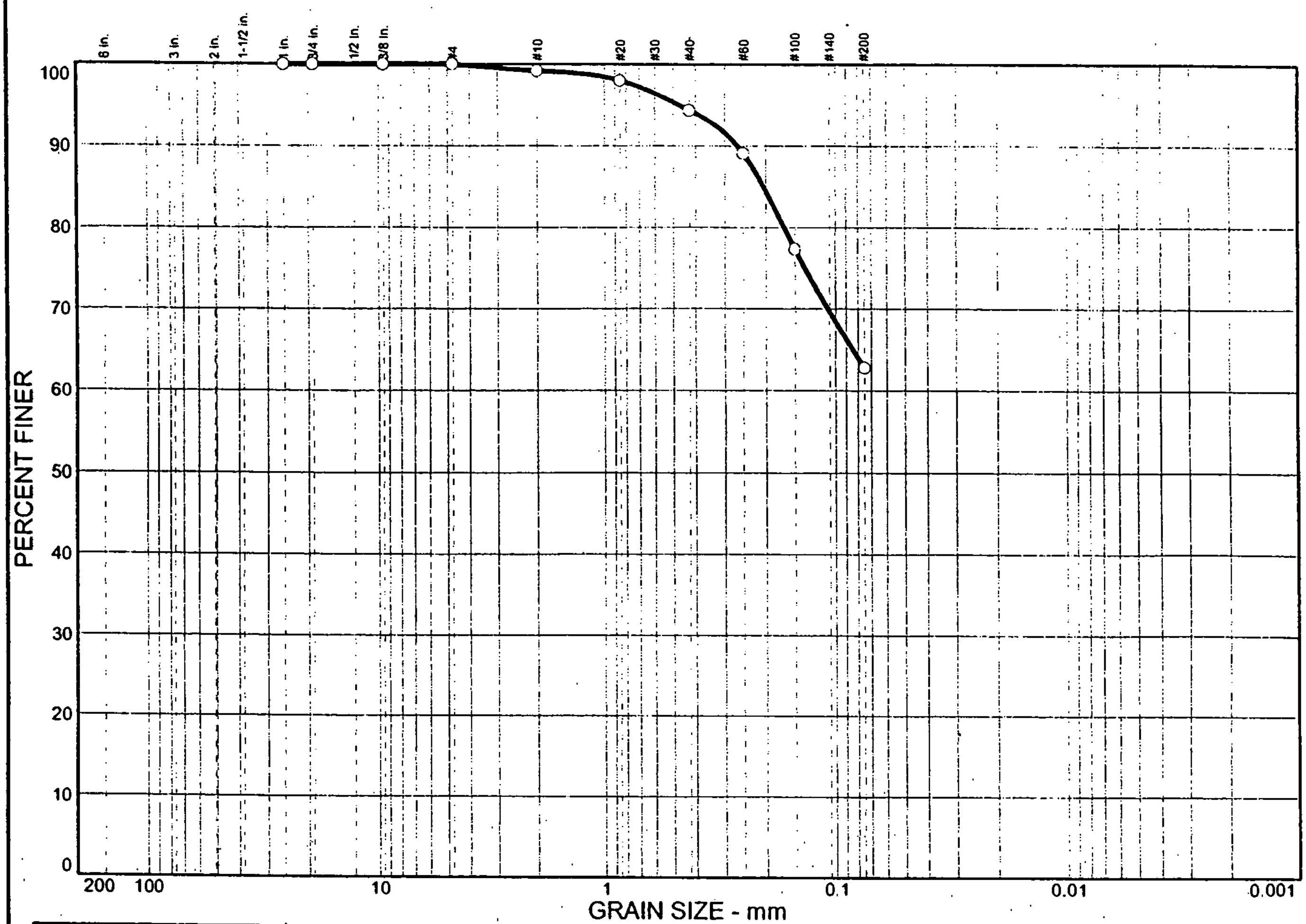
○Natural Moisture = 20.4%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.8	4.8	31.6	62.8	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	19	16	0.205							

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Sandy Silt	ML	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 4 **Sample No.:** ST-1(Top) **Elev./Depth:** 11.0'-12.0'

Remarks:

○ Natural Moisture = 19.5%

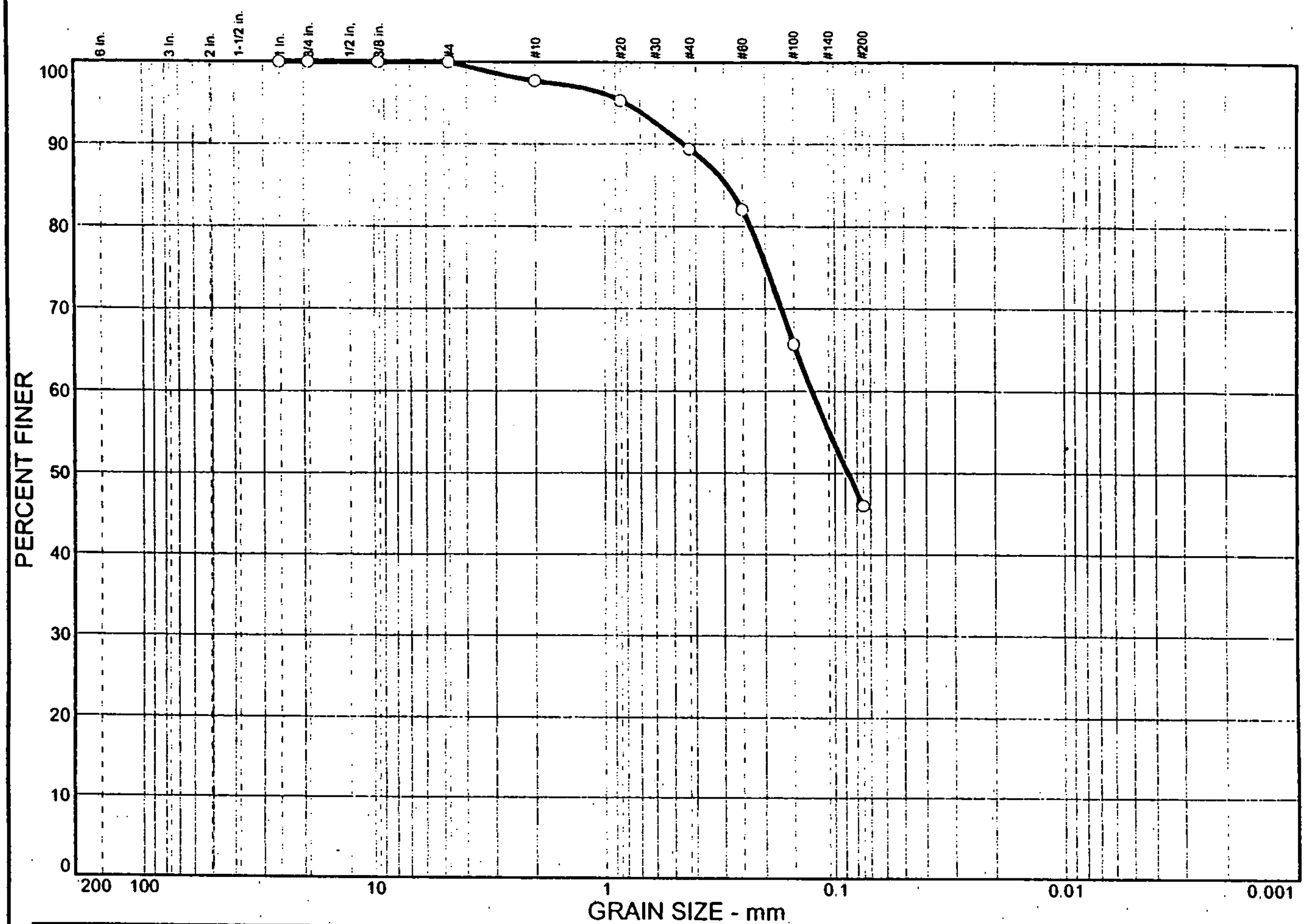
Plasticity Index = 3

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	2.3	8.3	43.4	46.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	40	20	0.290	0.125	0.0874					

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Brown-Yellow Clayey SAND	SC	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 4 **Sample No.:** ST-1(Bottom) **Elev./Depth:** 12.0'-13.0'

Remarks:

○Natural Moisture = 18.2%

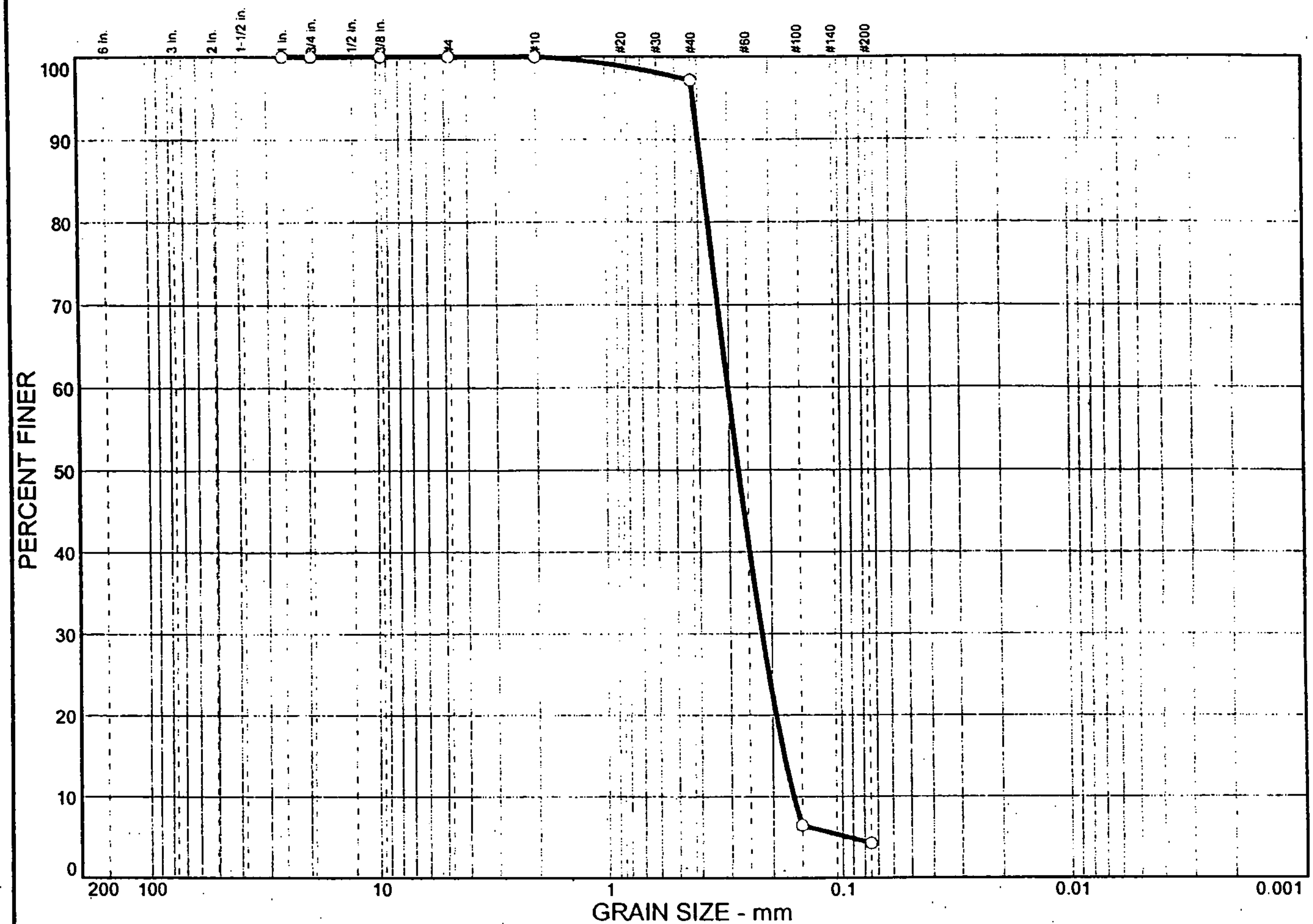
Plasticity Index = 20

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	2.8	92.9	4.3	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.381	0.302	0.274	0.220	0.179	0.163	0.98	1.86

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Poorly graded Fine SAND,trace fine	SP	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 4 **Sample No.:** S-5 **Elev./Depth:** 23.5'-25.0'

Remarks:

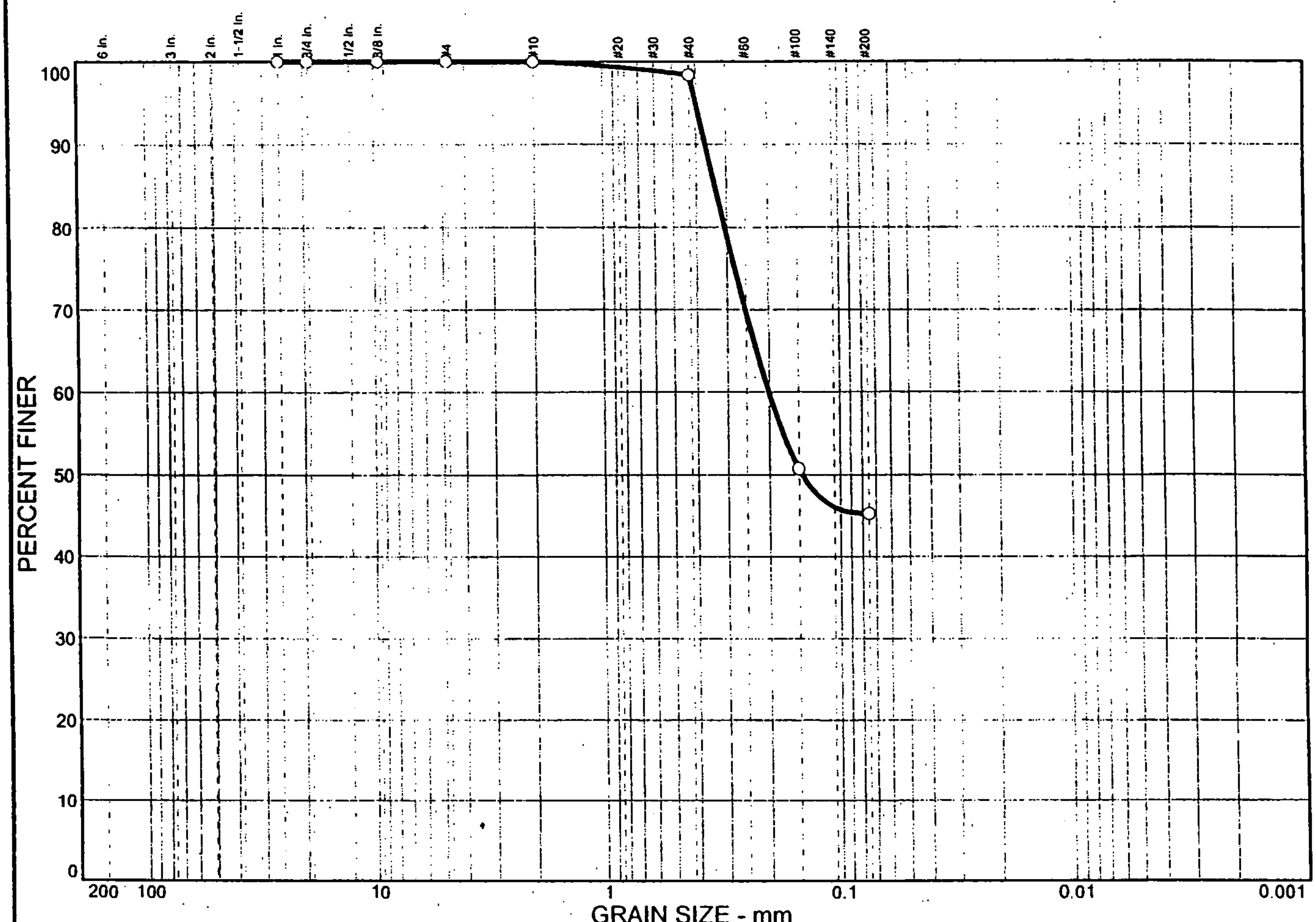
○Natural Moisture = 24.4%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.6	53.2	45.2	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.335	0.201	0.145					

MATERIAL DESCRIPTION	USCS	AASHTO
○ Grayish Brown,Clayey Fine SAND,trace Silt	SC	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 4 **Sample No.:** S-7 **Elev./Depth:** 33.5'-35.0'

Remarks:

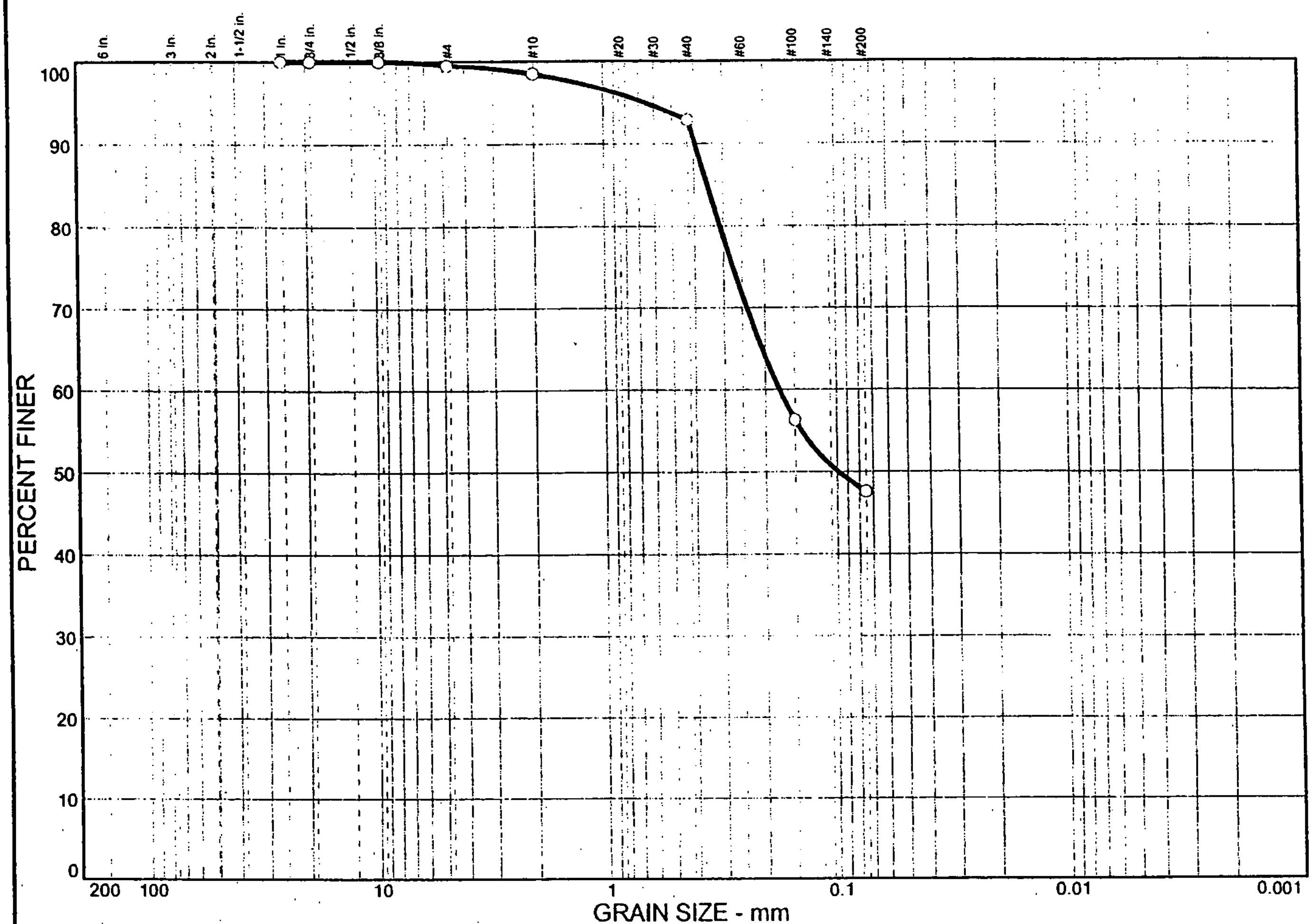
○ Natural Moisture = 53.9%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.5	1.0	5.6	45.3	47.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.351	0.174	0.0988					

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Clayey to Silty F-M SAND	SC-SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 5 **Sample No.:** S-5 **Elev./Depth:** 23.5'-25.0'

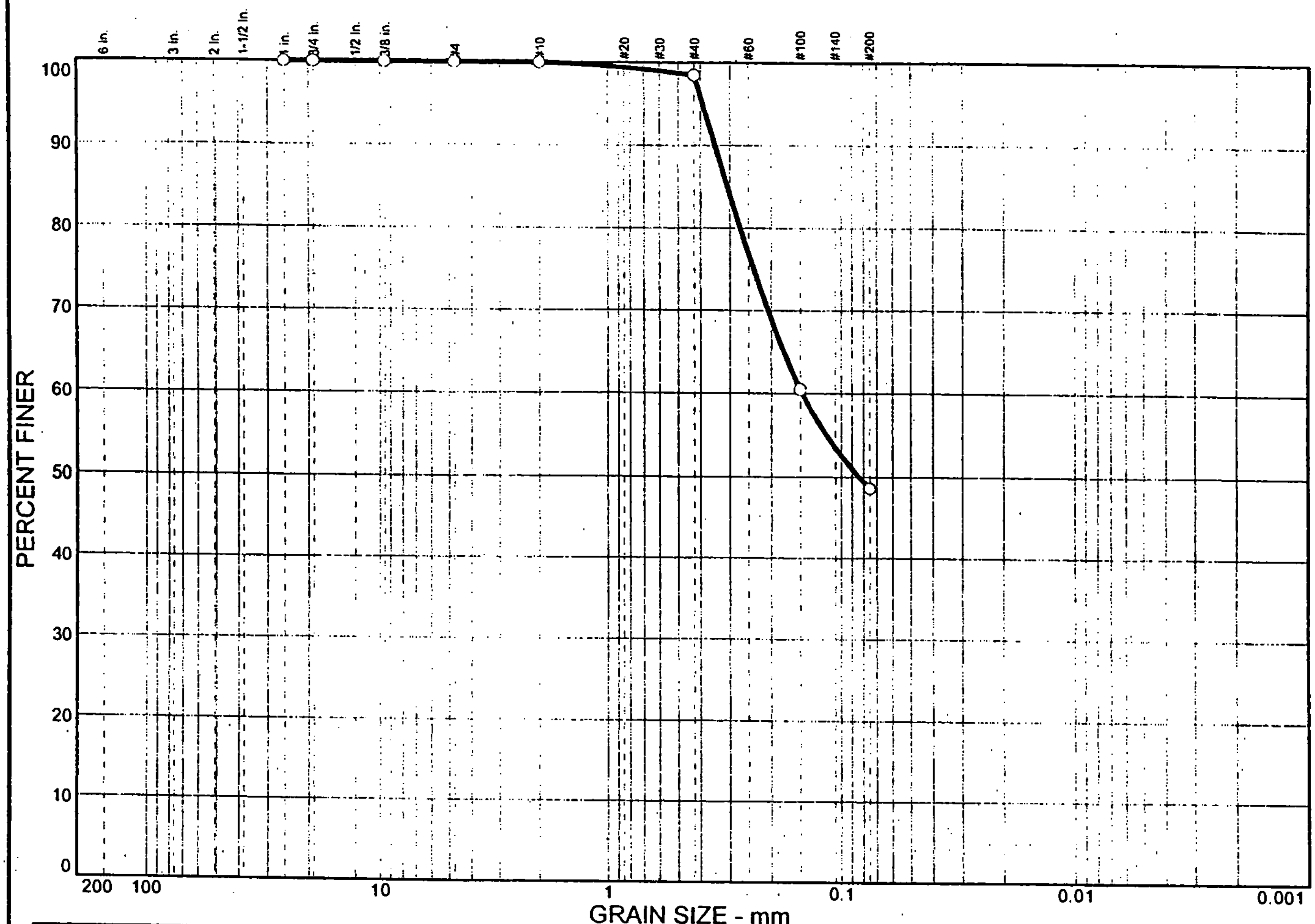
Remarks:
○ Natural Moisture = 28.6%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.5	50.0	48.5	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.307	0.147	0.0838					

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brown,Silty Fine SAND,trace Clay	SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 6 **Sample No.:** S-3 **Elev./Depth:** 15.0'-17.0'

Remarks:

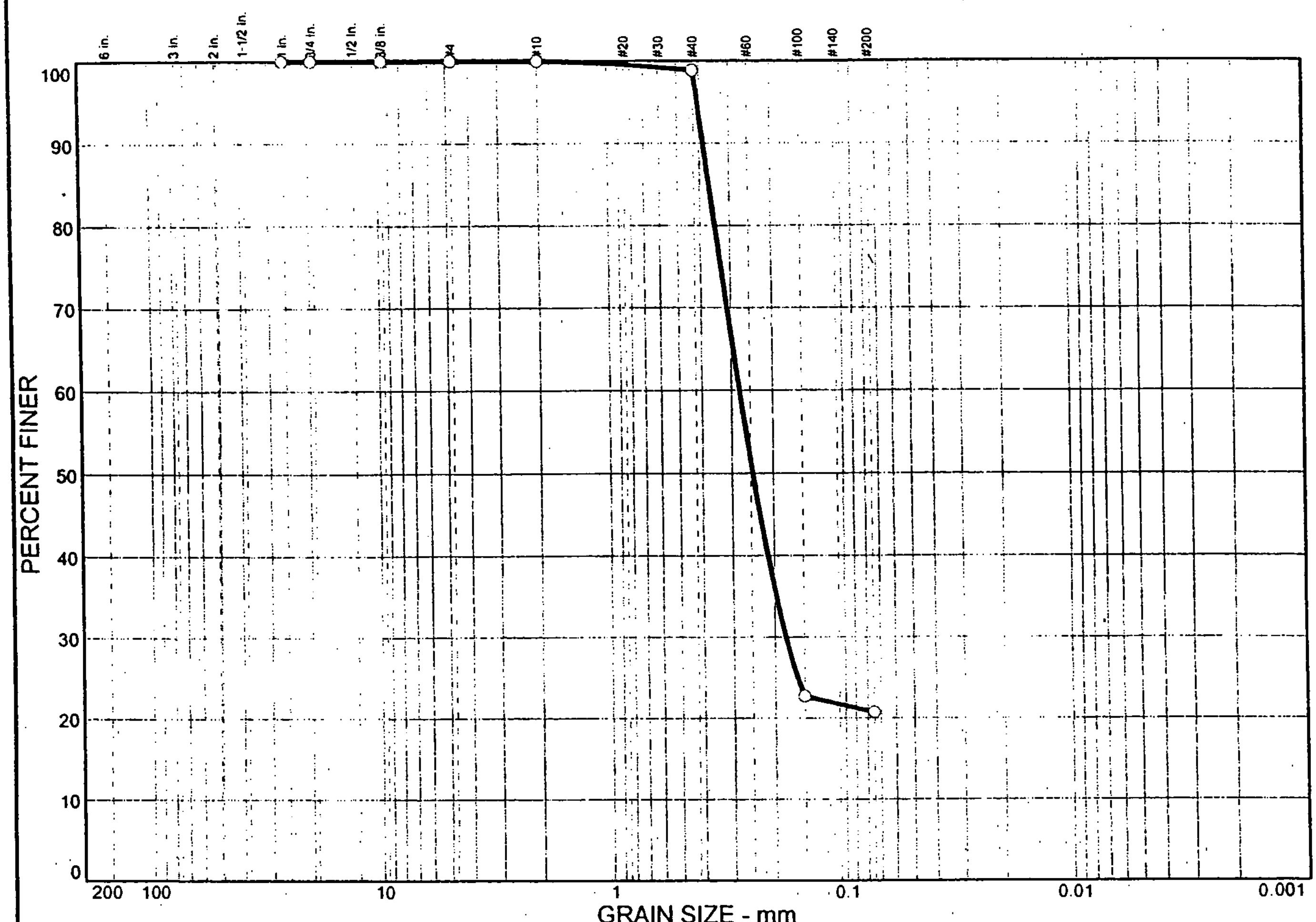
○Natural Moisture = 26.7%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.1	78.2	20.7	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.366	0.277	0.244	0.179				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Dark Gray,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 6 **Sample No.:** S-8 **Elev./Depth:** 38.5'-40.0'

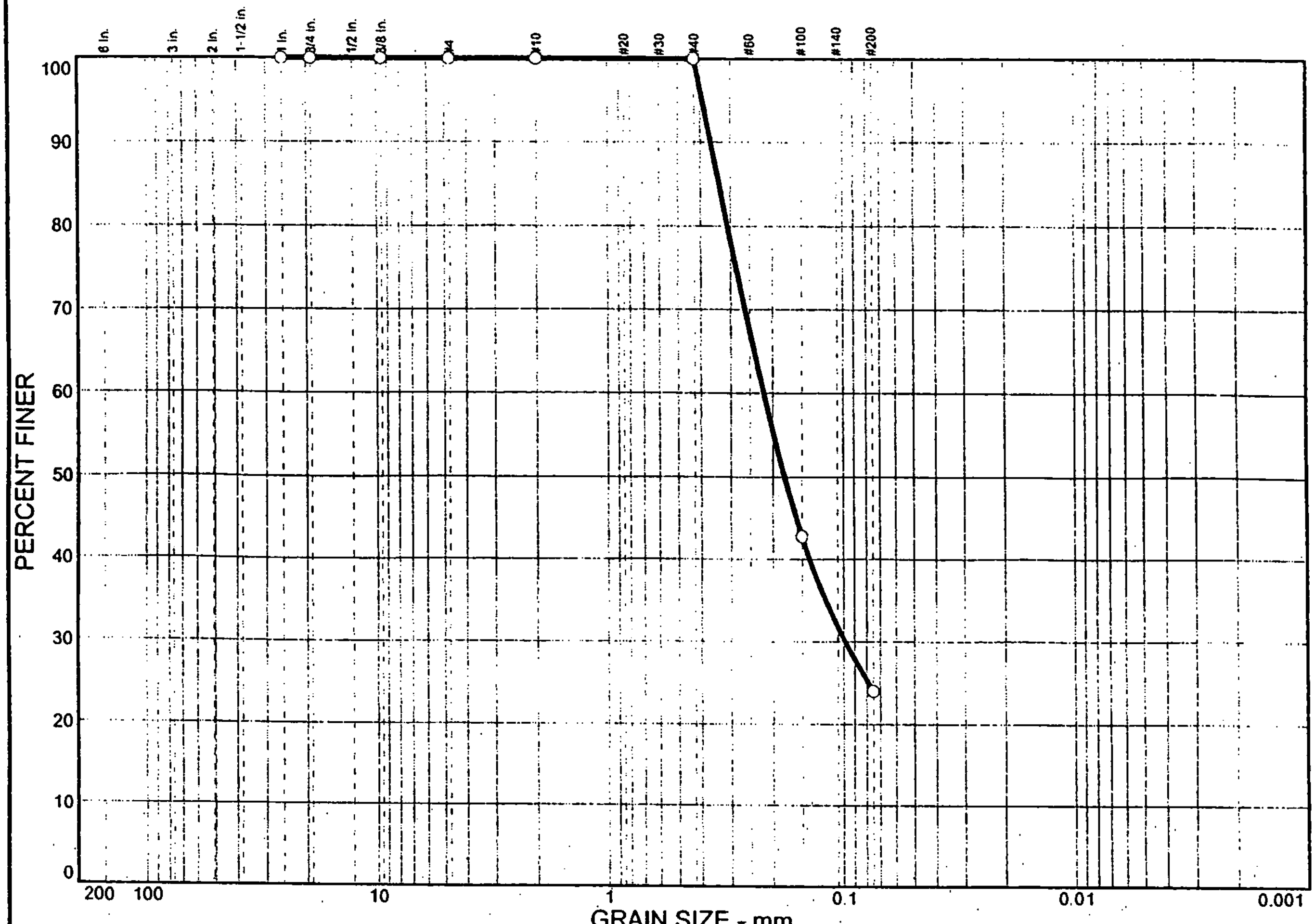
Remarks:
○ Natural Moisture = 22.8%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.0	76.0	24.0	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.335	0.218	0.178	0.0982				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 7 **Sample No.:** S-2 **Elev./Depth:** 15.0'-17.0'

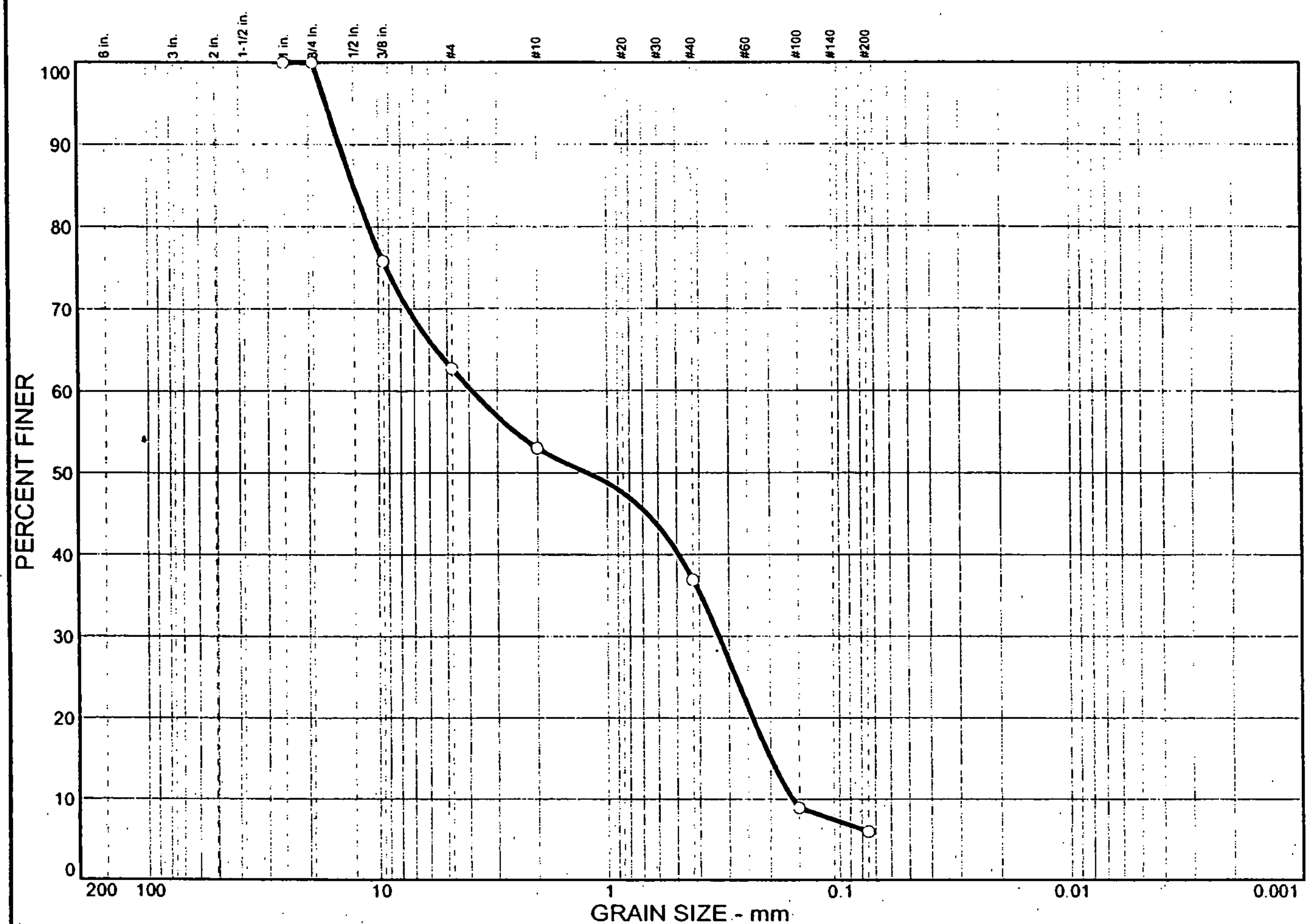
Remarks:
○ Natural Moisture = 26.8%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	37.3	9.7	16.1	30.9	6.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			12.8	3.89	1.22	0.331	0.199	0.160	0.18	24.29

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Poorly Graded SAND and Fine GRAVEL,trace Silt	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 7 **Sample No.:** S-6 **Elev./Depth:** 28.5'-30.0'

Remarks:

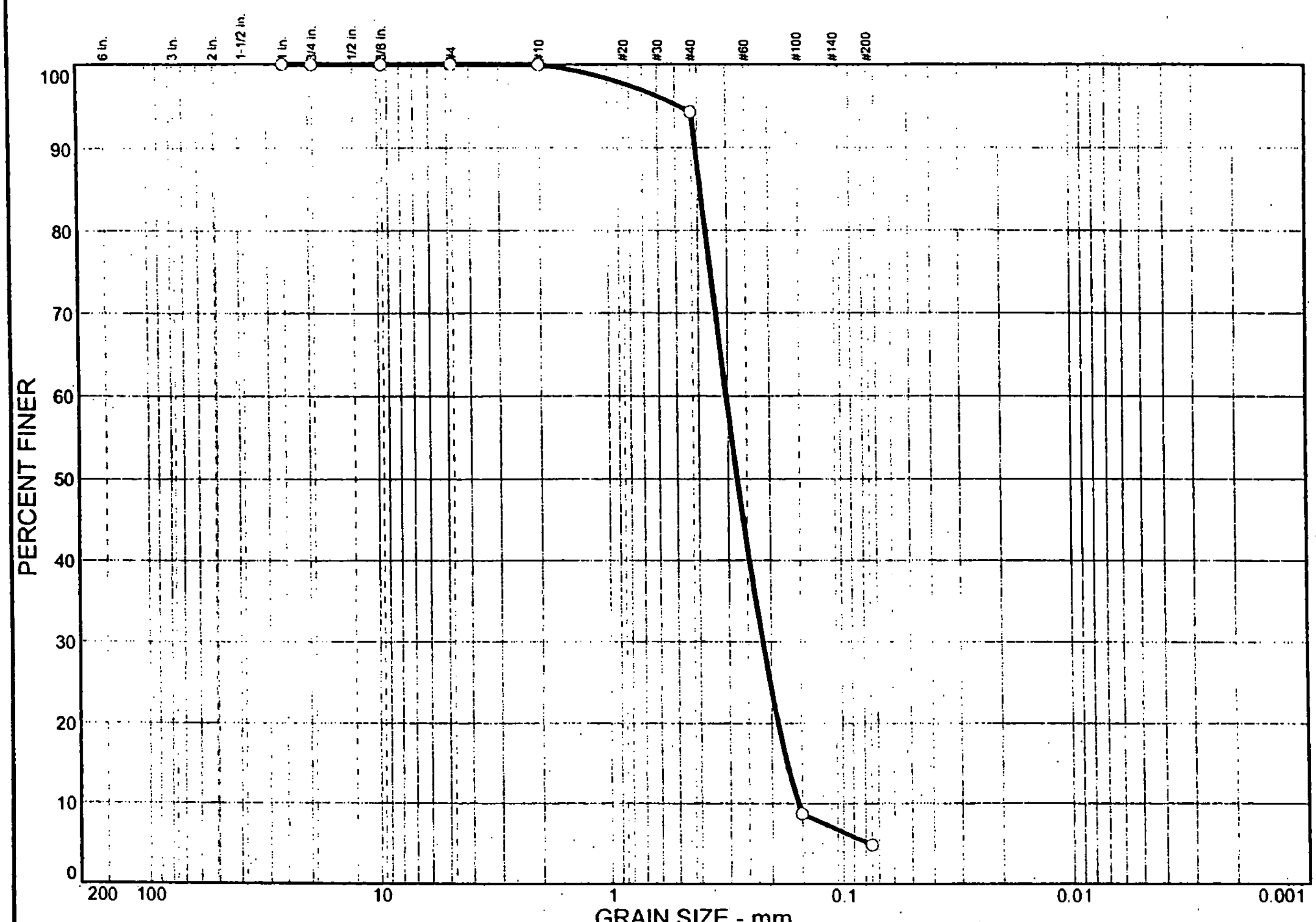
○ Natural Moisture = 13.2%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	5.7	89.4	4.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.389	0.304	0.274	0.217	0.172	0.155	1.00	1.96

MATERIAL DESCRIPTION	USCS	AASHTO
○ Grayish Brown,Poorly Graded SAND,trace Fine	SP	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 8 **Sample No.:** S-2 **Elev./Depth:** 12.0'-14.0'

Remarks:

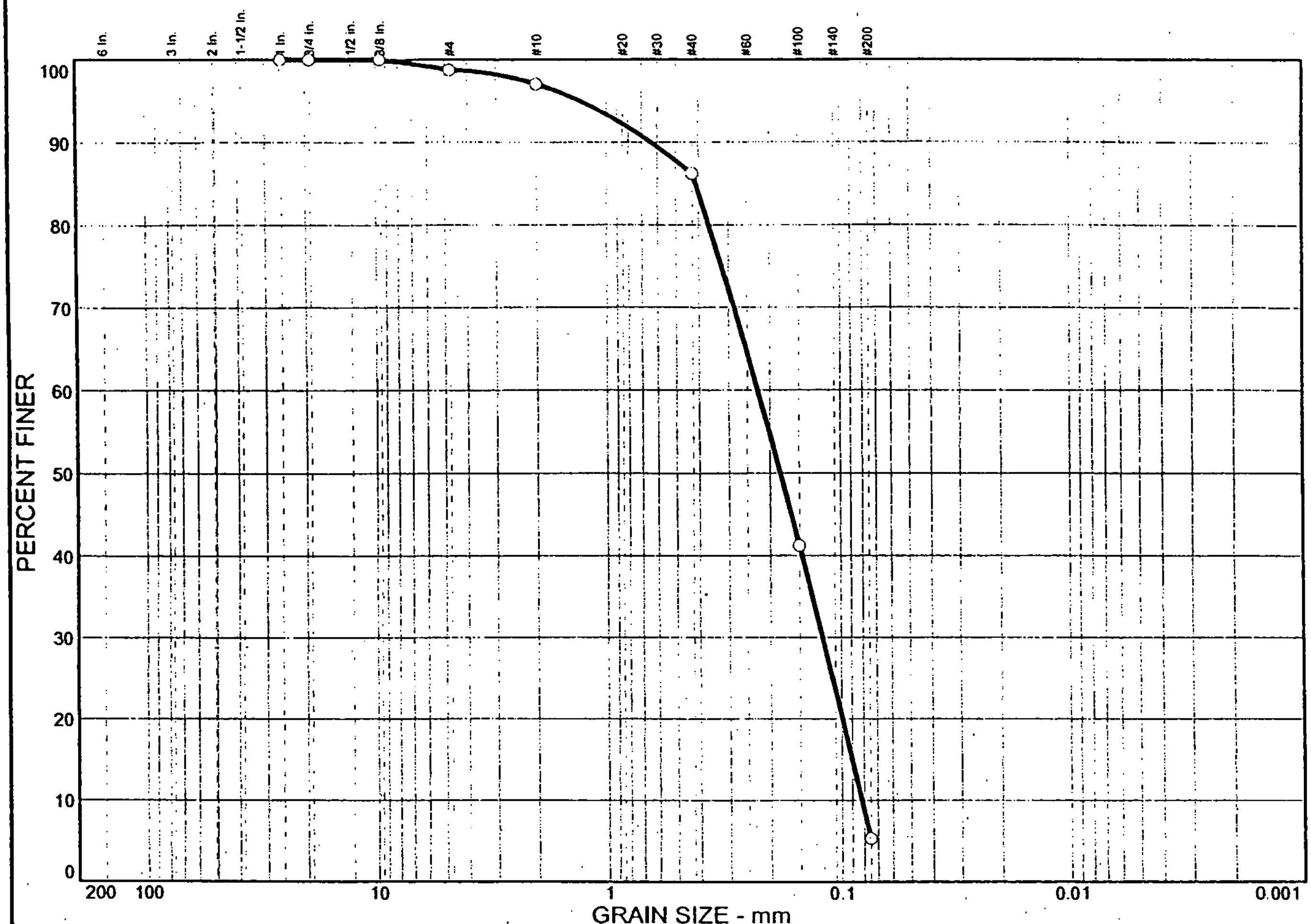
○ Natural Moisture = 23.9%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	1.3	1.7	10.8	80.9	5.3	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.412	0.225	0.181	0.120	0.0900	0.0819	0.78	2.75

MATERIAL DESCRIPTION	USCS	AASHTO
○ Orange Brown,Poorly Graded SAND,trace Silt	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 8 **Sample No.:** S-5 **Elev./Depth:** 23.5'-25.0'

Remarks:

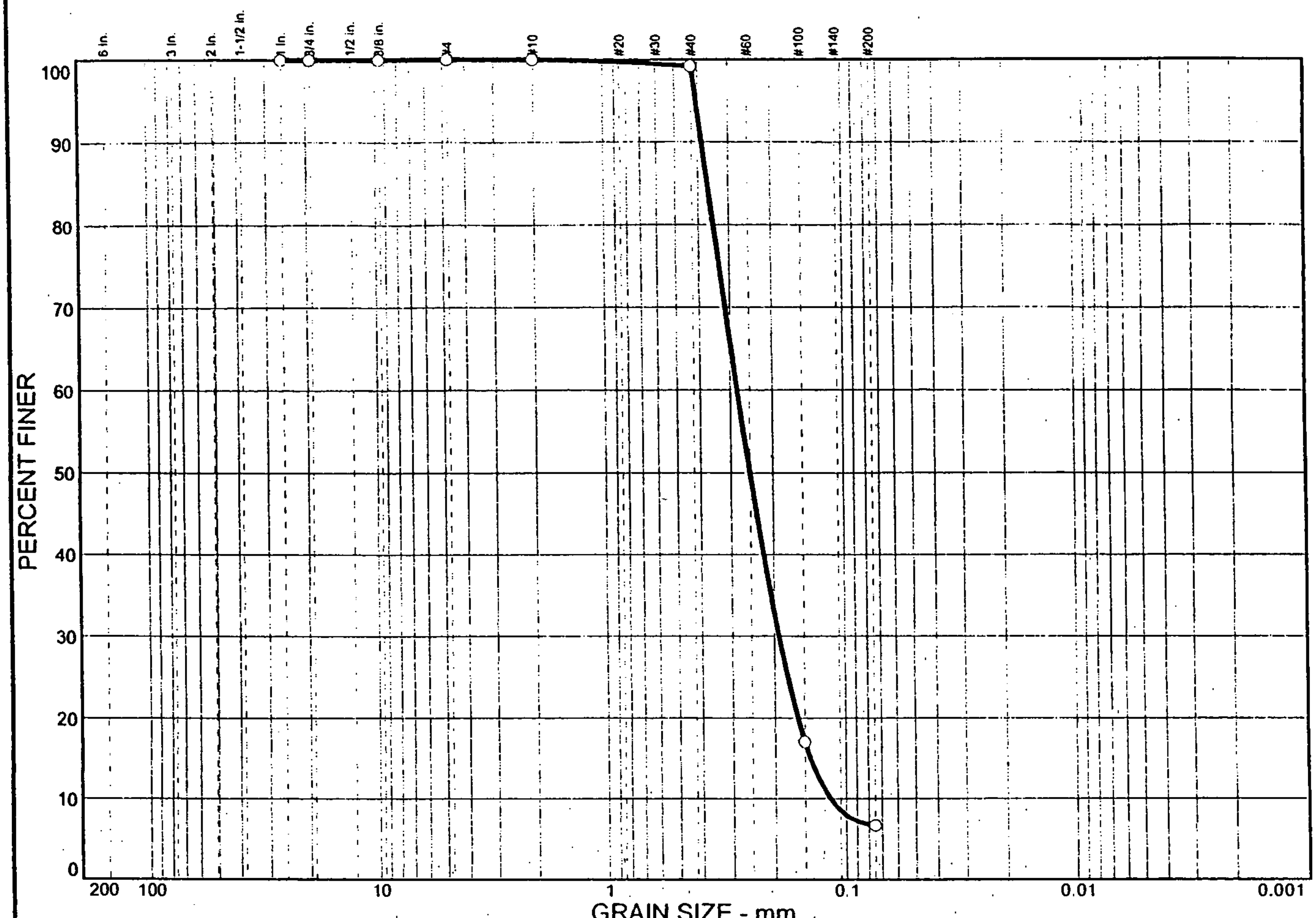
○ Natural Moisture = 15.8%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.8	92.5	6.7	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.367	0.281	0.250	0.191	0.142	0.117	1.12	2.41

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Gray,Fine SAND,trace Silt	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 9 **Sample No.:** S-6 **Elev./Depth:** 30.0'-32.0'

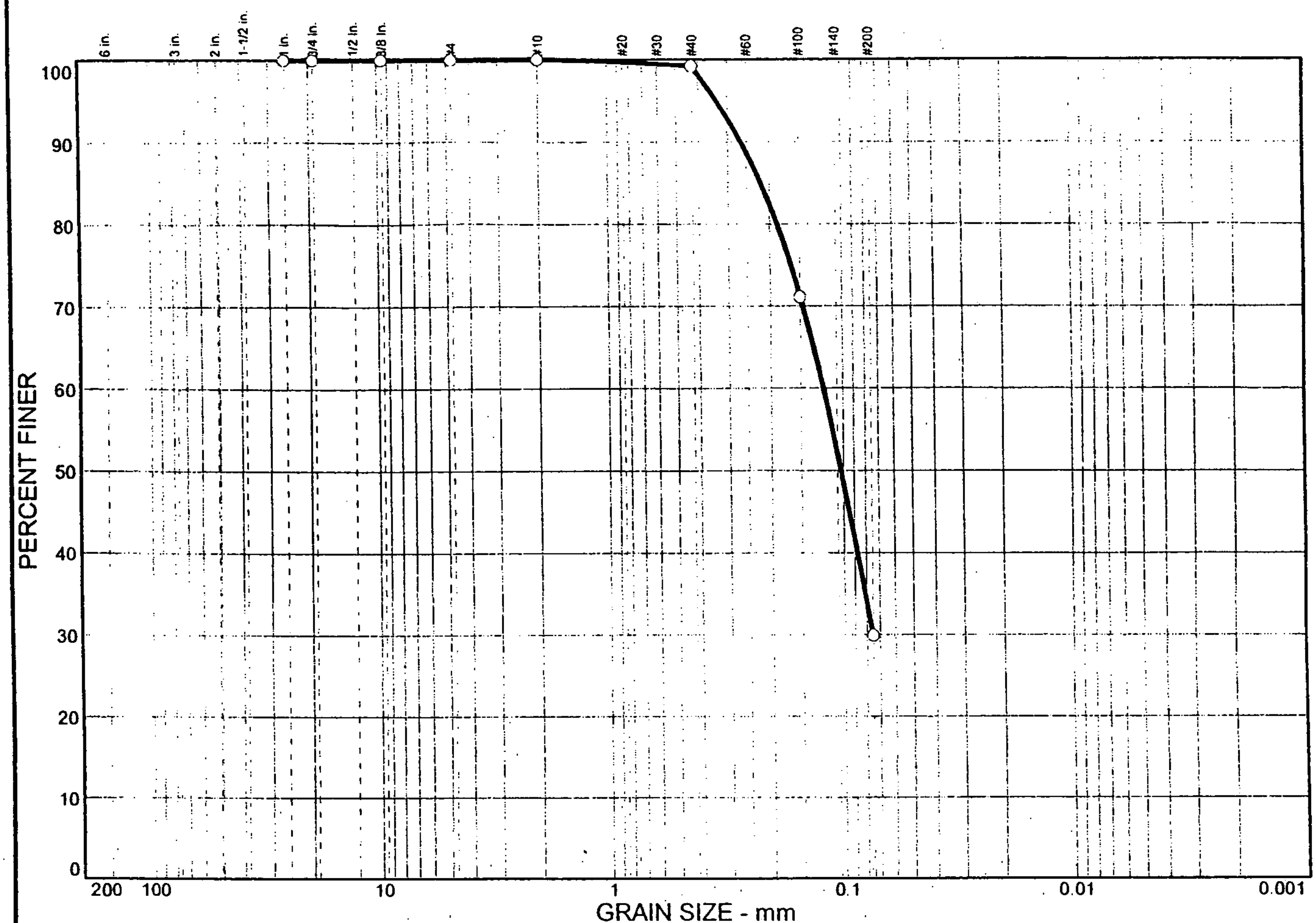
Remarks:
○ Natural Moisture = 29.2%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.8	69.3	29.9	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.218	0.121	0.102	0.0751				

MATERIAL DESCRIPTION	USCS	AASHTO
○ M.Gray,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 9 **Sample No.:** S-10 **Elev./Depth:** 48.5'-50.0'

Remarks:

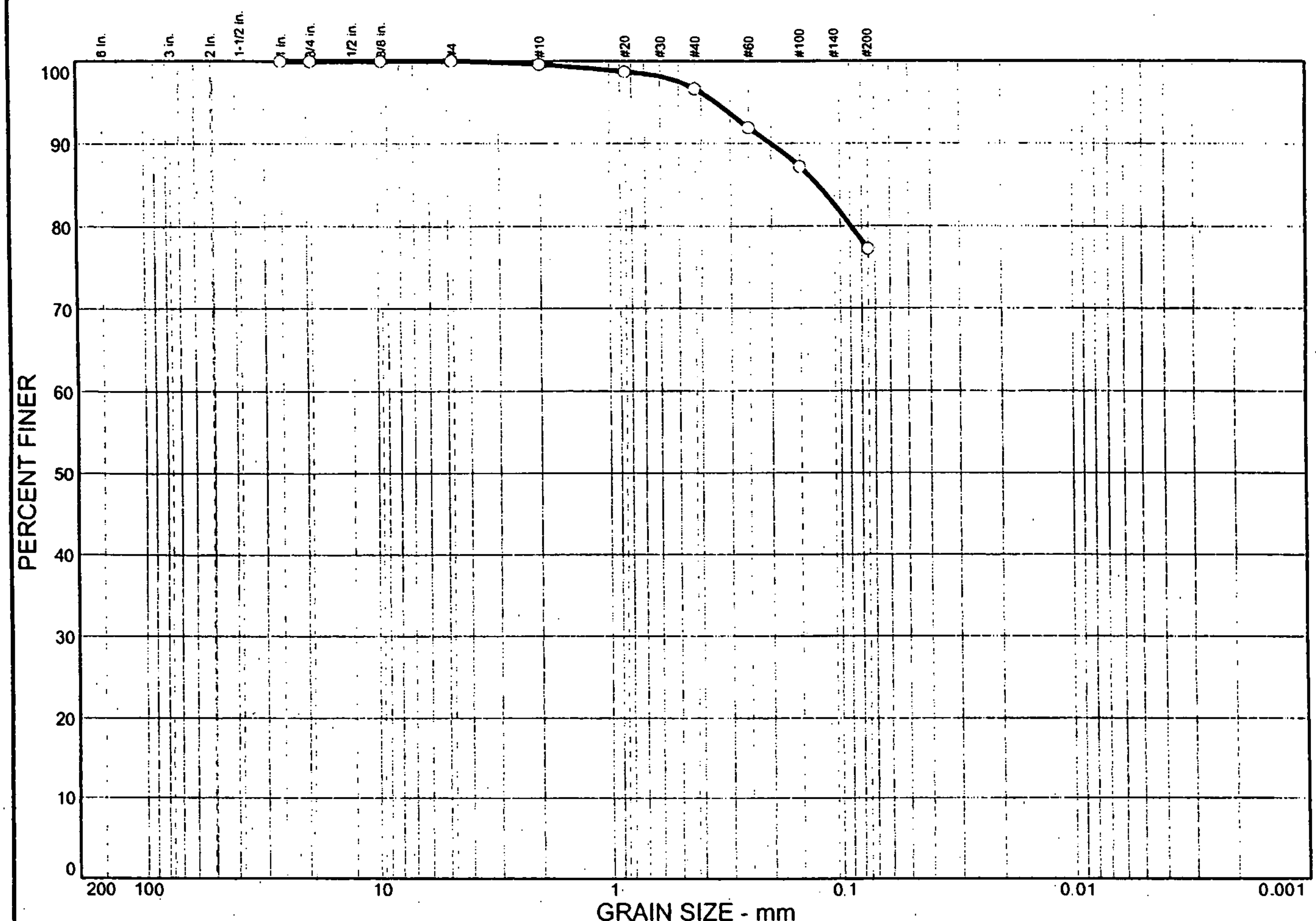
○ Natural Moisture = 25.7%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.4	3.0	19.4	77.2	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	23	18	0.125							

MATERIAL DESCRIPTION	USCS	AASHTO
○ Tan,Silty CLAY with Sand	CL-ML	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 10 **Sample No.:** ST-1(Top) **Elev./Depth:** 15.0'-16.0'

Remarks:

○ Natural Moisture = 25.4%

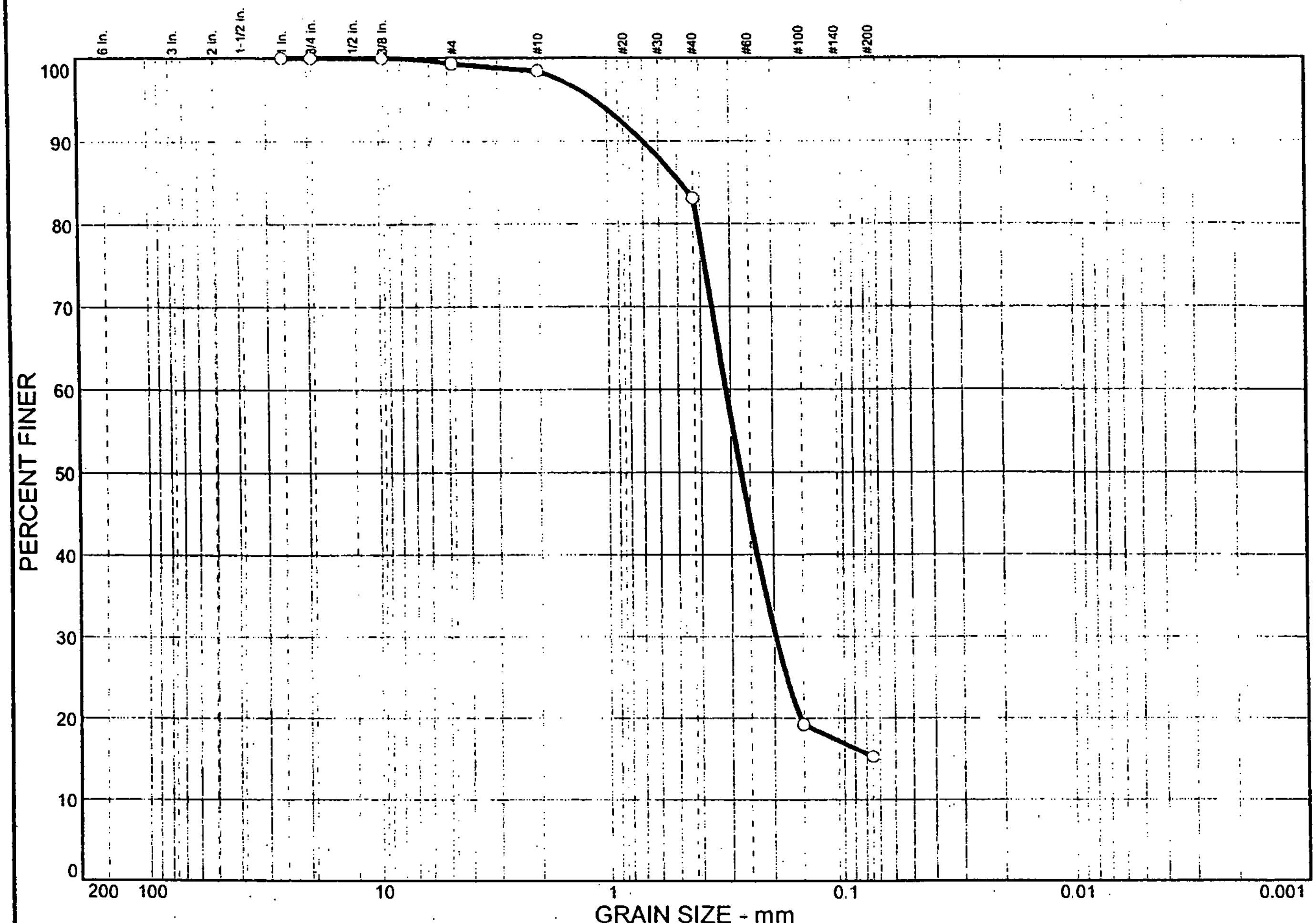
Plasticity Index = 5

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.7	0.8	15.4	67.8	15.3	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.481	0.313	0.272	0.196				

MATERIAL DESCRIPTION	USCS	AASHTO
○ M.Gray,Silty F-M SAND,trace Clay	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 10 **Sample No.:** S-4 **Elev./Depth:** 23.5'-25.0'

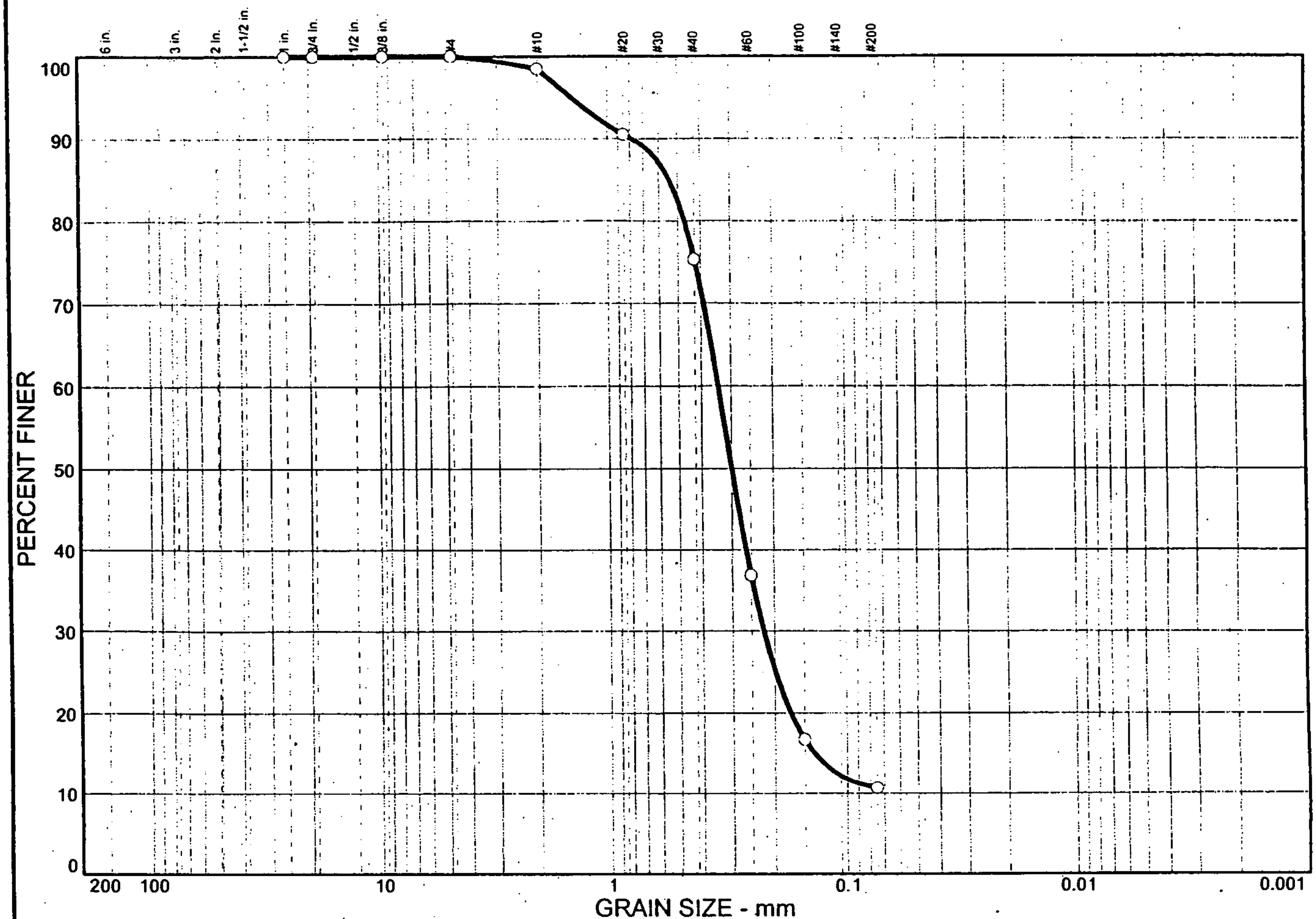
Remarks:
○ Natural Moisture = 18.9%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	1.5	23.2	64.6	10.7	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	17	15	0.543	0.340	0.299	0.222	0.137			

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Silty SAND	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 10 **Sample No.:** ST-1(Bottom) **Elev./Depth:** 16.0'-17.0'

Remarks:

○ Natural Moisture = 18.4%

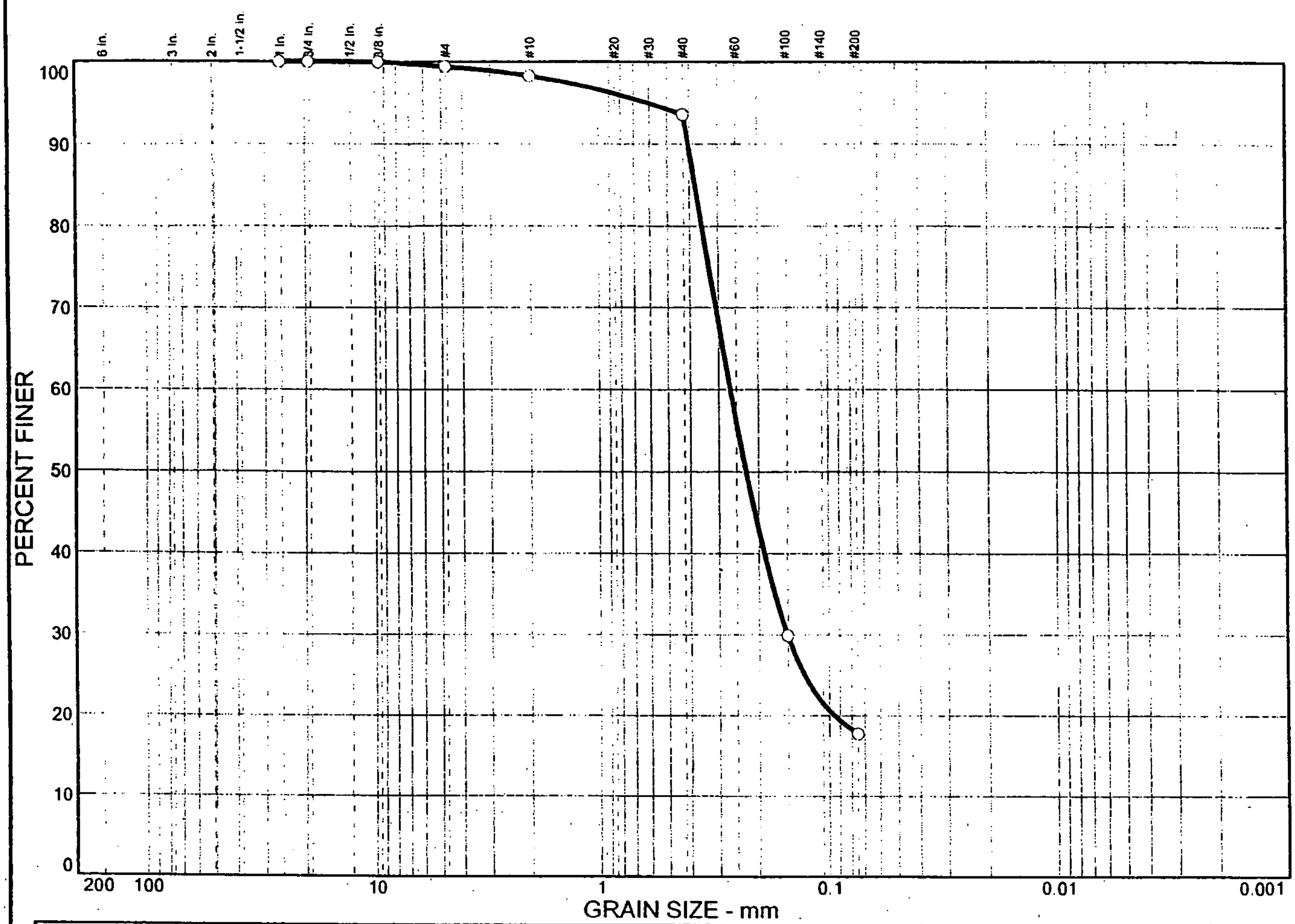
Plasticity Index = 2

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.6	1.1	4.7	75.9	17.7	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.378	0.266	0.227	0.150				

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Brown,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 11 **Sample No.:** S-4 **Elev./Depth:** 19.0'-21.0'

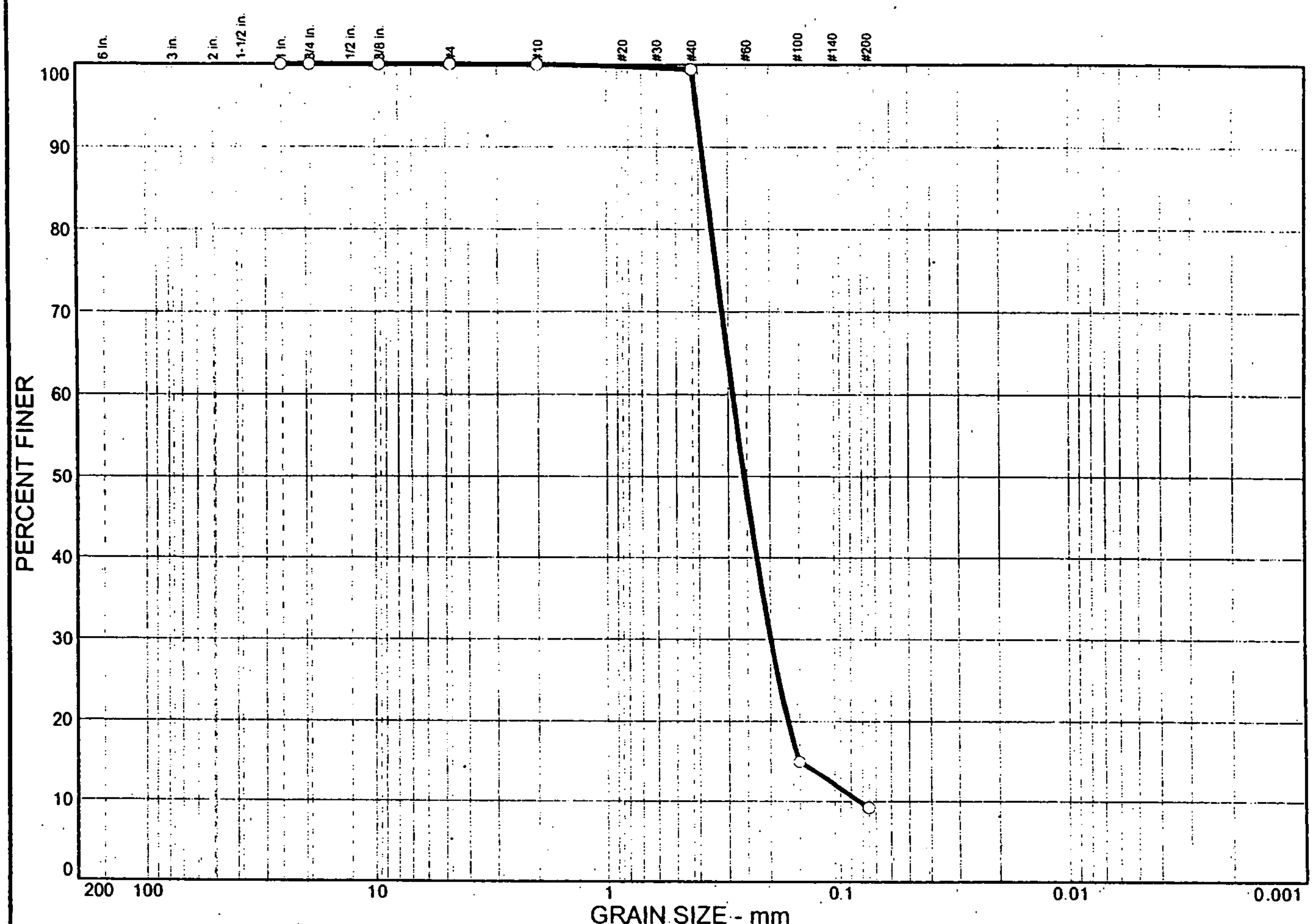
Remarks:
○ Natural Moisture = 22.6%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.6	90.2	9.2	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.369	0.286	0.257	0.199	0.150	0.0827	1.67	3.46

MATERIAL DESCRIPTION	USCS	AASHTO
○ Orange Brown,Poorly Graded SAND,trace Fine	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 12 **Sample No.:** S-4 **Elev./Depth:** 18.5'-20.5'

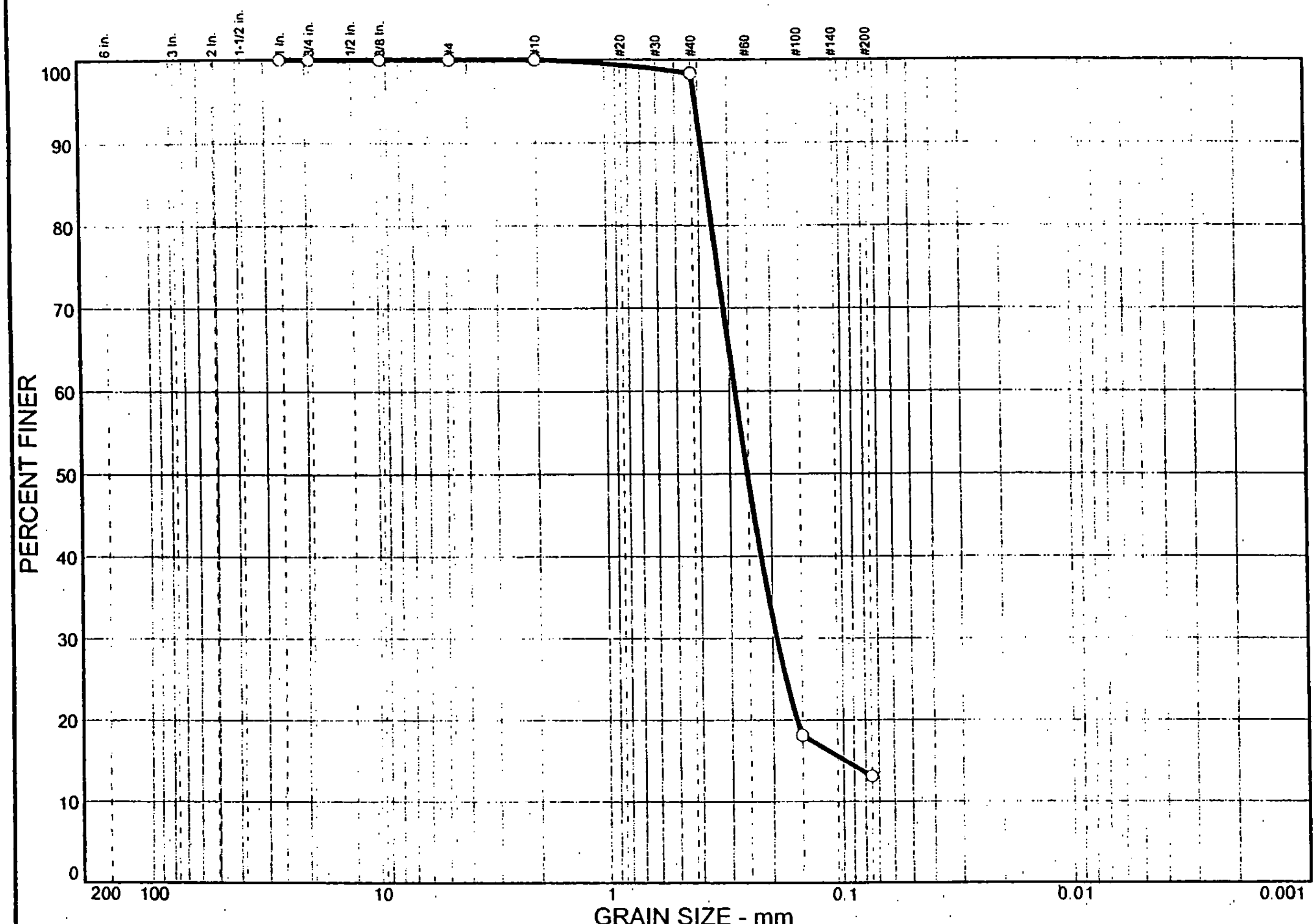
Remarks:
○ Natural Moisture = 24.1%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.6	85.3	13.1	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.370	0.283	0.252	0.191	0.0976			

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Silty Fine SAND,trace Clay	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 13 **Sample No.:** S-7 **Elev./Depth:** 28.5'-30.0'

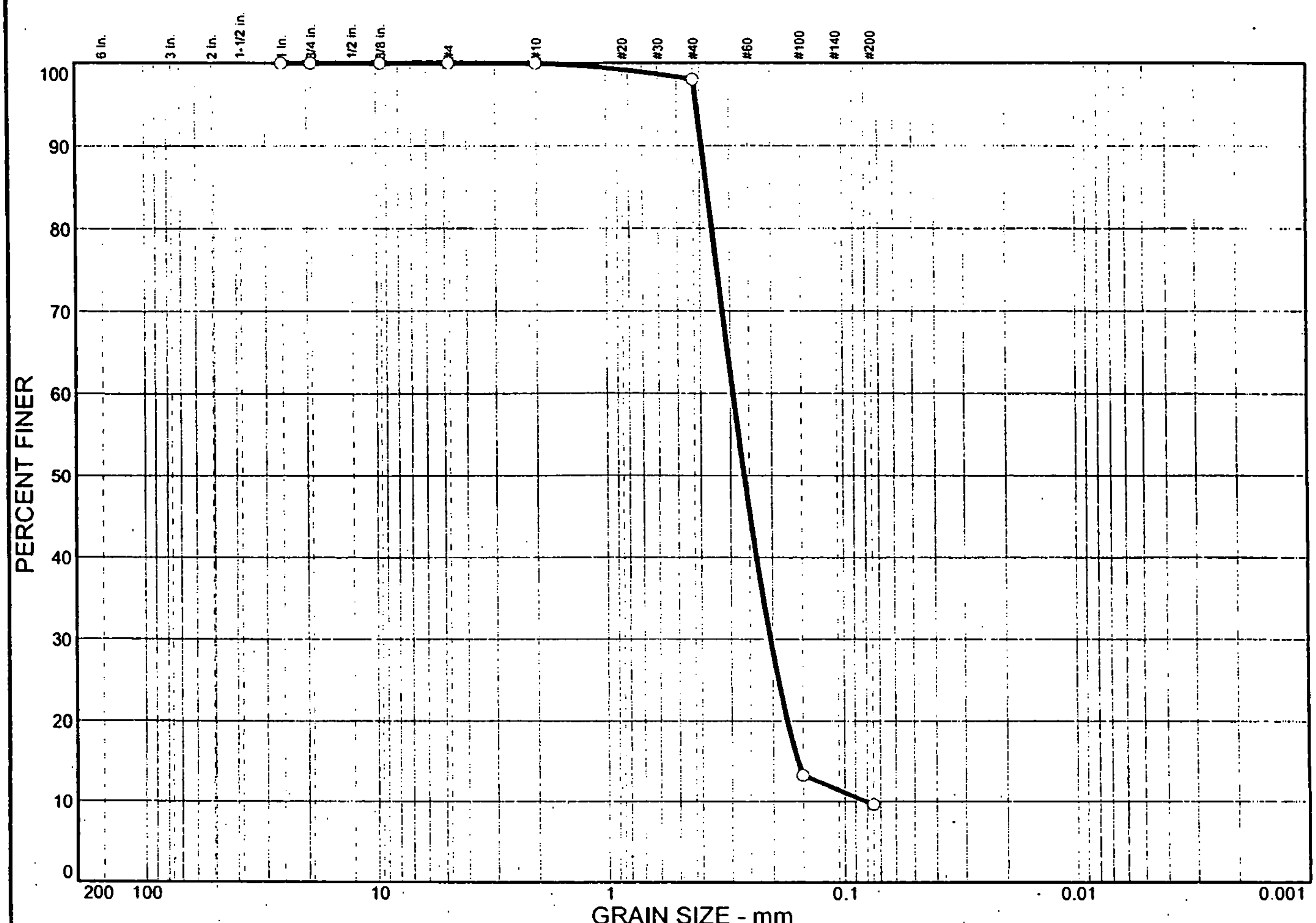
Remarks:
○Natural Moisture = 21.8%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	2.0	88.4	9.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.375	0.292	0.262	0.205	0.157	0.0810	1.77	3.60

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Poorly Graded SAND,trace Silt	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 14 **Sample No.:** S-6 **Elev./Depth:** 23.5'-25.0'

Remarks:

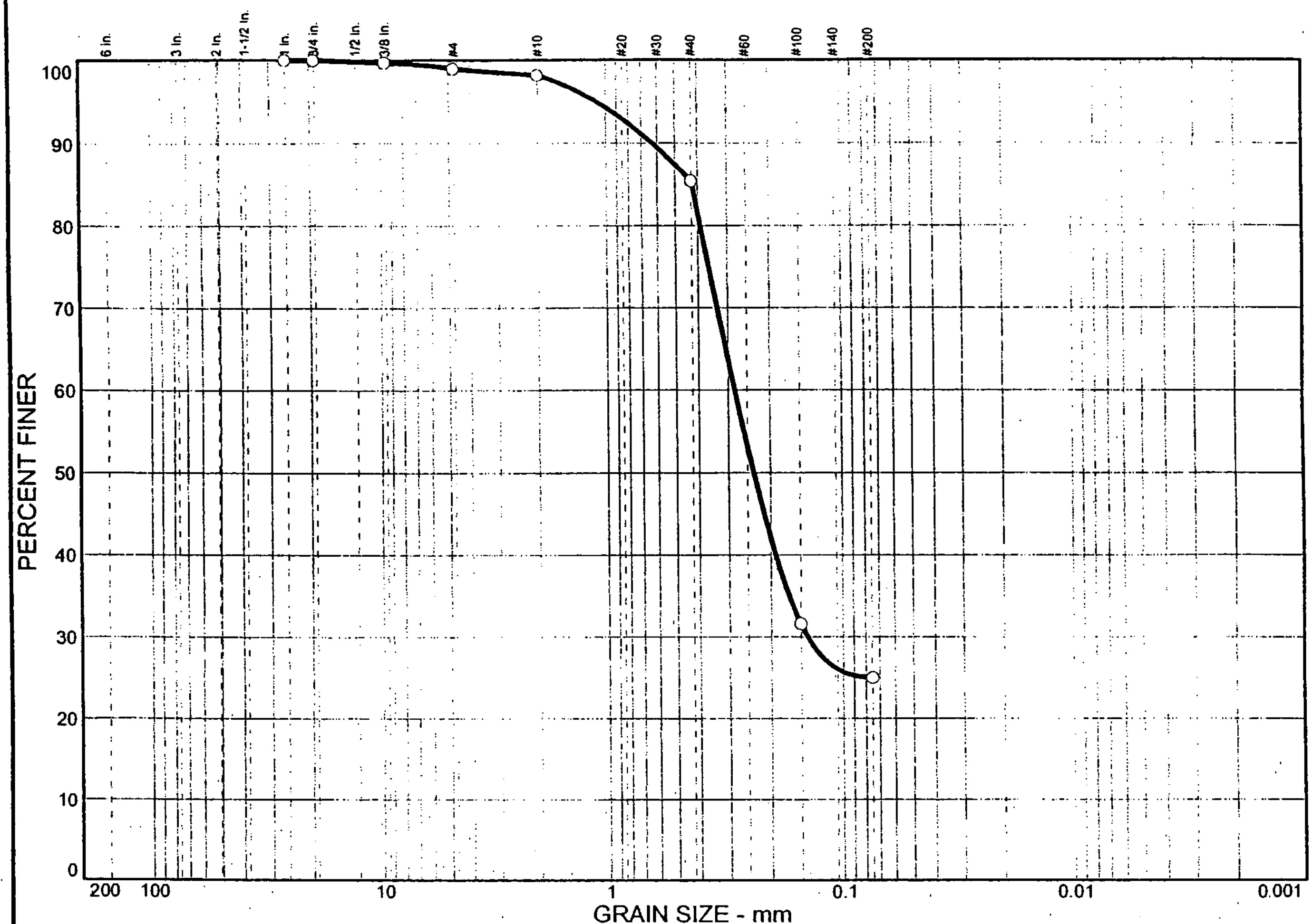
○ Natural Moisture = 22.6%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	1.0	0.8	12.8	60.4	25.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.422	0.281	0.235	0.140				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Orange Brown,Silty F-M SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 15 **Sample No.:** S-5 **Elev./Depth:** 18.5'-20.0'

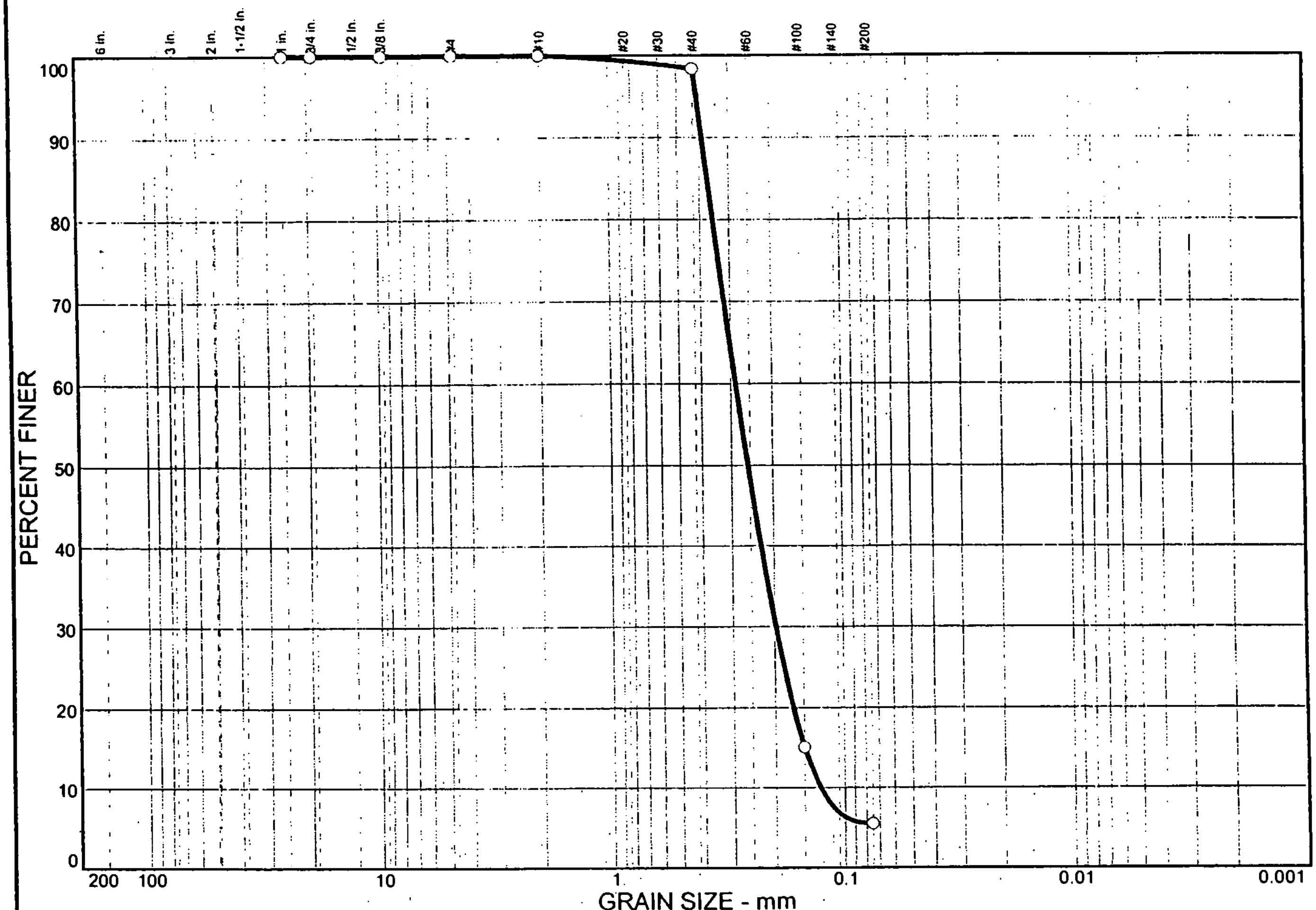
Remarks:
○ Natural Moisture = 25.7%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.6	92.9	5.5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.371	0.286	0.255	0.197	0.150	0.128	1.06	2.24

MATERIAL DESCRIPTION	USCS	AASHTO
○ Grayish Brown,Poorly Graded Fine SAND,trace Silt	SP-SM	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 16 **Sample No.:** S-2 **Elev./Depth:** 14.0'-16.0'

Remarks:

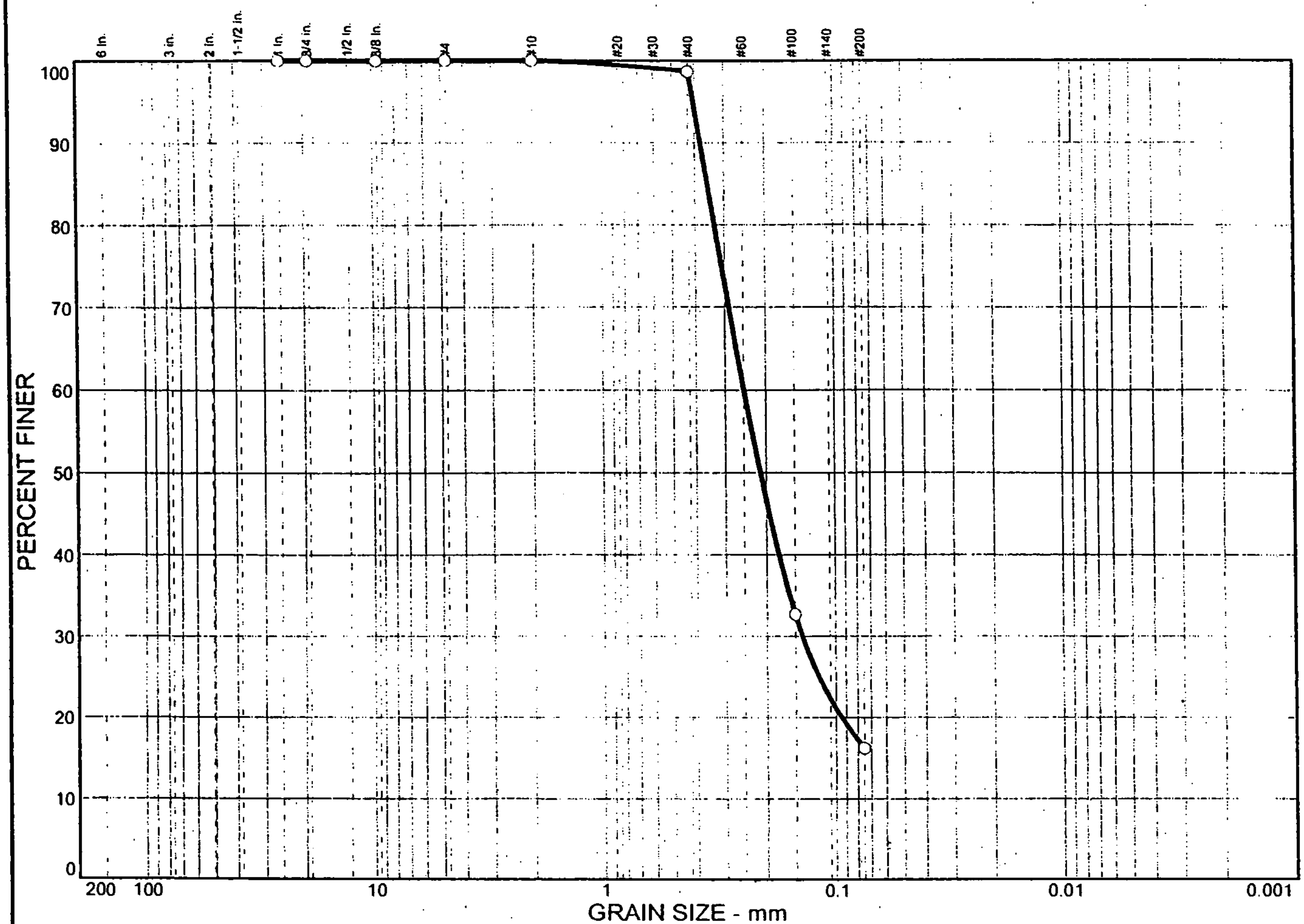
○ Natural Moisture = 28.0%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	1.3	82.5	16.2	

╳	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.354	0.248	0.212	0.140				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Gray,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 16 **Sample No.:** S-6 **Elev./Depth:** 28.5'-30.0'

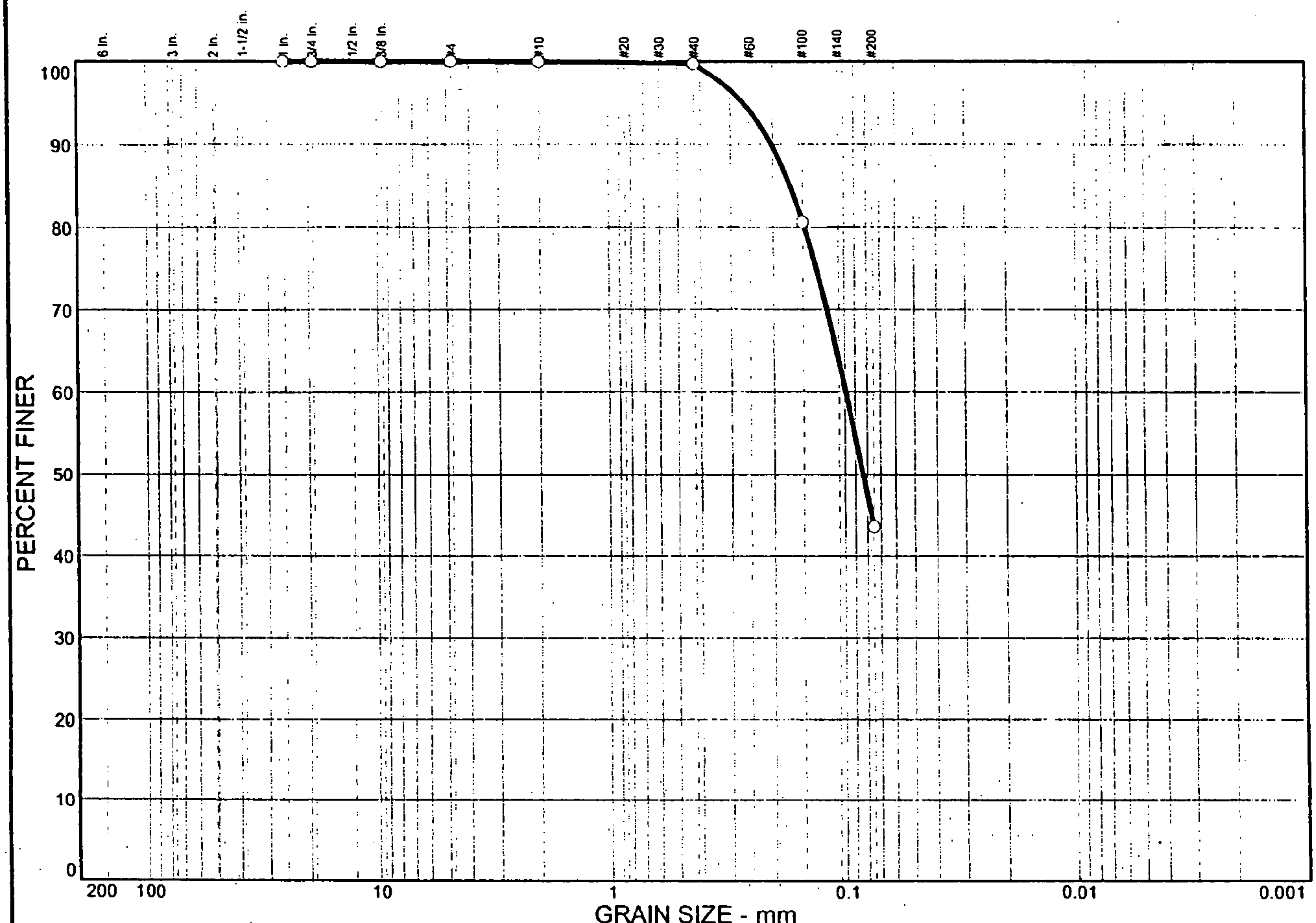
Remarks:
○ Natural Moisture = 23.6%

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	0.3	56.1	43.6	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.170	0.0989	0.0834					

MATERIAL DESCRIPTION	USCS	AASHTO
○ Brownish Gray,Silty-Clayey Fine SAND	SM-SC	

Project No. 01556-04 **Client:** Roy F. Weston

Project: Barren Island

○ **Source:** G 17 **Sample No.:** S-4 **Elev./Depth:** 19.0'-20.0'

Remarks:

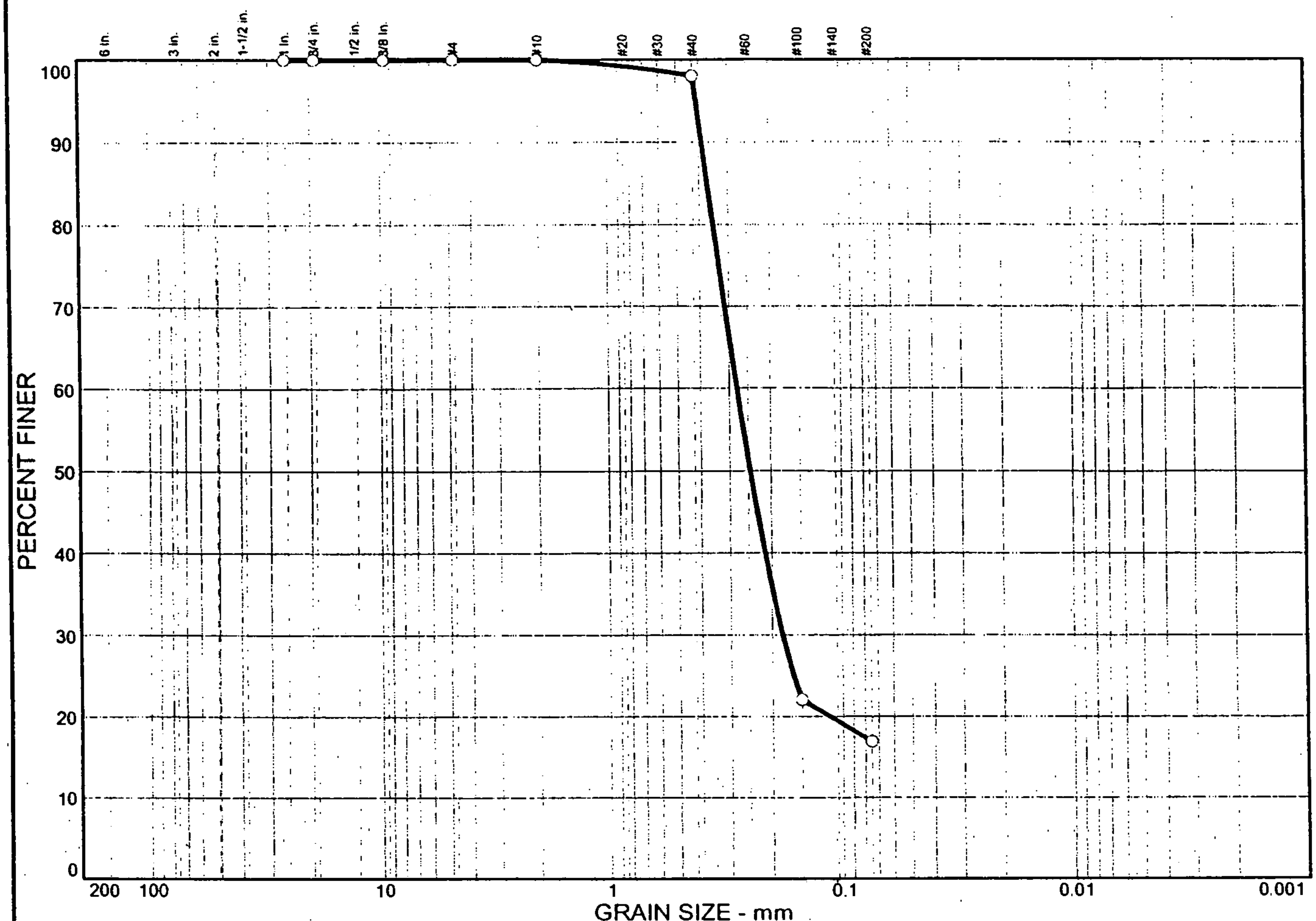
○

Particle Size Distribution Report

E2CR, Inc.

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL		% SAND			% FINES	
		CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
○	0.0	0.0	0.0	0.0	2.0	81.1	16.9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.369	0.278	0.245	0.180				

MATERIAL DESCRIPTION	USCS	AASHTO
○ L.Brown & Gray,Silty Fine SAND	SM	

Project No. 01556-04 **Client:** Roy F. Weston
Project: Barren Island

○ **Source:** G 18 **Sample No.:** S-7 **Elev./Depth:** 28.5'-30.0'

Remarks:
○

Particle Size Distribution Report

E2CR, Inc.

Plate

Boring logs

E2CR, INC.

BORING LOG

PROJECT: Barren Island				PROJECT NO.: 01556-04	BORING NO.: G - 1
SITE: Eastern Shore, Maryland	BEGUN: 09/26/01	COMPLETED: 09/26/01	HOLE SIZE:		GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 20.481 / Lon. 76° 76.060	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:		CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:		DEPTH OF BORING: 40
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs			PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10' @ 11:30 am
5	-5								
10	-10		Dark gray, wet, fine Sandy CLAY (CL)	S-1	24"	2- 2- 3- 3	DS	7"	
			Orange brown and gray, wet, Silty fine SAND (SM)	S-2	24"	6- 5- 4- 3	DS	18"	
15	-15		Medium gray and orange brown, fine Sandy CLAY (with layers of Silty fine SAND (CL)	S-3	24"	1- 1- 1- 1	DS	10"	
				S-4	24"	2- 2- 2- 9	DS	16"	
20	-20		Brownish gray, wet, Sandy SILT (ML)						
25	-25			S-5	18"	3- 4- 7	DS	18"	
			Brownish gray, wet, Silty fine to coarse SAND, trace to little fine to medium Gravel (with thin layers of fine Gravel) (SP)	S-6	18"	28- 9- 5	DS	16"	
30	-30								
			Greenish gray, moist, Silty CLAY, little fine Sand (CL)						
35	-35			S-7	18"	3- 5- 5	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 1	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY, little fine Sand (CL)	S-8	18"	5- 7- 10	DS	18"	
40	-40		Pinkish gray, moist, Silty CLAY (CL)						
			Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 2
SITE: Eastern Shore, Maryland	BEGUN: 10/02/01	COMPLETED: 10/02/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 19.886 / Lon. 76° 15.715	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 40
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth of 8.0' taken @ 9:00 am
5	-5								
			Light brown, Silty fine to coarse SAND (SM)	S-1	24"	3- 7- 4- 10	DS	8"	
10	-10		Orange brown to gray, Silty CLAY and fine SAND (CL-SC)	S-2	24"	3- 3- 2- 2	DS	24"	
				S-3	24"	1- 1- 1- 1	DS	10"	
15	-15			S-4	24"	3- 3- 4- 4	ds	14"	
			Light gray, Silty fine to medium SAND (SM)						
			Medium Gray, Silty fine SAND (SM)	S-5	24"	1- 1- 2- 2	DS	10"	
20	-20			S-6	24"	3- 4- 7- 10	DS	8"	
			Medium Gray, fine to medium SAND, trace Silt (SP)						
				S-7	24"	2- 2- 2- 3	DS	7"	
25	-25		Pinkish brown to greenish gray, Silty CLAY and fine SAND (CL)	S-8	24"	2- 2- 2- 2	DS	22"	
				S-9	18"	8- 8- 10	DS	18"	
30	-30								
35	-35			S-10	18"	3- 5- 8	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 2	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Medium gray, Silty CLAY, little fine Sand (CL)	S-11	18"	4- 5- 7	DS	18"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC. — BORING LOG

PROJECT Barren Island			PROJECT NO. 01556-04	BORING NO. G - 3
SITE Eastern Shore, Maryland	BEGUN 10/02/01	COMPLETED 10/02/01	HOLE SIZE	GROUNO ELEVATION 0.00 at water level
COOROINATES Lat. 38° 19.051 / Lon. 76° 15.445	OEPTH WATER ENC.	AT ENO ORILL	AT 72 Hrs	CAVEO OEPTH
DRILLER J. Sies	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	OEPTH OF BORING 50
TYPE OF DRILL RIG & METHOO	OEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ OEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE OATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water Depth 9.3' @ 12:00 noon
5	-5								
10	-10		Medium to light gray, wet, Silty fine to coarse SAND, trace fine Gravel (SP)	S-1	24"	5- 5- 3- 1	DS	6"	
			Light gray and orange brown, moist, laminated, Silty CLAY (with thin Sand lenses) (CL)	S-2	24"	3- 2- 2- 1	DS	8"	
15	-15		Medium gray, wet, SAND (SC)	S-3	24"	WOH/24"	DS	16"	
				S-4	24"	WOR/24"	DS	18"	
20	-20								
				S-5	18"	2- 2- 4	DS	18"	
25	-25		Medium gray, wet, Silty SAND (SC)						
30	-30		Medium gray, moist, Silty CLAY (CL)	S-6	18"	2- 2- 2	DS	18"	
			Greenish gray, wet to moist, Clayey fine SAND and SILT (SC)						
35	-35			S-7	18"	3- 3- 3	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 3

PROJECT	PROJECT NO.	PAGE
Barren Island	01556-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, wet to moist, Clayey fine SAND and SILT (SC)						
40	-40			S-8	18"	1- 1- 2	DS	18"	
			Greenish gray, moist, Silty CLAY, little fine Sand, trace shell fragments (CL)						
45	-45		Medium gray, wet, Clayey fine to medium SAND (with Silty Clay lenses) (SC-SM)	S-9	18"	2- 2- 2	DS	18"	
			Pinkish gray and brown, mottled, moist, Silty CLAY and fine SAND (CL)						
50	-50			S-10	18"	5- 7- 9	DS	18"	
			Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT				PROJECT NO.	BORING NO.
Barren Island				01556-04	G - 4
SITE: Eastern Shore, Maryland	BEGUN: 10/03/01	COMPLETED: 10/03/01	HOLE SIZE:		GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 18.494 / Lon. 76° 14.946	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:		CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:		DEPTH OF BORING: 45
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs			PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water Depth 6.2' @ 9:00 am
5	-5								
			Brownish gray, wet, fine Sandy CLAY, trace shell fragments (CL)	S-1	24"	WOH/24"	DS	NR	
				S-2	24"	WOH/24"	DS	6"	
10	-10		Orange brown, moist, fine Sandy CLAY (CL)						
			Medium gray, moist, fine Sandy SILT (ML)	ST-1	24"	Pushed Tube	ST	22"	
			Medium gray and orange brown, moist, Silty CLAY, trace to little fine Sand (CL)	S-3	24"	4- 4- 8- 8	DS	16"	
15	-15								
			Light gray and orange brown, wet, Clayey fine SAND, with Silty Sand lenses (SM)						
20	-20			S-4	18"	2- 2- 2	DS	18"	
			Brownish gray, wet, fine to medium SAND, trace Silt (SP)						
25	-25			S-5	18"	6- 5- 14	DS	10"	
			Dark brownish gray, wet, Silty fine to medium SAND (SM)						
30	-30			S-6	18"	3- 2- 1	DS	18"	
			Greenish gray, moist, Clayey SAND (SC)						
35	-35			S-7	18"	WOH/24"	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 4

PROJECT	PROJECT NO.	PAGE
Barren Island	01556-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, moist, Silty CLAY (CL)						
				S-8	18"	1- 1- 1	DS	18"	
40	-40								
				S-9	18"	3- 4- 6	DS	18"	
45	-45		Bottom of Boring @ 45.0 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 5
SITE: Eastern Shore, Maryland	BEGUN: 10/03/01	COMPLETED: 10/03/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 18.269 / Lon. 76° 15.631	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 45
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water Depth 10.0' @ 11:00 am
5	-5								
10	-10		Dark gray, wet, Silty fine SAND (SM)	S-1	24"	1- 1- 1- 3	DS	9"	
				S-2	24"	3- 1- 1- 1	DS	12"	
15	-15		Dark gray, wet, fine SAND and SILT, trace Clay (SM)	S-3	24"	WOH/24"	DS	9"	
				S-4	24"	1- 1- 1- 1	DS	12"	
20	-20								
25	-25		Dark to medium gray, wet to moist, Clayey fine to medium SAND and SILT, trace shell fragments (with a layer (6") of Sandy Clay) (SM-SC)	S-5	18"	WOH/18"	DS	18"	
			Medium to light gray, wet to moist, Clayey fine to medium SAND	S-6	18"	WOR/12"-2	DS	16"	
30	-30								
			Medium gray, moist, fine Sandy CLAY						
35	-35			S-7	18"	WOR/18"	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 5
PROJECT Barren Island	PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Medium gray, moist, fine Sandy CLAY						
			Light brown to brownish gray, wet, Silty fine to medium SAND (SP-SM)	S-8	18"	5- 7- 8	DS	18"	
40	-40								
			Greenish gray, moist, Silty CLAY, trace fine Sand (MH)	S-9	18"	5- 7- 7	DS	18"	
45	-45		Bottom of Boring @ 45.0 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 6
SITE: Eastern Shore, Maryland	BEGUN: 10/04/01	COMPLETED: 10/04/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 18.461 / Lon. 76° 15.754	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 55
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 9.8' @ 8:00 am
5	-5								
10	-10		Brownish gray to orange brown, wet, Silty fine to medium SAND, trace shell fragments (SP-SM)	S-1	24"	1- 1- 1- 4	DS	6"	
				S-2	24"	8-10-10-5	DS	21"	
15	-15		Orange brown, wet, fine SAND with SILT (SM)	S-3	24"	1- 1- 3- 4	DS	21"	
			Orange brown, wet, Silty fine to medium SAND (SM)	S-4	24"	10-10-10-5	DS	12"	
20	-20								
			Brownish gray, wet, fine to medium SAND, trace Silt (SP-SM)	S-5	18"	4- 3- 2	DS	18"	
25	-25								
30	-30		Brownish gray, wet, Silty to CLayey fine to medium SAND (SM-SC)	S-6	18"	WOH/18"	DS	15"	
35	-35		Greenish gray, very moist, Silty CLAY, little fine Sand (with lenses of Silty Sand)	S-7	18"	WOH/18"	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 6
PROJECT Barren Island	PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, very moist, Silty CLAY, little fine Sand (with lenses of Silty Sand)						
			Dark gray, wet, Silty fine to medium SAND (SM)						
40	-40			S-8	18"	4- 4- 5	DS	18"	
45	-45			S-9	18"	3- 2- 2	DS	12"	
			Greenish gray, moist to very moist, Silty CLAY, trace to little fine Sand (CL)						
50	-50			S-10	18"	2- 2- 2	DS	18"	
55	-55			S-11	18"	4- 4- 5	DS	18"	Piezometer in S-11 = 2.4
			Bottom of Boring @ 55.0 feet						
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT			PROJECT NO.	BORING NO.
Barren Island			01556-04	G - 7
SITE: Eastern Shore, Maryland	BEGUN: 10/04/01	COMPLETED: 10/04/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 18.752 / Lon. 76° 16.370	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 45
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12.0' @ 10:30 am
5	-5								
10	-10								
			Brownish to greenish gray, wet, Silty fine SAND (SM)	S-1	24"	1- 1- 1- 3	DS	9"	
15	-15			S-2	24"	3- 1- 1- 1	DS	17"	
				S-3	24"	1- 1- 1- 3	DS	8"	
20	-20			S-4	24"	1- 2- 3- 3	DS	12"	
25	-25		Orange brown and gray, wet, Silty fine to medium SAND, trace fine gravel (SM)	S-5	18"	5- 7- 4	DS	12"	
30	-30		Brownish gray, wet, Silty fine to coarse SAND and GRAVEL (with cobbles at base) (SP-SM)	S-6	6"	50/6"	DS	6"	
35	-35			S-7	18"	18-50/4"	DS	10"	

E2CR, Inc.	BORING LOG	BORING NO. G - 7	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Brownish gray, wet, Silty fine to coarse SAND and GRAVEL (with cobbles at base)						
			Greenish gray, moist, Silty CLAY, trace fine Sand (CL)	S-8	18"	3- 4- 7	DS	18"	
40	-40								
			Greenish gray, moist, Silty CLAY, trace fine Sand and shell fragments (CL)	S-9	18"	3- 4- 6	DS	18"	
45	-45		Bottom of Boring @ 45.0 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
Barren Island	01556-04	G - 8

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	10/04/01	10/04/01		0.00 at water level
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 72 Hrs**	**CAVED DEPTH**
Lat. 38° 18.961 / Lon. 76° 16.509				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
J. Sies	140 lbs.			35
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10.0' @ 2:00 pm
5	-5								
10	-10		Dark gray, wet, fine to medium SAND (SP)	S-1	24"	WOH/24"	DS	NR	
				S-2	24"	2- 4- 4- 4	DS	12"	
15	-15			S-3	24"	1- 2- 2- 1	DS	8"	
			Medium gray, wet, Silty fine SAND to fine SAND and SILT (SM)	S-4	24"	1- 2- 2- 3	DS	19"	
20	-20								
			Medium gray, wet, Silty fine to medium SAND (SM)						
25	-25		Orange brown, wet, fine to coarse SAND, trace Silt (SP)	S-5	18"	3- 3- 6	DS	14"	
30	-30		Medium gray, moist, Silty CLAY, trace to fine SAND (with occasional lenses of Silty Sand) (CH)	S-6	18"	3- 3- 3	DS	5"	
35	-35			S-7	18"	4- 5- 8	DS	10"	

E2CR, Inc.	BORING LOG	BORING NO. G - 8

PROJECT	PROJECT NO.	PAGE
Barren Island	01556-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Bottom of Boring @ 35.0 feet						
40	-40								
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 9
SITE: Eastern Shore, Maryland	BEGUN: 09/19/01	COMPLETED: 09/19/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 19.700 / Lon. 76° 17.229	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 65
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 18.0' @ 11:00 am
5	-5								
10	-10								
15	-15								
			Medium gray, fine SAND, trace Silt and mica (SP-SM)	S-1	24"	4- 4- 4- 4	DS	12"	
20	-20			S-2	24"	5- 5- 5- 6	DS	13"	
				S-3	24"	4- 3- 4- 5	DS	16"	
25	-25			S-4	24"	3- 3- 4- 5	DS	24"	
				S-5	24"	7- 4- 5- 5	DS	24"	
30	-30			S-6	24"	4- 3- 3- 4	DS	24"	
35	-35			S-7	24"	2- 2- 2- 2	DS	6"	

E2CR, Inc.	BORING LOG	BORING NO. G - 9
PROJECT Barren Island	PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Medium gray, fine SAND, trace Silt and mica (SP-SM)						
			Medium gray, fine SAND, trace Silt, with Clayey fine Sand lenses (SM)	S-8	18"	1- 1- 1	DS	18"	
40	-40								
			Medium gray, Silty fine SAND, trace to little Clay (SM)	S-9	18"	WOH/18"	DS	18"	
45	-45								
				S-10	18"	1- 1- 1	DS	18"	
50	-50								
			Medium gray, Silty fine SAND (SM)	S-11	18"	5- 10- 12	DS	18"	
55	-55								
			Medium to light gray, fine SAND, trace Silt (SP)	S-12	18"	5- 11- 18	DS	14"	
60	-60								
				S-13	18"	15-28-31	DS	18"	
65	-65		Bottom of Boring @ 65.0 feet						
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT		PROJECT NO.	BORING NO.
Barren Island		01556-04	G - 10

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	09/27/01	09/27/01		0.00 at water level
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 72 Hrs**	**CAVED DEPTH**
Lat. 38° 20.646 / Lon. 76° 16.585				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
J. Sies	140 lbs.			35
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10.8 ' @ 9:00 am
5	-5								
10	-10								
			Black to orange brown and gray, fine Sandy CLAY, with fine Sand (CL)	S-1	24"	1- 1- 1- 1	DS	9"	
				S-2	24"	3- 2- 2- 2	DS	18"	
15	-15		Medium gray, moist to wet, Silty CLAY, little fine Sand (with Sandy lenses)	ST-1	24"	Pushed Tube	ST	24"	
			Medium gray, wet, Silty to Clayey fine to medium SAND (with lenses of Silty Clay) (SM)	S-3	24"	1- 1- 1- 1	DS	18"	
20	-20								
25	-25			S-4	18"	2- 2- 2	DS	18"	
			Greenish gray, moist, Silty CLAY, trace to little fine Sand (CL)						
30	-30			S-5	18"	4- 4- 7	DS	18"	
35	-35			S-6	18"	4- 5- 8	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 10	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Bottom of Boring @ 35.0 feet						
40	-40								
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 11
SITE: Eastern Shore, Maryland	BEGUN: 09/26/01	COMPLETED: 09/26/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 20.178 / Lon. 76° 16.734	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 40
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12.5' @ 8:30 am
5	-5								
10	-10								
			Dark gray, Silty fine to medium SAND, trace shell fragments (SP-SM)	S-1	18"	6- 7- 8	DS	10"	
15	-15		Light gray and orange Silty fine to medium SAND (SM)	S-2	12"	28- 50/4"	DS	9"	
			Light greenish gray, Silty fine to medium SAND, with a lens of Sand (SP-SM)	S-3	24"	6- 2- 1- 1	DS	17"	
20	-20		Medium gray, Silty fine to medium SAND (SM)	S-4	24"	2- 2- 6- 8	DS	16"	
			Greenish gray, Silty fine to medium SAND (SM)						
25	-25		Brownish gray, Clayey fine SAND and SILT (with trace fine to medium Gravel @ base) (SM)	S-5	18"	WOH/18"	DS	18"	
				ST-1	12"	Pushed Tube	ST	12"	
30	-30		Medium gray, fine to medium SAND, trace to little fine to coarse Gravel and Silt (SP-SM)	S-6	6"	50/5"	DS	5"	
			Greenish gray, Silty CLAY and fine SAND (CL)	S-7	18"	5- 7- 9	DS	18"	
35	-35								

E2CR, Inc.	BORING LOG	BORING NO. G - 11	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, Silty CLAY and fine SAND (CL)						
				S-8	18"	5- 8- 10	DS	18"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC. — BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 12
SITE: Eastern Shore, Maryland	BEGUN: 09/27/01	COMPLETED: 09/27/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 19.430 / Lon. 76° 16.493	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 40
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12.6' @ 1:00 pm
5	-5								
10	-10								
			Dark gray, wet, Silty fine Sand (SM)	S-1	24"	WOH/24"	DS	NR	
15	-15		Dark gray to orange brown, wet, Silty fine SAND (SM)	S-2	24"	2- 2- 2- 2	DS	16"	
			Orange brown, wet, Silty fine SAND (SP-SM)	S-3	24"	2- 2- 2- 3	DS	9"	
20	-20			S-4	24"	4- 8- 4- 4	DS	20"	
25	-25		Light orange brown, wet, Silty fine SAND, trace medium grains) (SP-SM)	S-5	18"	5- 5- 5	DS	18"	
				S-6	18"	5- 6- 8	DS	11"	
30	-30		Medium gray, wet, fine to medium Sandy GRAVEl (SP)						
			Medium gray, moist, Silty CLAY, little to trace fine Sand (CL)						
35	-35			S-7	18"	5- 7- 8	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 12	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Medium gray, moist, Silty CLAY, little to trace fine Sand (CL)	S-8	18"	5- 8- 10	DS	18"	
40	-40		Bottom of Boring 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT		PROJECT NO.		BORING NO.
Barren Island		01556-04		G - 13

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	10/29/01	10/29/01		0.00 at water level
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 72 Hrs**	**CAVED DEPTH**
N 38° 19.224' / E 76° 15.937'				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
J. Sies	140 lbs.			50
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 11.0' @ 8:00 am
5	-5								
10	-10								
			Medium gray, wet to moist, Silty CLAY, trace fine SAND with occasional lenses of Clayey Sand (CL)	S-1	24"	WOH/24"	DS	13"	
				S-2	24"	2- 3- 4- 4	DS	7"	
15	-15			S-3	24"	2- 3- 3- 3	DS	16"	
				S-4	24"	4- 4- 4- 2	DS	12"	
20	-20			S-5	18"	WOH/18"	DS	12"	
25	-25			S-6	18"	3- 1- 1	DS	16"	
			Medium gray, wet, Silty to Clayey fine to medium SAND (with thin lenses of Sandy Clay) (SM)						
30	-30			S-7	18"	1- 1- 1	DS	18"	
35	-35			S-8	18"	4- 6- 7	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 13
PROJECT Barren Island	PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Medium gray, wet, Silty to Clayey fine to medium SAND (with thin lenses of Sandy Clay) (SM)						
			Greenish gray, wet, Clayey fine SAND and SILT (SC)	S-9	18"	3-3-3	DS	18"	
40	-40								
45	-45			S-10	18"	3-3-4	DS	18"	
			Greenish gray, moist, fine Sandy CLAY (CL-ML)	S-11	18"	3-3-3	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island			PROJECT NO.: 01556-04	BORING NO.: G - 14
SITE: Eastern Shore, Maryland	BEGUN: 09/25/01	COMPLETED: 09/25/01	HOLE SIZE:	GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 19.959 / Lon. 76° 16.269	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:	CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:	DEPTH OF BORING: 50
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs		PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 10.0' @ 2:30 pm
5	-5								
10	-10		Greenish brown, Silty fine SAND, trace shell fragments (SM)	S-1	24"	1- 1- 1- 1	DS	5"	
			Medium gray, Silty CLAY, trace fine roots (CL)	S-2	24"	1- WOH/ 18"	DS	6"	
15	-15		Medium gray, Clayey fine SAND	S-3	24"	1- 1- 1- 1	DS	14"	
			Grayish brown, Silty fine to medium SAND (SP)	S-4	24"	7-10-10-4	DS	12"	
20	-20		Medium to dark gray, Clayey fine SAND (with Silty fine to medium SAND layers) (SP-SM)	S-5	24"	2- 2- 3- 4	DS	22"	
25	-25			S-6	18"	8- 12- 20	DS	18"	
30	-30		Greenish gray, Clayey fine SAND and SILT (SC)	S-7	18"	3- 3- 3	DS	18"	
35	-35		Greenish Silty CLAY (CL)	S-8	18"	3- 3- 3	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 14

PROJECT	PROJECT NO.	PAGE
Barren Island	01556-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, Clayey fine SAND and SILT (SC)						
				S-9	18"	3- 3- 5	DS	18"	
40	-40								
			Greenish gray, Clayey SILT, little fine Sand (MH)						
				S-10	18"	2- 2- 2	DS	18"	
45	-45								
				S-11	18"	3- 5- 6	DS	18"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT	PROJECT NO.	BORING NO.
Barren Island	01556-04	G - 15

SITE	BEGUN	COMPLETED	HOLE SIZE	GROUND ELEVATION
Eastern Shore, Maryland	10/03/01	10/03/01		0.00 at water level
COORDINATES	**DEPTH WATER ENC.**	**AT END DRILL**	**AT 72 Hrs**	**CAVED DEPTH**
Lat. 38° 18.801 / Lon. 76° 14.843				
DRILLER	**WEIGHT OF HAMMER**	**HEIGHT OF FALL**	**TYPE OF CORE**	**DEPTH OF BORING**
J. Sies	140 lbs.			40
TYPE OF DRILL RIG & METHOD	**DEPTH TO ROCK**	**LOGGED BY:**		**PAGE NO.**
		C. Jacobs		1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 3.5'
5	-5		Brownish gray, wet, fine Sandy CLAY, trace shell fragments (CL)	S-1	24"	WOH/24"	DS	8"	
				S-2	24"	WOH/24"	DS	19"	
10	-10								
			Light brown, wet fine Sandy SILT (ML)	S-3	24"	4- 5- 6- 6	DS	18"	
15	-15		Brown to orange brown, wet to moist, Silty fine to medium SAND (with lenses of Silty Clay (SM)	S-4	24"	4- 5- 6- 6	DS	15"	
20	-20			S-5	18"	2- 2- 2	DS	16"	
25	-25		Bluish gray, wet, Silty fine to medium SAND, with lenses of Silty Clay (SM)	S-6	14"	WOH/12"-8	DS	14"	
30	-30		Greenish gray, moist, Silty CLAY, some fine Sand (CL)	S-7	18"	WOH/18"	DS	18"	
			SAND and GRAVEL layer						
35	-35		Dark gray, wet, Silty fine to medium SAND, trace Clay and	S-8	18"	9- 11- 16	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 15	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			shell fragments (SM)						
			Greenish gray, moist, Silty CLAY, little fine Sand (CL)	S-9	18"	5- 6- 8	DS	10"	
40	-40		Bottom of Boring @ 40.0 feet						
45	-45								
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT Barren Island			PROJECT NO. 01556-04	BORING NO. G - 16
SITE Eastern Shore, Maryland	BEGUN 10/05/01	COMPLETED 10/05/01	HOLE SIZE	GROUND ELEVATION 0.00 at water level
COORDINATES Lat. 38° 18.994 / Lon. 76° 16.829	DEPTH WATER ENC.	AT END DRILL	AT 72 Hrs	CAVED DEPTH
DRILLER J. Sies	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE	DEPTH OF BORING 70
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs		PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12.0' @ 8:00 am
5	-5								
10	-10								
			Medium gray, wet, fine SAND, trace Silt (with layers of fine to medium Sand) (SP-SM)	S-1	24"	1- 1- 3- 4	DS	7"	
15	-15			S-2	24"	6- 4- 4- 2	DS	15"	
				S-3	24"	2- 3- 3- 5	DS	9"	
20	-20			S-4	24"	8-12-12-20	DS	20"	
				S-5	18"	WOH/18"	DS q	18"	
25	-25		Medium gray, wet, fine SAND and SILT (SM)						
30	-30		Medium gray, wet, fine SAND with trace Silt (SM)	S-6	18"	5- 10- 15	DS	12"	
35	-35			S-7	18"	4- 3- 2	DS	18"	

E2CR, Inc.	BORING LOG	BORING NO. G - 16	
PROJECT Barren Island		PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Greenish gray, wet, fine SAND and SILT (SM)						
40	-40			S-8	18"	3- 3- 3	DS	18"	
45	-45			S-9	18"	3- 3- 3	DS	13"	
			Medium gray, wet, fine SAND, trace Silt (SP-SM)						
50	-50		Medium to brownish gray, wet, Silty fine to medium SAND, trace coarse Sand, fine Gravel, and shell fragments (SM)	S-10	18"	4- 6- 9	DS	17"	
55	-55		Grayish brown, moist, Silty CLAY, little Sand and organics	S-11	18"	5- 6- 7	DS	11"	
			Medium brown and gray, very moist to wet, fine to medium Sandy PEAT (with lenses of fine to medium Sand) (SM)						
60	-60			S-12	18"	2- 3- 5	DS	12"	
			Grayish brown, wet, Silty fine to medium Sand, some organics (with lenses of Peat and Silty Clay) (SM)						
65	-65			S-13	18"	4- 5- 5	DS	13"	
70	-70		Brownish gray Silty CLAY lens (CL)	S-14	18"	3- 4- 6	DS	12"	
			Bottom of Boring						
75	-75								

E2CR, INC.

BORING LOG

PROJECT: Barren Island				PROJECT NO.: 01556-04	BORING NO.: G - 17
SITE: Eastern Shore, Maryland	BEGUN: 10/29/01	COMPLETED: 10/29/01	HOLE SIZE:		GROUND ELEVATION: 0.00 at water level
COORDINATES: Lat. 38° 17.990 / 76° 16.013	DEPTH WATER ENC.:	AT END DRILL:	AT 72 Hrs:		CAVED DEPTH:
DRILLER: J. Sies	WEIGHT OF HAMMER: 140 lbs.	HEIGHT OF FALL:	TYPE OF CORE:		DEPTH OF BORING: 45
TYPE OF DRILL RIG & METHOD:	DEPTH TO ROCK:	LOGGED BY: C. Jacobs			PAGE NO.: 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 12.0'
5	-5								
10	-10								
			Dark gray and brown, wet, Silty fine SAND (SM)	S-1	24"	3- 4- 4- 4	DS	0"	
15	-15		Brownish gray, wet, fine SAND and SILT, trace to little Clay (SM-SC)	S-2	24"	4- 4- 5- 6	DS	7"	
				S-3	24"	WOR/10"	DS	10"	
20	-20			S-4	24"	WOR/24"	DS	10"	
			Brownish gray, wet, Silty fine SAND (SM)						
25	-25			S-5	18"	3- 3- 4	DS	12"	
			Light brownish gray, wet, fine to medium SAND, trace Silt (SP-SM)						
30	-30			S-6	18"	4- 4- 4	DS	10"	
			Light brownish gray, wet, Silty fine to medium SAND to Silty fine to coarse SAND, trace to						
35	-35			S-7	18"	12- 14- 18	DS	10"	

E2CR, Inc.	BORING LOG	BORING NO. G - 17
PROJECT Barren Island	PROJECT NO. 01556-04	PAGE 2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			some fine to coarse Gravel (SP-SM)						
			Greenish gray, moist, Silty CLAY, trace fine Sand (CL)	S-8	18"	2- 3- 3	DS	18"	
40	-40								
				S-9	18"	4- 5- 6	DS	18"	
45	-45		Bottom of Boring @ 45.0 feet						
50	-50								
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

E2CR, INC.

BORING LOG

PROJECT Barren Island			PROJECT NO. 01556-04		BORING NO. G - 18
SITE Eastern Shore, Maryland	BEGUN 10/29/01	COMPLETED 10/29/01	HOLE SIZE		GROUND ELEVATION 0.00 at water level
COORDINATES Lat. 38° 18.103 / 76° 14.338	DEPTH WATER ENC.	AT END DRILL	AT 72 Hrs		CAVED DEPTH
DRILLER J. Sies	WEIGHT OF HAMMER 140 lbs.	HEIGHT OF FALL	TYPE OF CORE		DEPTH OF BORING 50
TYPE OF DRILL RIG & METHOD	DEPTH TO ROCK	LOGGED BY: C. Jacobs			PAGE NO. 1

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE DATA: SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
0	0		Water						Water depth 6.0'
5	-5								
			Dark gray and brown, wet, Silty fine SAND (SC-SM)	S-1	24"	1- 1- 2- 2	DS	5"	
				S-2	24"	2- 3- 4- 4	DS	12"	
10	-10								
			Brownish gray, wet, fine SAND and SILT, trace to little Clay (SM-SC)	S-3	24"	WOH/24"	DS	12"	
				S-4	24"	1- 1- 2- 3	DS	16"	
15	-15		Greenish gray and brown, very moist to wet, Silty CLAY (with lenses of fine Sand)						
			Orange brown and gray, wet, Sandy SILT (ML)	S-5	18"	5- 7- 7	DS	12"	
20	-20								
			Light brown and orange, wet, Silty fine to medium SAND (SM)	S-6	18"	5- 5- 5	DS	10"	
25	-25								
30	-30			S-7	18"	2- 2- 2	DS	6"	
35	-35			S-8	18"	2- 2- 4	DS	6"	

E2CR, Inc.	BORING LOG	BORING NO. G - 18

PROJECT	PROJECT NO.	PAGE
Barren Island	01556-04	2

DEPTH	STRATA ELE./ DEPTH	GRAPHIC LOG	DESCRIPTION	SAMPLE NO.	SAMPLE LENGTH	N-VALUE/ RQD (%)	SAMPLE TYPE AND DIAMETER	SAMPLE RECOVERY	REMARKS:
			Light brown and orange, wet, Silty fine to medium SAND (SM)						
				S-9	18"	4- 4- 4	DS	10"	
40	-40								
			Medium brown, wet, Silty fine to medium SAND to Silty fine to coarse SAND, trace to some fine to coarse Gravel (SP-SM)	S-10	18"	2- 2- 4	DS	8"	
45	-45								
			Brownish gray, moist, Silty CLAY (CL)						
				S-11	18"	4- 4- 4	DS	12"	
50	-50		Bottom of Boring @ 50.0 feet						
55	-55								
60	-60								
65	-65								
70	-70								
75	-75								

APPENDIX D

ENVIRONMENTAL CONDITIONS REPORT

Preliminary Assessment of Environmental Conditions on Barren Island, Dorchester County, Maryland
Roy F. Weston, Inc.
April 2002

APPENDIX D

FINAL REPORT

PRELIMINARY ASSESSMENT OF ENVIRONMENTAL CONDITIONS ON BARREN ISLAND DORCHESTER COUNTY, MARYLAND

Prepared for

MARYLAND ENVIRONMENTAL SERVICE
Annapolis, Maryland
Contract No. 01-07-30

Prepared by

ROY F. WESTON, INC.
1400 Weston Way
West Chester, Pennsylvania 19380

April 16, 2002

WO# 12790.001.001

TABLE OF CONTENTS

Section **Page**

TABLE OF CONTENTS (CONTINUED)

Section **Page**

LIST OF FIGURES

LIST OF TABLES

Title **Page**

EXECUTIVE SUMMARY

Barren Island is an uninhabited island owned by the United States Fish and Wildlife Service (USFWS) that is located in the eastern portion of the middle Chesapeake Bay, to the east of the mouth of the Patuxent River, 1 mile off the eastern shore in Dorchester County, MD. The Island is currently approximately 180 acres, which is entirely used as ecological habitat. Barren Island serves as a satellite refuge for the Blackwater National Wildlife Refuge (BNWR), which is also located in Dorchester County, Maryland. Barren Island consists of several different types of high quality habitat including low and high salt marsh, tidal flats, and forest habitat. According to estimates by the USFWS, Barren Island is eroding along its western shore at a rate of approximately 10 to 14 feet per year, which is equivalent to a loss rate of 2.4 to 3.4 acres per year. The Island has lost approximately 450 acres in the past 325 years as the result of erosion.

Barren Island is under consideration for a beneficial use of dredging material placement project under the Maryland Port Administration's Dredged Material Management Program (DMMP). This study, conducted by Roy F. Weston, Inc. under contract to Maryland Environmental Service (MES), evaluates the current environmental conditions and potential environmental impacts associated with two conceptual environmental restoration area configurations that would provide shoreline stabilization and restoration along the western shoreline of the Island, as well as provide additional marsh and upland habitat areas around Barren Island.

The two conceptual configurations currently being assessed are a 1,000 acre environmental restoration area (Alignment #1) and a 2,000 acre environmental restoration area (Alignment #2). Both alignments are proposed for placement in shallow water habitat. Both alignments would be constructed with stone armored sand dikes extending west and south from Barren Island into the Chesapeake Bay Mainstem and would include marsh and upland habitat areas. Both alignments will provide a tidal flat area between Barren Island proper and the environmental restoration area, and will not be directly tied into Barren Island.

Water quality around Barren Island is generally good. Low turbidity levels and shallow water depths permit light to penetrate the entire water column to a distance of one-half mile around

Barren Island. Shallow waters also prevent the formation of a pycnocline during summer months. Adequate dissolved oxygen concentrations (>5 mg/L) occur year round to depths of 7 feet, although dissolved oxygen concentrations are stressful (< 5 mg/L) below 7 feet during summer months in some of the area in Alignment #2. Dissolved oxygen concentrations below 5 mg/L are stressful to the growth, reproduction, and survival of the Bay's fish, shellfish and bottom dwelling organisms. The shallow water habitat around Barren Island supports significant submerged aquatic vegetation (SAV) beds in the wave shadow of the Island (south and east) and commercial blue crabbing areas (north and west). There are two MD Natural Oyster Bars (NOB 23-2 and NOB 23-4) that lie west and northwest and east and southeast, respectively, from Barren Island.

Barren Island supports waterfowl habitat, feeding grounds, and nesting areas. A Great Blue Heron rookery is located on the south end of the Island, and a Brown Pelican colonial nesting area on a small breakaway portion of the southern part of Barren Island. A Bald Eagle nest on the southern portion of the Island supports a single nesting pair of Bald Eagles (federally threatened). Numerous other bird species are known to frequent the Island, including the Least Tern (federally endangered) and Black Skimmer (state endangered).

Barren Island also supports white-tailed deer, diamondback terrapins, red-bellied turtles, and various other terrestrial mammals, reptiles, and amphibians. The Island also contains suitable habitat for the Delmarva Fox Squirrel (federally endangered) and the Northeastern Tiger Beetle (federally threatened), although neither of these species have ever been documented on the Island. No formal survey for these species has occurred to date.

The shallow water habitat that would be impacted by either alignment is not considered to be of high value. The existing benthic habitat in the proposed project is of low quality. The proposed alignments are both located within a section of the Barren Island Grounds that are used for commercial fishing (blue crab and finfish). There are limited data on finfish and shellfish landings and habitat utilization in the area. The alignment area is designated as Essential Fish Habitat by the National Marine Fisheries Service (NMFS) and as Critical Area.

There are no CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) liability issues associated with Barren Island, although several fuel tanks associated with an early 20th century hunting lodge were previously removed from the Island by USFWS. The Island has a rich history of human use and settlement, including pre-colonial use by Native Americans, historical settlement during the colonial periods, and as a hunting club in the early 20th century. A colonial-era cemetery is located on the western-central portion of the Island, which is currently eroding into the Chesapeake Bay. The Maryland Historical Trust Office of Preservation Services has indicated that no areas of historical, cultural, or archaeological significance will be affected by the proposed project.

Impacts associated with the proposed alignments would include a short-term increase in water turbidity (associated with dike construction and dredged material placement and inflow periods), a short term increase in water nutrient levels (associated with dike construction and dredged material placement and inflow periods), a reduction in the size of the Barren Island Grounds, shallow water habitat, and a reduction in size of the commercial crabbing area (1,000-acres for Alignment #1, 2,000-acres for Alignment #2). These habitats would be replaced with low marsh, high marsh, and upland habitat.

The proposed project would cause a potential short-term impact on nesting waterfowl for both alignments, as they would likely be discouraged from nesting or remaining on the western shore of Barren Island during construction activities. This impact could extend into the Great Blue Heron Rookery and Bald Eagle nesting area on Barren Island, or into the brown pelican nesting area on the small remnant island to the south of Barren Island. For a similar environmental restoration project at Poplar Island, the construction schedule was coordinated with the USFWS and Maryland Department of Natural Resources (MDNR) to avoid impacts to Great Blue Heron habitat and Bald Eagle habitat during critical time periods for these species.

The anticipated increased total suspended solids (TSS) levels and sedimentation during construction and placement activities could potentially impact the SAV beds and natural oyster bars around Barren Island if adequate monitoring and control mechanisms are not employed.

This impact is expected to be greater for Alignment #2 because it is larger and construction and placement will last longer.

The proposed project would also create a potential short-term impact on local shipping. Barge and tug traffic to and from Barren Island during construction of the dike system and placement of the dredged material would generally increase the local shipping traffic during this period. This impact on navigation would be slightly greater for Alignment #2, because it would cover a longer time period and involve more barges and tugs.

Because both Alignment #1 and Alignment #2 are not proposed to tie directly into Barren Island, it is not anticipated that the current habitats on Barren Island would be adversely impacted in the long term. In fact, the overall long term impact on the habitat on Barren Island is expected to be positive through reduction or elimination of current erosion of the Island, a potential increase in the wave "shadow" area around Barren Island and subsequently the SAV habitat in that area, and addition of significantly more low marsh, high marsh, and upland habitat for continued ecological restoration. In addition, the current alignment configurations will provide a tidal flat area between Barren Island and the proposed alignments. This type of habitat is currently a very small component of Barren Island.

The Maryland Historical Trust reported that no known historical, cultural, or archaeological resources will be affected by the proposed project. It is anticipated that the proposed project will preserved undocumented sites by stemming overall erosion of the Island. The impact of the proposed project on preservation of the cemetery along the southwestern edge of Barren Island is unknown because neither alignment lies adjacent to this area; however, the alignments may provide wind or wave protection to the remnants, which could result in preservation of the cemetery. Neither alignment footprint appears to cover areas of historical significance. It is not expected that the proposed project will impact any historically significant areas.

Prior to selection and finalization of the construction plans for this project, it is recommended that a baseline ecological assessment be conducted of the benthic community within the footprint of that alignment, as this area has not been evaluated for ecological value. In addition, the

USFWS should be consulted regarding construction plans for the selected alignment and the impact of the possible impacts and benefits associated with construction of a dredged material placement facility on the environmental conditions of the Island. It has been shown on Barren Island through previous restoration efforts that elevation differences as little as 0.1 foot can severely impact the successful colonization by desired plant species. In addition, a previous attempt to restore least tern nesting areas on Barren Island was successful until natural grasses became established on the placed loose shell. These experiences have provided USFWS a unique knowledge of the Barren Island habitats and effects of particular restoration attempts. NMFS will need to be consulted regarding EFH impacts.

In conclusion, it is expected that both of the proposed alignments for the beneficial reuse of dredged material west of Barren Island would be beneficial to the area and the island by reducing erosion and increasing upland, marsh, and tidal flat habitat. It is anticipated that these benefits could outweigh the trade-offs of reducing the area of the Barren Island Grounds (a commercial fisheries area for finfish and crabbing), reducing the amount of shallow water habitat, and impacting water quality in the short-term.

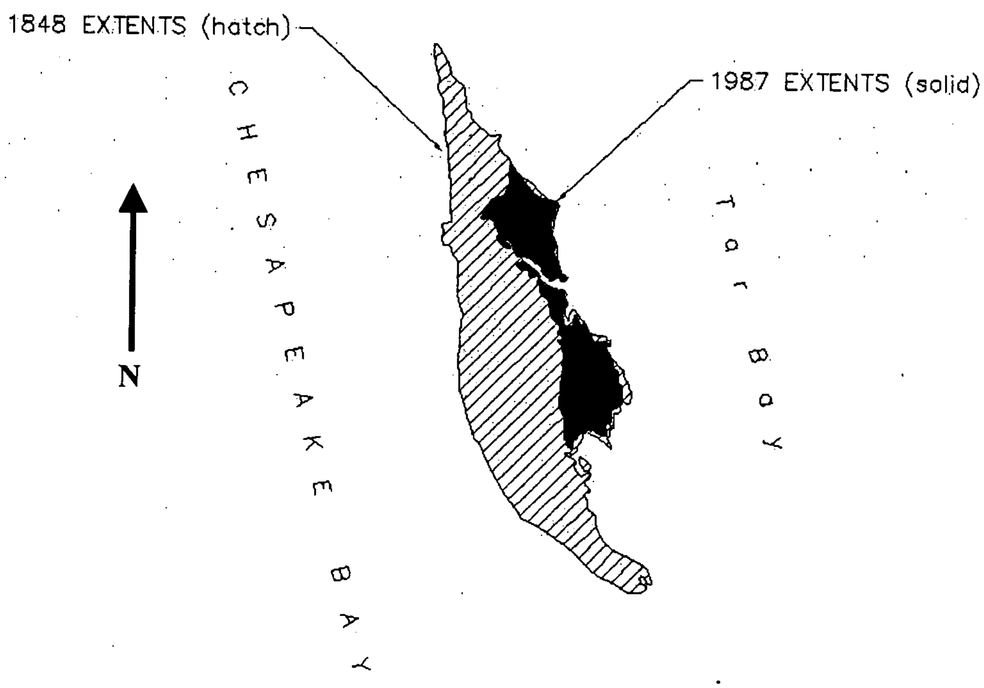
1. INTRODUCTION

Islands in the Chesapeake Bay are eroding and disappearing at an alarming rate due to rising sea levels. Islands in the Bay, populated during colonial times, have disappeared or have substantially decreased in size due to submergence and related shoreline erosion (USGS, 1998). Barren Island, a Chesapeake Bay island located in Dorchester County, Maryland, is estimated, according to one source, to have lost approximately 78% of its historical acreage to erosion since 1848, with most of the erosion occurring on the western side of the island due to the predominately north to south littoral drift (USACE, 1994). A second study of erosion rates indicates approximately 450 acres of Barren Island have been lost over the last 325 years (Gelenter, 1990), which corresponds to an average annual loss rate of 0.7 acres per year. The United States Fish and Wildlife Service (USFWS) estimates that the current erosion rate could be as high as 10 to 14 feet of western shoreline lost per year, or 2.4 to 3.4 acres per year (J. Gill, USFWS, personal communication, 2001). Although estimates of the erosion rate on Barren Island are not precise, the studies all indicate that high erosions rates are present on the island, which, if left unchecked, threaten the future existence of this resource. Figure 1 depicts the outline of Barren Island in 1848 and 1987.

The erosion of the islands in the Chesapeake Bay adds to the amount of sediment that is constantly deposited in the shipping channels within the Bay. Every year, millions of cubic yards of sediment are dredged from the Chesapeake Bay shipping channels to maintain access to the ports in the Bay. The Maryland Port Administration (MPA) is implementing a program to beneficially reuse dredge materials from the Chesapeake Bay to restore eroding islands, thereby restoring natural habitat. Barren Island is currently being studied by the MPA as a potential site for a large-scale beneficial reuse and habitat restoration project. The proposed project would consist of the construction of an armored sand dike west and south of Barren Island, which would be backfilled with maintenance dredge material from the Chesapeake Bay channels. Two alignments of the sand dike are currently under evaluation, a 1,000-acre environmental restoration area and a 2,000-acre environmental restoration area. At present, neither alignment would connect the restored area to the existing Barren Island shoreline. An approximately 400 foot span would remain between Barren Island and the restored area that would provide a sheltered shallow water habitat area. The proposed beneficial use island will protect the western shore of Barren Island from future erosion by sheltering it from the currents in the Bay.

The Barren Island area currently provides valuable habitat for many species of birds, fish, and shellfish. The proposed large-scale shoreline protection and habitat restoration project would substantially increase the size of habitat. Based on an evaluation of existing literature and databases, the following report details the existing environmental conditions at Barren Island, and the potential impacts associated with this beneficial use habitat restoration project.

Figure 1. Historical Size of Barren Island (1848 and 1987)



Source: Map adapted from a historical map provided by USFWS Refuge Manager John Gill during Site Reconnaissance (Appendix A).

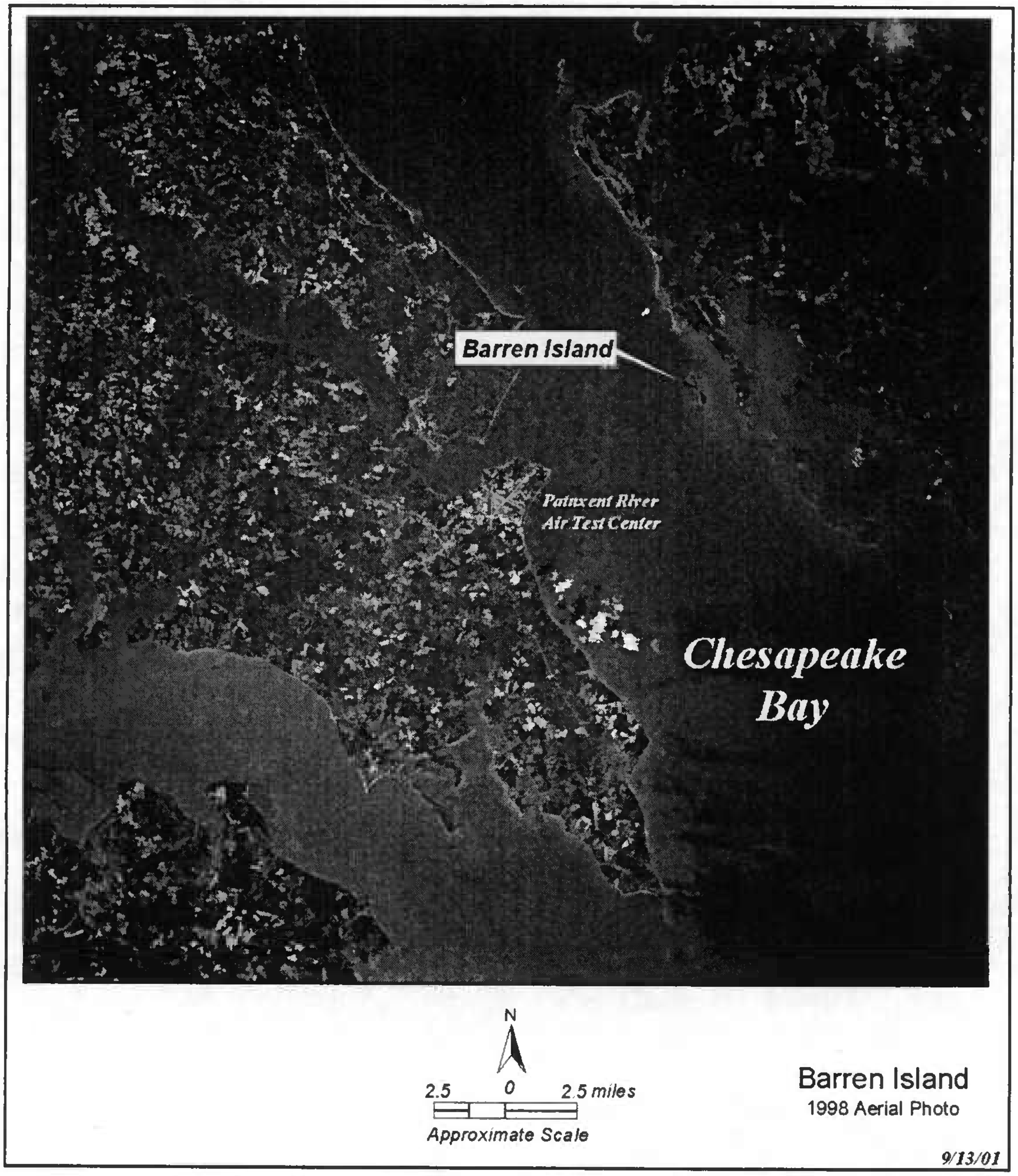
2. SITE LOCATION

Barren Island is an approximately 180-acre island located in the Chesapeake Bay in the southwestern side of Dorchester County in Maryland. As shown in Figure 2, Barren Island is located northeast of the Patuxent River Air Test Center. Tar Bay Island lies to the east side of Barren Island, and the Chesapeake Bay lies to the west of Barren Island. The closest land mass to Barren Island is Upper Hooper Island, which is the northern-most island in the Hooper Island chain. The Honga River lies to the east of Upper Hooper Island. The location of Barren Island on a USGS quadrangle map is available in the Site Reconnaissance Report (Appendix A).

Barren Island is currently owned by the United States Fish and Wildlife Service (USFWS), and was purchased from a private landowner in 1991. The island currently provides habitat for a wide variety of wildlife, and also protects nearby Hoopers Island from shoreline erosion. Barren Island is a satellite refuge for the nearby Blackwater National Wildlife Refuge (BNWR), and serves as a key habitat for many species of birds.

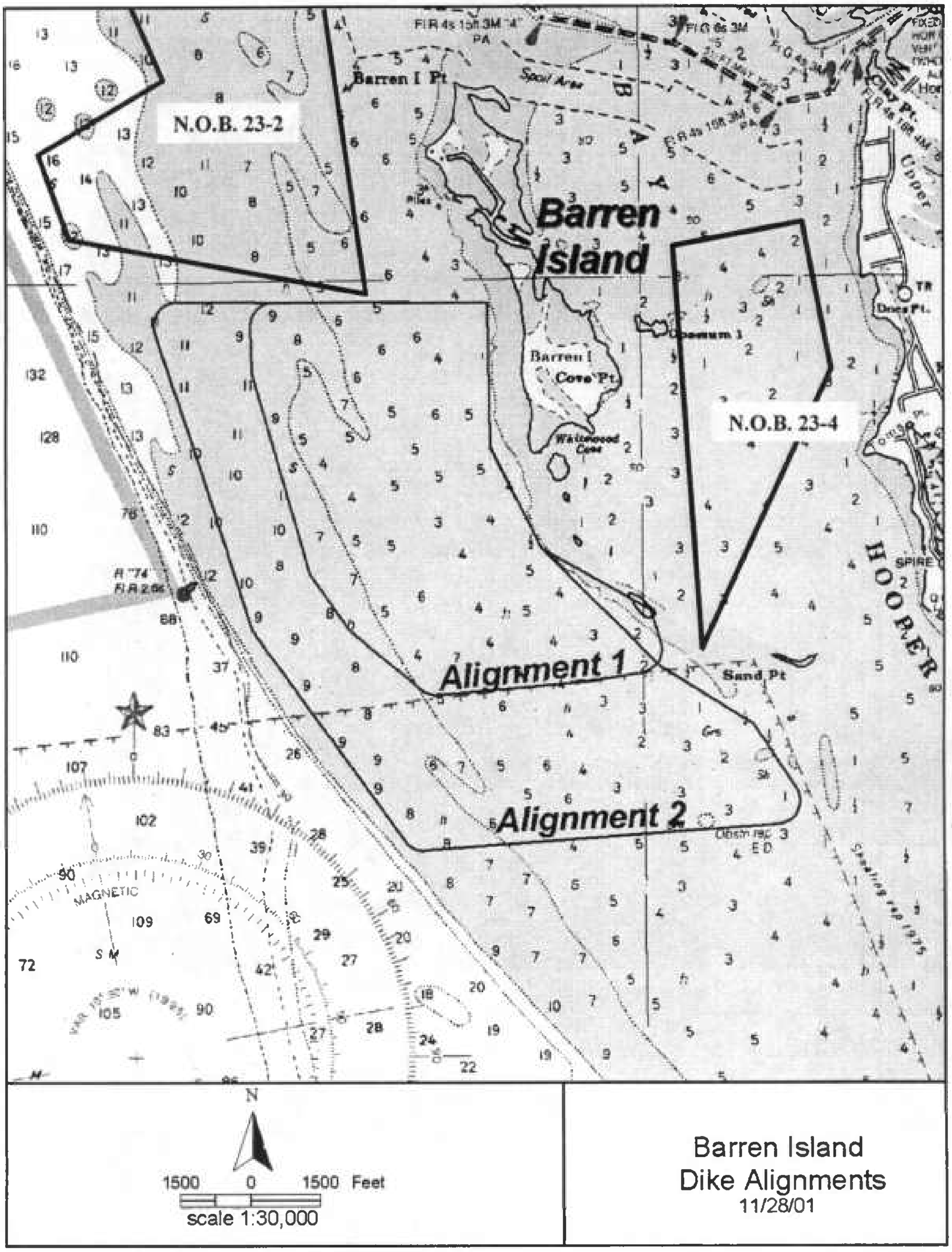
The proposed project would occur along the west and south side of Barren Island, extending west and south into the Chesapeake Bay towards the navigation channel. Two possible dike alignments for the project are proposed. The 1,000-acre alignment (Alignment #1) would extend approximately 4,000 feet to the west from Barren Island at its widest point; the 2,000-acre alignment (Alignment #2) would extend approximately 6,000 feet to the west at its widest point. Figure 3 shows the footprints of the two alternate dike alignments for the proposed beneficial reuse and habitat restoration project at Barren Island.

Figure 2. Aerial Photograph of Barren Island, Dorchester County, Maryland



Source: Photograph reprinted with permission of Applied Coastal Research and Engineering (ACRE, 2001).

Figure 3. Proposed 1,000 and 2,000 acre expansions of Barren Island



Source: Photograph reprinted with permission of Applied Coastal Research and Engineering (ACRE, 2001).

3. HABITAT DESCRIPTION

Barren Island is currently uninhabited, and has been for almost 100 years. The last inhabitant is believed to have left in the early 1900s (Roe, 2001). Although remnants of a hunting lodge and a few other man-made structures are present on the island, the island has returned to a natural state, and the entire island is under the protection of the USFWS as ecological habitat.

Topography of the island is very flat, as is typical on Bay islands. The elevation ranges from 0 feet to an estimated 6 feet above mean high tide (MHT). This low topography, in conjunction with rising sea levels, has resulted in rapid erosion of the island.

The island has approximately four miles of shoreline, consisting of low salt marsh, high salt marsh, sandy beaches, vegetated and unvegetated mud flats, and eroding woodlands. A deteriorated wooden bulkhead and geotextile tubes are present on the northern shoreline and part of the western shoreline. An 11-acre salt marsh was created along then western shoreline in 2001 using sand dredged from local channels. Other than areas altered by bulkheads or dredged material placement, the shoreline is in a natural state. Upland areas on the island consist of approximately 65-70% woodland. Lowland areas on the island consist of salt marshes and small ponds. Small pockets of salt pans and low salinity wetland areas are also present. Salt pans occur where trapped pockets of mesohaline bay water have evaporated, leaving higher salt concentrations. Freshwater marsh areas occur in lowland areas with an impervious clay or silt substrate that traps rainwater.

A site reconnaissance was conducted on 10 October 2001 (Appendix A) to assess and map habitat types throughout the entire island. North Barren Island consists of low salt marsh, high salt marsh, and upland shrub and forested areas. Central Barren Island is comprised entirely of salt marsh habitat. South Barren Island is comprised of low salt marsh, high salt marsh, and forest. Small areas of vegetated and unvegetated mud flats, low salinity wetlands, and salt pans were observed on the north and south ends. Forests in the southern end of the island appeared to contain a higher percentage of mature trees, and great blue heron and bald eagle nests were present in the southern end. Shallow water habitat surrounds Barren Island on all sides. Beds of submerged aquatic vegetation (SAV) occurred on the south and east sides of the island. Refer to the Site Reconnaissance report and Photolog in Appendix A for pictures of Barren Island.

The variety of different habitat types present on the land and in the water surrounding Barren Island is consistent with habitat types typically found on Bay islands. The type of habitat present at a specific location is dependent on water elevation and type of substrate present. Five main habitat types were observed on or near Barren Island: shallow water habitat, salt marshes, mud flats, sandy beaches, and wooded areas. Overall, the quality of the habitats present on Barren Island is classified by the USFWS as high (J. Gill, USFWS, personal communication, 2001). The following sections describe each of the five main habitat types in further detail.

Most of Barren Island and its surrounding habitats (SAVs, shallow water, intertidal wetland) would be considered a Critical Area under the Critical Area Act. Critical Areas are defined as "all land within 1,000 feet of the Mean High Water Line of tidal waters or the landward edge of tidal wetlands and all waters of and lands under the Chesapeake Bay and its tributaries." The keystone of this program is the development of programs that provide protection of land (buffers) adjacent to wetlands and tidal waters, threatened and endangered species protection programs, critical habitat protection (e.g., heron and tern nesting areas), and protecting anadramous fish spawning areas.

3.1 Shallow Water Habitat

Shallow water habitat, defined as areas with water depth less than 10 feet, surrounds Barren Island on all sides. These shoal areas border the shoreline and extend outward into the Bay. Figure 3 provides depth measurements of the waters surrounding the island. Mean water depths adjacent to the shoreline average approximately 3 feet to the east side of the island, 4.8 feet to the south, 9 feet to the west and 7 feet to the north (ACRE, 2001).

Shallow water habitat is comprised of the subtidal zone, which is the zone lying between mean low tide and the bottom of the euphotic zone (the limit of light penetration; approximately 9-10 feet in the Chesapeake). Water depths in all directions of Barren Island for at least one-half mile are shallow enough for light to penetrate the entire water column, permitting photosynthesis to occur in the water and in the benthos. Shallow water habitat around Barren Island contains three important plant communities: phytoplankton, benthic algae, and submerged aquatic vegetation (SAV). Although phytoplankton and benthic algae are not discussed further in this report, SAV beds in the vicinity of Barren Island are discussed in Section 6.6. In addition to plant communities, shallow water habitat contains swimming organisms (nekton) and benthic (bottom-dwelling) organisms. Finfish and benthic organisms in the vicinity of Barren Island are discussed further in Sections 6.1 and 6.2, respectively.

The species composition in shallow water habitats is dependent on salinity of local waters. Salinity distribution in the Mid-Atlantic estuarine waters is classified into 3 salinity categories: salinity less than 5 ppt (oligohaline waters), salinity between 5 and 18 ppt (mesohaline waters), and salinity greater than 18 ppt (polyhaline/euhaline waters). The boundaries of these three salinity zones shift throughout the Bay depending on the volume of freshwater flow and the season. Surface waters surrounding Barren Island usually fall within the mesohaline range with some minor excursions into the polyhaline range throughout the year, generally in the autumn months.

3.2 Shoreline Habitats

Shoreline habitats are located in the intertidal zone, the zone between mean low tide (MLT) and mean high tide (MHT), and the supratidal zone, the zone from MHT to the limit of spring tides. The intertidal zone contains tidal flats which are unvegetated wet areas of mud or sand that do not contain rooted plants, and are subject to tidal inundation. Mud flats occur sporadically along the shoreline of Barren Island, and also typically border marsh areas. Tidal flats on Barren Island include mud flats (mixture of silt, clay, and organic material) and sandy beaches (mixture of sand, pebbles, and shell material). A sandy beach occurs on the northwest side of Barren Island, behind the geotextile tubes. The specific plant and animal communities present depend on the type of substrate and level of tidal inundation, as discussed further in Section 6.

Salt marshes are also present along or near the shoreline of Barren Island. Salt marshes are communities of emergent grasses, low shrubs, or other herbaceous plants rooted in soils that are alternately inundated and drained by tidal action. Salt marshes are typically dominated by a few species of emergent, salt-tolerant grasses (*Spartina sp.*), although other species of herbaceous plants may be present. Low and high salt marshes are present throughout Barren Island, with large tracts in the northern, central, and southern portions of the island. Plant species present in salt marshes are discussed further in Section 6.7.

3.3 Upland Habitat

Uplands on Barren Island are comprised of shrub and forest areas. It is estimated that approximately 65-70% of the upland area on Barren Island is wooded (J. Gill, USFWS, personal communication, 2001). A variety of upland shrubs were observed, and no dominant shrub species was evident. The forest areas consist of mixed coniferous and deciduous trees, and are dominated by loblolly pine (*Pinus taeda*). Mature forests are present on Barren Island, particularly on the southern end. Some of the largest loblolly pine specimens observed during site reconnaissance (see Appendix A) exceeded 2 foot diameter breast height (dbh). The mature loblolly pine forests serve as prime nesting habitat for larger species of waterfowl, such as great blue herons (*Ardea herodias*), and bald eagles (*Haliaeetus leucophalus*).

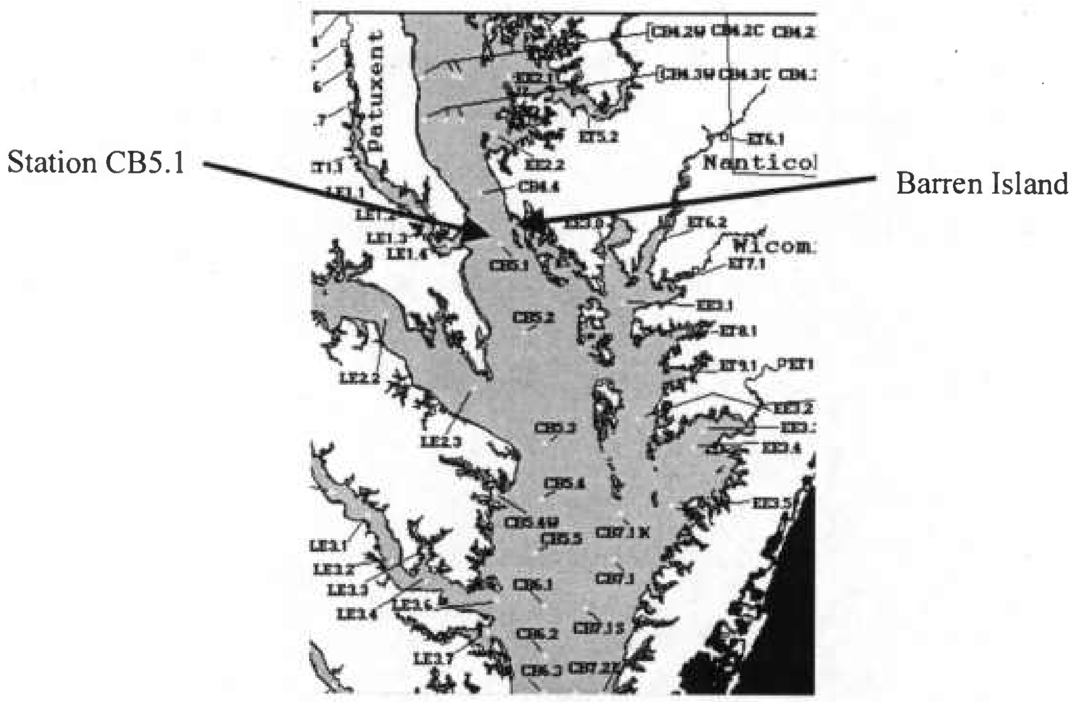
4. WATER QUALITY

Water quality conditions in the Chesapeake Bay, including the region near Barren Island, are dependent on numerous factors, such as land usage in the watershed, tidal effects, and physical and chemical characteristics of freshwater stream flow. The Chesapeake Bay watershed drains an approximately 64,000 square mile area that covers portions of six states (New York, Pennsylvania, West Virginia, Delaware, Maryland and Virginia) and the entire District of Columbia. Approximately 15 million people live in this area, whose actions cumulatively affect soil, air, and water quality conditions.

4.1 Surface Water

Numerous surface water quality parameters are regularly monitored by the Maryland Department of Natural Resources (MD DNR) as part of ongoing Chesapeake Bay Monitoring Programs. Monitored parameters include salinity, dissolved oxygen, total suspended solids, Secchi depth, nutrient levels, chlorophyll-a concentrations, total organic carbon, temperature, and nutrients. One of the monitoring stations in this program, Station CB5.1, is located in close proximity to Barren Island on the west side of the island in the channel (CBP, 2001b), as shown in Figure 4. Data from this station for the last 15 years (1985 to 2001) were downloaded and used to calculate average monthly values for a variety of water quality parameters (see Table 1 through Table 7). Note that this station is located in the channel in the Bay, and bottom depths at this location exceed 20 feet. In order to best evaluate water quality in the vicinity of Barren Island, only data from the top 10 feet were included in this analysis. Water quality data were split into four depth zones for comparison: 0 to 1 feet, 1 to 4 feet, 4 to 7 feet, and 7 to 10 feet.

Figure 4. Location of CBP Water Quality Monitoring Station (CB5.1)



Source: CBP Water Quality Database (CBP, 2001b)

Salinity: As discussed previously, the portion of the Chesapeake Bay in which Barren Island lies is subject to the ebb and flow of ocean tides. As a result, one of the most important water quality characteristics within this tidal area is salinity. Salinity is measured as the number of grams of dissolved salt in 1,000 grams of water, and is expressed in parts-per-thousand (ppt). Salinity gradually increases from the fall line of the Bay (low salinity) to the Bay's mouth (high salinity), and has an impact on the habitats of living resources and physical processes in the Bay. Surface waters surrounding Barren Island are typically mesohaline (5-18 ppt), with occasional excursions into the polyhaline range (18+ ppt) during autumn. Salinity at Barren Island gradually increases with depth. Table 1 lists the average monthly salinity in the Chesapeake Bay near Barren Island over the last 15 years.

In some areas of the Bay, density differences lead to the formation of a pycnocline, a distinct boundary in the water column separating two areas of different density. The pycnocline acts as a physical barrier to exchange between surface and bottom waters and is a contributing factor in the depletion of dissolved oxygen from bottom waters. Refuge Manager John Gill indicated that waters are too shallow in the vicinity of Barren Island to form a pycnocline. This statement is supported by the consistent salinity readings over the various depths throughout the year.

Overall, the consistent salinity present at Barren Island allows for a well-mixed shallow water habitat to occur throughout the year. The lack of a pycnocline ensures that dissolved oxygen levels will not be depleted on the bottom, and nutrient cycling is not impeded. The salinity range present at Barren Island dictates that only salt-tolerant flora and fauna are present in and around the island. The proposed project is not expected to affect salinity levels in the waters around Barren Island.

Table 1. Average Monthly Salinity in the Chesapeake Bay Near Barren Island

Month	Average Salinity (ppt) [a,b]			
	0-1 ft	**1-4 feet**	**4 to7 feet**	**7-10 feet**
January	15.0	15.2	15.7	16.3
February	14.5	14.7	15.0	15.7
March	13.1	13.6	14.1	14.9
April	11.6	12.0	12.6	13.4
May	11.3	11.2	12.1	13.6
June	12.2	11.9	12.6	14.7
July	12.7	12.8	13.1	14.9
August	13.8	13.8	14.2	15.9
September	15.7	15.7	16.1	16.8
October	16.9	17.0	17.2	17.8
November	16.2	16.5	16.5	16.9
December	15.6	15.9	15.6	16.4

ppt = Parts per thousand.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.
[b] Sample size (n) for each value presented in the table ranged from n=22 to n=104.

__Dissolved Oxygen__: Sufficient dissolved oxygen (DO) throughout the water column is essential to the health and survival of aquatic organisms. DO concentrations below 5 mg/L are stressful to the growth, reproduction, and survival of the Bay's fish, shellfish and bottom dwelling organisms. DO concentrations below 2 mg/L are severely stressful and potentially lethal (CBP, 2001e). Table 2 lists the average monthly dissolved oxygen concentration in the Bay near Barren Island.

Table 2. Average Monthly Dissolved Oxygen Concentration near Barren Island

	Average Dissolved Oxygen Concentration (mg/L) [a,b]			
Month	**0-1 ft**	**1-4 feet**	**4 to7 feet**	**7-10 feet**
January	12.0	11.9	11.8	11.3
February	12.4	12.3	12.2	11.9
March	11.9	11.9	11.8	11.4
April	11.2	10.9	10.2	9.4
May	9.8	9.7	8.7	6.7
June	8.9	8.9	6.7	4.3
July	7.9	7.6	5.6	3.1
August	8.0	7.5	5.8	3.4
September	7.6	7.5	6.5	5.1
October	8.4	8.4	7.9	7.1
November	9.6	9.5	9.2	8.7
December	10.5	10.3	10.3	9.9

mg/L = Milligrams per Liter.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.
[b] Sample size (n) ranged for each value in the table ranged from n=22 to n=134.

As shown in the table, DO concentrations are at healthy levels in the top 7 feet of the water column throughout the year near Barren Island. DO concentrations dip below 5 mg/L on average during the summer months (June through August) in the 7-10 ft range of the water column. As shown on Figure 3, water depths greater than 7 feet are present at the western edge of both alignment footprints. Areas to the east, south and west of Barren Island are shallow, so benthic biota that inhabit this area are not oxygen-stressed during summer months. Benthic organisms that occur in depths greater than 7 feet in the alignment footprints are likely oxygen-stressed during summer months. These stressed areas include a portion of a natural oyster bar (N.O.B. 23-2). The effect of the proposed project on DO levels in unknown; therefore, DO monitoring is recommended during the construction phase of the proposed project.

Total Suspended Solids/Turbidity: The clarity of the water column affects the survival of SAV and other photosynthetic organisms in the Bay. Clear water allows more light energy to reach primary producers like SAV and phytoplankton. The health of SAV is important because it provides habitat for numerous organisms and oxygenates the water. The health of phytoplankton is essential since phytoplankton comprise the base of the food chain for the entire ecosystem. Elevated levels of total suspended solids (TSS) result in high turbidity levels, reducing the depth of light penetration in the water. Elevated TSS levels also negatively affect the feeding ability of filtering organisms, such as oysters.

Table 3 lists the average monthly TSS concentrations at various locations in the water column. On average, TSS concentrations are highest in spring months (March through May), which is likely due to higher levels of rain and corresponding runoff. A second, more qualitative measure of water clarity is Secchi depth. The Secchi depth is the depth at which a white and black disk, when lowered into the water, is no longer visible. Clear water adsorbs less light than turbid water; thus the less turbid the water, the greater the Secchi depth. Table 3 also lists the average Secchi depth by month in the Bay measured from the Chesapeake Bay Monitoring Program Station CB5.1 (see Figure 4 for location). Secchi depths are lowest in the summer months.

Typical turbidity levels in the water surrounding Barren Island currently permit light to reach to approximately 5 to 8 feet deep. Therefore, light penetrates the entire water column for the majority of surface waters surrounding Barren Island, with the exception of some of the deeper waters at the western edge of the alignment footprints. The current turbidity levels permit SAV to thrive on the south and east sides of the island. The proposed project will undoubtedly increase TSS levels in the vicinity of the project, although these effects will likely be greatest on the west side of the island where SAV does not occur. However, elevated TSS levels on the west side may negatively affect the natural oyster bar in the area (N.O.B. 23-2). Since TSS levels correlate to different levels of turbidity, depending on the type of material suspended in the water column (sand vs. silt) (DOER, 2000), it is not possible to estimate impact on water clarity that will result from the proposed project until the properties of the material to be placed are determined. TSS and turbidity levels should be monitored during the dike construction and dredged materials placement phases of the proposed environmental restoration project.

Table 3. Average TSS Concentrations in the Bay near Barren Island

	Average TSS Concentrations (mg/L)[a,b]				Secchi Depth[a]
Month	**0-1 ft**	**1-4 feet**	**4 to7 feet**	**7-10 feet**	**(feet)**
January	5.5	5.3	6.1	6.5	7.0
February	7.0	8.5	7.6	9.5	6.8
March	5.5	8.4	10.2	9.3	6.8
April	6.3	7.8	6.9	8.7	5.6
May	6.7	7.8	7.9	8.5	6.7
June	6.2	6.9	6.7	5.2	5.0
July	6.9	7.5	6.0	6.3	4.8
August	5.5	6.8	6.7	5.6	5.5
September	7.6	5.7	6.2	5.1	5.6
October	5.8	7.7	6.4	6.7	6.7
November	5.2	6.2	6.0	6.1	7.1
December	4.8	5.3	6.1	5.5	7.6

mg/L = Milligrams per liter.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.
[b] Sample size (n) for each value in the table ranged from n=7 to n=55.

Temperature: Temperature affects the rates of chemical and biochemical reactions in the water. Many biological, physical, and chemical processes are temperature dependent including the distribution, abundance and growth of living resources, the solubility of compounds in seawater, rates of chemical reactions, density, mixing, and current movements. The Bay is shallow, and as a result, water temperature fluctuates considerably on an annual basis, ranging from 3 °C in the winter to 27 °C in the late summer. Table 4 lists the average monthly water temperatures for four depth zones in the Bay near Barren Island.

Temperatures in the vicinity of Barren Island exhibit typical seasonal fluctuations. The consistency of temperature among the four depth zones supports the absence of a pycnocline during summer months in the shallow waters around Barren Island. Temperature is not expected to be affected by the proposed project. Note that the temperature in the shallow tidal flat areas on the shoreline of Barren Island are expected to be higher than temperatures measured in the channel at Monitoring Station CB5.1.

pH: The pH of waters in the Bay is relatively constant throughout the course of the year and over the water column. Over the 15 years of data in the CBP Water Quality Database, pH ranged from 7.6 to 8.4, with no seasonal or depth trends evident. On average, pH is typically 8.0 units, which is within normal ranges of Chesapeake Bay waters. If pH were to drastically change, the dissolved concentrations of metals, nutrients, and other substance would be affected. However, the proposed project is not expected to affect pH levels.

Table 4. Average Monthly Water Temperatures in the Bay near Barren Island

Month	Average Temperature (°C)[a,b]			
	0-1 ft	1-4 feet	4 to7 feet	7-10 feet
January	3.7	3.8	3.7	4.0
February	3.1	3.0	3.0	3.1
March	6.3	6.1	5.7	5.5
April	11.5	11.1	10.6	10.1
May	17.7	17.4	16.6	15.7
June	23.1	22.7	21.5	20.4
July	26.8	26.5	25.9	25.0
August	26.8	26.4	26.3	26.0
September	24.1	24.2	24.0	24.2
October	19.0	19.1	19.1	19.3
November	12.7	12.8	12.6	12.9
December	8.1	8.2	7.9	8.3

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.
[b] Sample size (n) for each value in the table ranged from n=22 to n=134.

Nutrients: Nutrients (nitrogen and phosphorus) are a necessary component of the Bay's food web, but excess nutrients cause harmful effects such as algal blooms. When algal blooms occur and the excess phytoplankton dies, oxygen is depleted from bottom waters during decomposition. As discussed previously, the low DO levels stress or kill other organisms. Excess nutrients in the Bay are a chronic problem due to many different anthropogenic sources, including sewage treatment plants and excess fertilizers.

The Chesapeake Bay Program closely measures numerous nutrient parameters to evaluate nutrient loadings in the Bay, including total nitrogen (TN), total dissolved nitrogen (TDN), total phosphorus (TP), total dissolved phosphorus (TDP), total organic nitrogen (TON), total organic phosphorus (TOP), particular organic nitrogen (PON), nitrate (NO_3^{2-}) as nitrogen, nitrite (NO_2^{3-}) as nitrogen, $NO_2 + NO_3$ as nitrogen, total kjeldahl nitrogen (TKN), ammonium nitrogen (NH_4^+) as nitrogen, and orthophosphate $(PO_4)^{3-}$ as phosphorous. Data for each of these parameters are available in the Chesapeake Bay Program Water Quality Database (CBP, 2001b). Average monthly values for TN and TP are presented in Table 5 and TDN and TDP are presented in Table 6, respectively. TN and TP concentrations are fairly constant throughout the year, with slight increases in TN during spring months and slight increases in TP during summer and fall months. Similar trends occurred for TDN and TDP concentrations.

Table 5. Average Monthly Concentrations of TN and TP near Barren Island

	Average Monthly Concentrations (mg/L)[a,b]							
	Total Nitrogen				Total Phosphorus			
Month	0-1 ft	1-4 feet	4 to7 feet	7-10 feet	0-1 ft	1-4 feet	4 to7 feet	7-10 feet
January	0.7	0.8	0.8	0.8	0.03	0.03	0.03	0.03
February	0.8	0.9	0.8	0.8	0.03	0.03	0.03	0.03
March	0.9	0.9	0.9	0.9	0.02	0.02	0.03	0.03
April	1.0	1.0	1.0	0.9	0.03	0.02	0.05	0.03
May	0.9	0.8	0.9	0.8	0.02	0.03	0.03	0.03
June	0.7	0.7	0.7	0.7	0.03	0.05	0.03	0.03
July	0.7	0.8	0.6	0.6	0.04	0.05	0.04	0.04
August	0.6	0.6	0.6	0.6	0.05	0.06	0.04	0.06
September	0.6	0.6	0.5	0.5	0.04	0.06	0.06	0.04
October	0.6	0.6	0.5	0.5	0.03	0.03	0.03	0.03
November	0.6	0.7	0.6	0.5	0.03	0.08	0.07	0.06
December	0.6	0.7	0.7	0.7	0.03	0.03	0.04	0.04

mg/L = Milligrams per liter.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.

[b] Sample size (n) for values included in the table ranged from n=8 to n=58.

Table 6. Average Monthly TDN and TDP Concentrations near Barren Island

	Average Monthly Concentrations (mg/L) [a,b]							
	Total Dissolved Nitrogen				Total Dissolved Phosphorus			
Month	**0-1 ft**	**1-4 feet**	**4 to7 feet**	**7-10 feet**	**0-1 ft**	**1-4 feet**	**4 to7 feet**	**7-10 feet**
January	0.6	0.7	0.6	0.6	0.01	0.02	0.02	0.01
February	0.6	0.8	0.7	0.7	0.02	0.02	0.01	0.02
March	0.8	0.8	0.8	0.7	0.01	0.02	0.02	0.02
April	0.8	0.8	0.8	0.7	0.01	0.02	0.01	0.01
May	0.7	0.7	0.7	0.6	0.01	0.02	0.02	0.02
June	0.5	0.5	0.5	0.5	0.02	0.02	0.02	0.02
July	0.5	0.5	0.5	0.5	0.02	0.02	0.02	0.02
August	0.4	0.4	0.4	0.4	0.02	0.04	0.02	0.03
September	0.4	0.4	0.4	0.4	0.02	0.03	0.03	0.03
October	0.4	0.5	0.5	0.5	0.02	0.02	0.02	0.02
November	0.5	0.6	0.6	0.5	0.02	0.03	0.03	0.04
December	0.5	0.6	0.7	0.6	0.02	0.02	0.02	0.02

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.

[b] Sample size (n) for values in the table ranged from n=6 to n=55.

Chlorophyll-a: Concentrations of active Chlorophyll-a, a pigment used by plants in photosynthesis, are a direct measure of the distribution and abundance of phytoplankton (primary producers) in the water column, and a surrogate measure of nutrient levels. The concentration of chlorophyll in the water provides an indication of whether phytoplankton are growing at healthy rates. In the waters near Barren Island, chlorophyll-a concentrations are highest during the spring and early summer from April through June. The depth zone in the water column containing the highest concentration fluctuates throughout the year. In later winter and spring, chlorophyll concentrations are consistently highest in deeper water (7 to 10 feet), while concentrations are highest in shallower waters (0 to 1 feet or 1 to 4 feet) for the remainder of the year. Table 7 lists the average monthly concentration of chlorophyll A in the bay near Barren Island.

The potential impact of nutrient releases from the proposed project on phytoplankton are unknown. However, excessive releases of nutrients should be avoided. As discussed in the previous section the proposed project could impact nutrient levels on the short term. Nutrient levels should be monitored as part of the proposed project.

Table 7. Average Monthly Concentrations of Chlorophyll-A in the Bay near Barren Island

Month	Average Chlorophyll-A Concentration (ug/L)[a,b]			
	0-1 ft	**1-4 feet**	**4 to7 feet**	**7-10 feet**
January	7.3	7.6	8.2	8.9
February	7.0	7.1	7.9	9.1
March	7.9	8.8	9.4	11.3
April	14.7	16.2	18.5	21.2
May	10.3	10.2	14.3	14.7
June	10.1	12.4	8.0	6.4
July	9.9	10.0	7.6	6.6
August	9.9	7.8	7.6	5.2
September	8.5	7.2	7.3	6.2
October	6.8	7.2	6.0	6.0
November	8.1	5.2	4.2	5.2
December	6.6	6.2	5.0	4.3

ug/L = Micrograms per liter.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.

[b] Sample size (n) for values in the table ranged from n=8 to n=50.

Total & Dissolved Organic Carbon: Organic matter plays a major role in aquatic systems. Total organic carbon (TOC) and dissolved organic carbon (DOC) concentrations affect biogeochemical processes, nutrient cycling, biological availability, chemical transport and interactions. Changes in the concentrations of TOC and DOC can cause reductions in primary productivity, system metabolism. High levels of organic carbon coincide with decreased dissolved oxygen concentrations. Table 8 lists the average monthly TOC and DOC concentrations in waters near Barren Island. TOC and DOC concentrations were fairly consistent throughout the year, with values slightly higher during spring months.

Table 8. Average Monthly TOC and DOC Concentrations near Barren Island

Month	Total Organic Carbon (mg/L)[a,b]				Dissolved Organic Carbon (mg/L)[a,b]			
	0-1 ft	1-4 feet	4 to7 feet	7-10 feet	0-1 ft	1-4 feet	4 to7 feet	7-10 feet
January	3.0	2.9	2.7	2.8	3.0	2.9	2.7	2.8
February	2.9	3.0	3.0	3.3	2.9	3.0	3.0	3.3
March	2.6	2.8	2.7	2.9	2.6	2.8	2.7	2.9
April	3.8	3.6	3.5	3.9	3.8	3.6	3.5	3.9
May	4.5	4.3	4.5	4.4	4.5	4.3	4.5	4.4
June	4.3	3.7	3.3	3.1	4.3	3.7	3.3	3.1
July	3.0	3.1	2.8	2.9	3.0	3.1	2.8	2.9
August	3.1	3.1	3.1	3.0	3.1	3.1	3.1	3.0
September	3.4	3.0	3.2	3.0	3.4	3.0	3.2	3.0
October	3.4	3.2	3.2	2.9	3.4	3.2	3.2	2.9
November	2.9	2.6	2.6	2.6	2.9	2.6	2.6	2.6
December	3.4	3.1	3.0	3.1	3.4	3.1	3.0	3.1

mg/L = Milligrams per liter.

[a] Data Collected from Chesapeake Bay Program Database, Station CB5.1, 1985 - 2001.

[b] Sample size (n) for values in the table ranged from n=4 to n=16.

Real-Time Data: In addition to the monitoring conducted as part of the CBP Water Quality Database, real-time data are available for several of the water quality parameters previously discussed as well as some for two the physical parameters evaluated in the Coastal Engineering Feasibility Study for the project (ACRE, 2001). A permanent Chesapeake Bay Observing System (CBOS) station, "Mid Bay Station," is located a few miles north of Barren Island (Latitude: 38.28.4, Longitude: 76.22.8) that continuously measures temperature, salinity, water velocity, and wind speed. The Mid Bay Station has probes on the buoy itself, as well as on 8- and 62-foot moorings. The purpose of the CBOS station is to provide long-term monitoring information on the physical properties of water in the Bay. (Although not available at this time, the CBOS program hopes to add additional ecosystem indicator parameters to its suite of measurements, including dissolved oxygen, chlorophyll, and zooplankton.) Real-time data are available for the Mid Bay Station online at the following website:
http://www.cbos.org/client.cgi?station=MB&sensor=TEMP.

4.2 Groundwater

Barren Island is located in the Coastal Plain Physiographic Province (see Figure 5). As stated in the USGS Groundwater Atlas of the United States (USGS, 1997), Segment 11, the Coastal Plain Physiographic Province is a lowland that extends from the Atlantic Ocean in the east to Chesapeake Bay in the west, and from North Carolina in the south to Raritan Bay in the north. The province is as much as 140 miles wide in North Carolina, narrowing northeastward to New Jersey. In the Barren Island area, the Coastal Plain Physiographic Province is underlain by semi-consolidated sediments that consist of silt, clay, and sand, with some gravel. This province is divided into numerous aquifer systems, aquifers, and confining units. Barren Island is underlain by the Northern Atlantic Coastal Plain aquifer system (see Figure 6), which is an aquifer system that consists of aquifers vertically stacked and hydraulically connected (i.e., the groundwater flow systems in the aquifer function similarly, and a change in conditions in one of the aquifers affects the others).

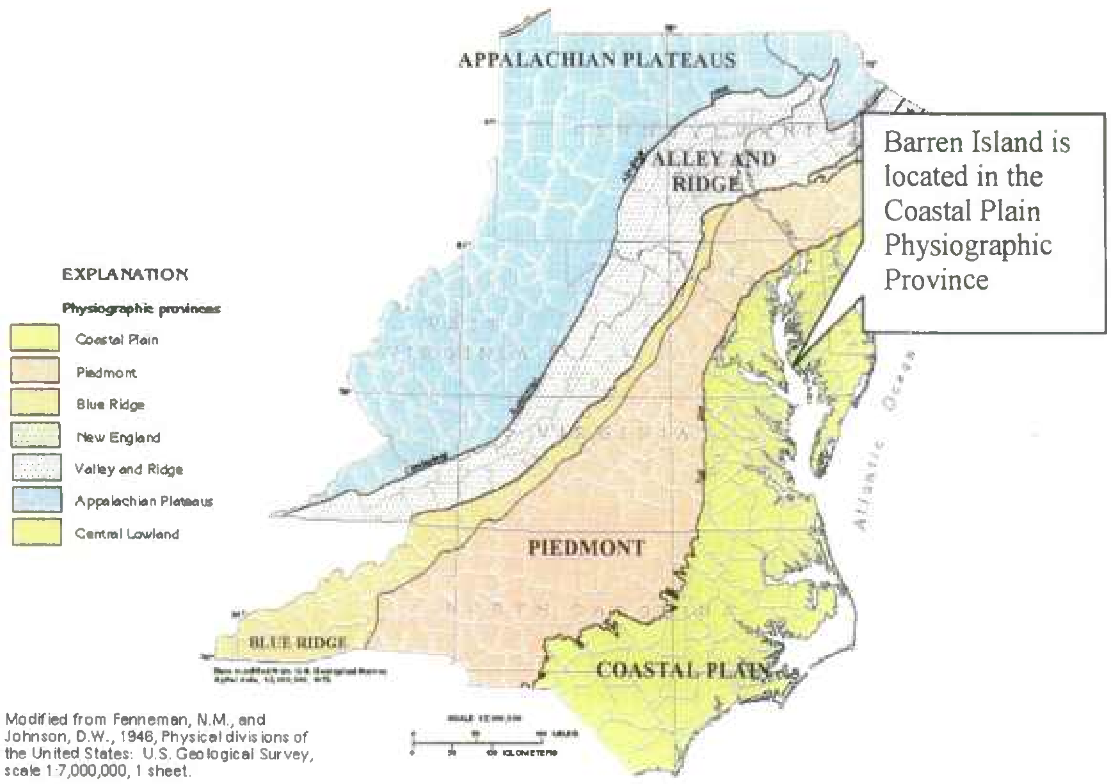


Figure 5. Map of Physiographic Provinces.

Source: USGS Segment 11 (USGS, 1997)

The sediments that compose the Northern Atlantic Coastal Plain aquifer system were deposited in nonmarine, marginal marine, and marine environments. Interbedding of fine- and coarse-grained Coastal Plain sediments is complex because of shifting deltaic and alluvial deposition sites and because of repeated transgressions and regressions of the sea. Sediment types and textures can vary greatly within short horizontal or vertical distances. Bodies of sand, gravel, or limestone can change facies laterally and become clayey or silty and, thus, less permeable. The sediment borings collected near Barren Island confirmed the variability in sediments in this region.

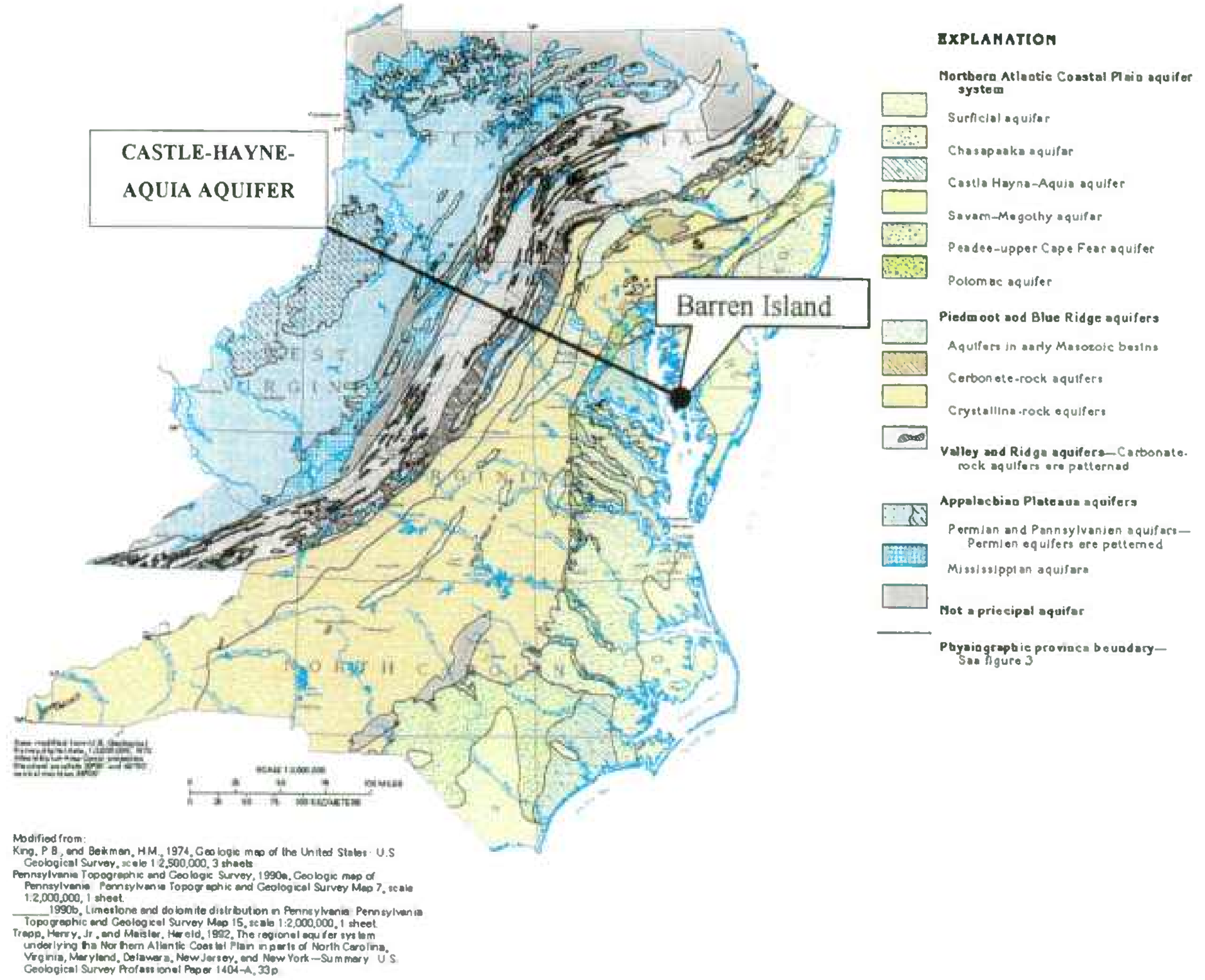


Figure 6. Aquifer Systems in Region near Barren Island

Source: Excerpted from USGS, 1997.

Many local aquifers in the area can be identified, but these local aquifers can be grouped on the basis of similar hydrologic characteristics and treated as regional aquifers. Six regional aquifers separated by four regional confining units make up the Northern Atlantic Coastal Plain Aquifer system. The sequence of aquifers is listed in Table 9. The Coastal Plain aquifers are, in descending order, the Surficial Aquifer, the Chesapeake Aquifer, the Castle Hayne-Aquia Aquifer, the Severn-Magothy Aquifer in the northern part of the segment, the Peedee-upper Cape Fear Aquifer in the southern part, and the Potomac Aquifer.

The primary aquifers in the Barren Island area are the Surficial Aquifer and the Chesapeake Aquifer. The Chesapeake Aquifer underlies the Surficial Aquifer in most places, but the two aquifers are separated by a clayey confining unit. Much of the water in the upper part of the Chesapeake Aquifer is under unconfined conditions, and the aquifer is closely connected to streams. The Chesapeake Aquifer is considered to be a principal aquifer only where the transmissivity of the aquifer is greater than 500 feet squared per day. In these areas, wells drilled in the aquifer yielded 50 gallons per minute or more. Elsewhere, the aquifer may yield water, but not in quantities sufficient for most uses; overall, it is considered to be a minor aquifer.

Groundwater is an important source of water for the public water supply in Maryland, constituting 19% of the total State supply. In the 12 Maryland counties located entirely within the Coastal Plain, ground water comprises 86% of the total water use. In six of these counties, over 90% of the water used is groundwater (MDE, 2001). The major water supply aquifers in the Coastal Plain are contained in the Patuxent, Patapsco Group, and the Magothy, Aquia and Piney Point Formations, the Chesapeake Group and the Quaternary deposits. The Aquia Formation is an important aquifer in southern Maryland and in some areas of the Eastern Shore. The Piney Point Formation is an important aquifer also in portions of southern Maryland and the central Eastern Shore. Aquifers of the Chesapeake Group and the Quaternary deposits are most important on the lower Eastern Shore (Somerset, Wicomico and Worcester Counties). Of the many aquifers in the Coastal Plain system, the Aquia aquifer is most widely used because of its wide extent, good water-bearing properties, and generally excellent water quality (Drummond, 2001). Water levels in the Aquia aquifer have steadily declined over the last several decades, and now brackish-water intrusion poses a threat to water quality in the Aquia aquifer.

The proposed project is not expected to impact groundwater resources in the region.

Table 9. Vertical Sequence of Aquifers

System	Series	Specific Unit Name	Principal Lithology	Hydrologic Unit Name	
Quaternary	Holocene	Surficial Aquifer	Sand and Gravel	Surficial Aquifer	Northern Atlantic Coastal Plain Aquifer System
	Pleistocene				
Tertiary	Pliocene	Upper Chesapeake Confining Unit	Clay and Silty Clay	Confining Unit	
	Miocene	Upper Chesapeake Aquifer	Sand	Chesapeake Aquifer	
		St. Mary's Confining Unit	Silt and Clay		
		Lower Chesapeake Aquifer	Sand		
		Lower Chesapeake Confining Unit	Clay and Sandy Clay	Confining Unit	
	Oligocene	Piney Point-Nanjemoy Aquifer	Limestone and Fine to Coarse, Glauconitic Sand	Castle Hayne-Aquia Aquifer	
	Eocene	Nanjemoy-Marlboro Confining Unit	Silt and Clay		
	Paleocene	Aquia-Rancocas Aquifer	Fine to Coarse, Glauconitic or Shelly Sand		
		Brightseat Confining Unit	Silt and Clay	Confining Unit	
Cretaceous		Severn Aquifer	Fine to medium, glauconitic sand	Severn-Magothy Aquifer	
		Severn Confining Unit	Clay and Silt		
		Matawan Aquifer	Fine to medium, Clayey sand		
		Matawan Confining Unit	Clay and Silty Clay		
		Magothy Aquifer	Fine to medium sand		
		Patapsco Confining Unit	Clay and Sandy Clay	Confining Unit	
		Patapsco Aquifer	Fine to Medium Sand	Potomac Aquifer	
		Potomac Confining Unit	Clay and Sandy Clay		
		Patuxent Aquifer	Fine to Coarse Sand		
		Confining Unit	Clay and Silt	Confining Unit	

Source: Excerpt from USGS Groundwater Atlas of the United States, Segment 11 (USGS, 1997).

Total freshwater withdrawals from the Chesapeake Aquifer during 1985 were estimated to be 195 million gallons per day (MGD) with about one-half used for public supply (45 MGD for domestic and commercial use; 39 MGD for agriculture; and 16 MGD for industrial, mining, and thermoelectric power uses). Total fresh ground-water withdrawals from the Castle Hayne-Aquia aquifer were estimated to be 164 million gallons per day during 1985. About 24 percent of the total withdrawals, or about 39 million gallons per day, were in Virginia, Maryland, Delaware, and New Jersey (18 MGD for domestic and commercial use, ~5 MGD for mining, industrial, and thermoelectric power use, and 2 MGD for agricultural purposes) (USGS, 1997).

5. SEDIMENT QUALITY

Understanding the composition of sediments in the proposed alignments and existing or potential contamination within these sediments is an important consideration. Under subcontract to WESTON, E2CR (Engineering Consultation Construction Remediation, Inc.) conducted a geotechnical investigation in the waters surrounding Barren Island in September and October 2001 in order to evaluate the types of sediments present in and around the footprint of the proposed project. This investigation included the classification of sediment cores from 18 locations to depths of up to 70 feet. A sediment core log summary is presented in Table 10. The 18 sediment core locations are illustrated in Figure 7. A separate report has been prepared by E2CR to document the results of the geotechnical program (E2CR, 2001).

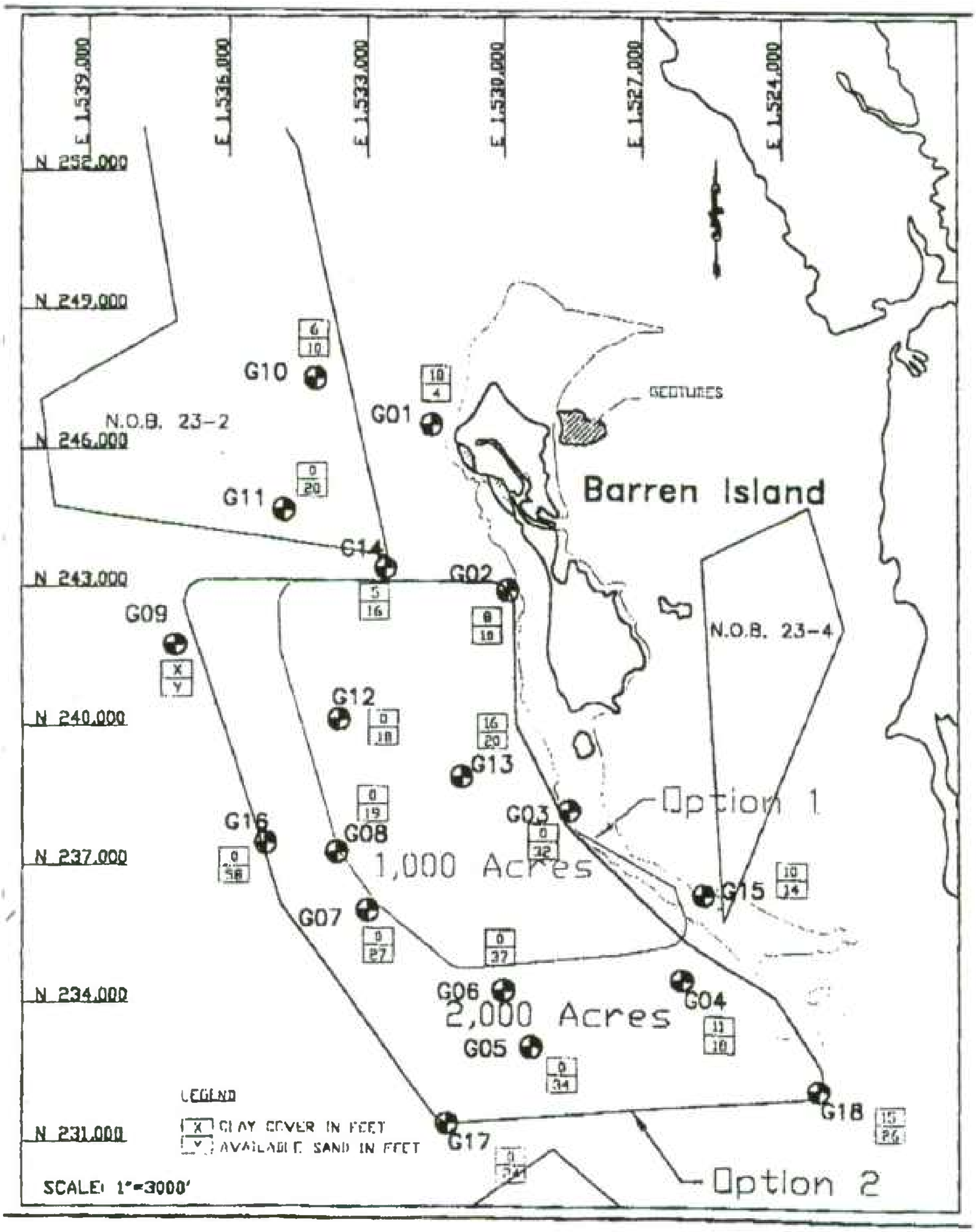
The shallowest sediment samples from all locations were most closely examined in order to determine the predominant sediment type available as habitat in close proximity to Barren Island. The uppermost sediment layers in the vicinity of Barren Island are all at least 3 feet thick, and most are in excess of 5 feet thick. Sediment core location G-03 had the thinnest surface sediment layer, consisting of silty sand, at 3 feet thick. The thickest surface sediment layer is found at sediment core G-09, which consisted of silty sand throughout its entire core depth of 47 feet (18 to 65 feet).

Based upon the sediment core logs, the predominant surface sediment layers immediately adjacent to the west side of Barren Island are interbedded silty sand and silty clay. To the northwest and southeast of the island, surface sediments are predominantly silty clay. Silty clay appears to also be locally isolated in a pocket just southwest of the island. Further into the channel and mainstem of the Bay, silty sand is the predominant surface sediment type, which is expected due to higher water velocities. An isolated pocket of mixed silty sand, clayey silt, and silty clay is located due west of the island, between the interbedded silty sand and silty clay sediments immediately adjacent to the island and the silty sand located further into the Bay mainstem. The specific locations of the various surface sediment types will be documented in the E2CR report.

In general, sediments between 3.5 and 12.0 feet are split between silty sand, silty clay, and interbeds of silty sand and silty clay. Between 12 and 27 feet, the majority of sediments are silty sand with a few cores showing silty clay, clayey sand, and interbeded silty sand, and silty clay at various depths. At 27 to 40 feet, sediments are once again split approximately equally between silty sand and silty clay, although several cores indicate more complex sediments including interbedded silty clay and silty sand, clayey sand and silt, and clayey sand.

Of the 18 cores, 11 cores characterized sediments greater than 40 feet, and of these, 8 cores characterized sediments greater than 45 feet. It appears that the sediments at these depths trend from more complex mixtures and interbeds towards more homogenous sediments of silty clay or silty sand. The three deepest cores (G-06 at 55 feet, G-09 at 65 feet, and G-16 at 70 feet) indicate that sediments at these depths consist primarily of silty clay (G-06), and silty sand (G-09 and G-16). Sediment core G-16 encountered an eight-foot thick layer of peat from 54 to 62 feet, which is embedded between relatively thick layers of silty sand.

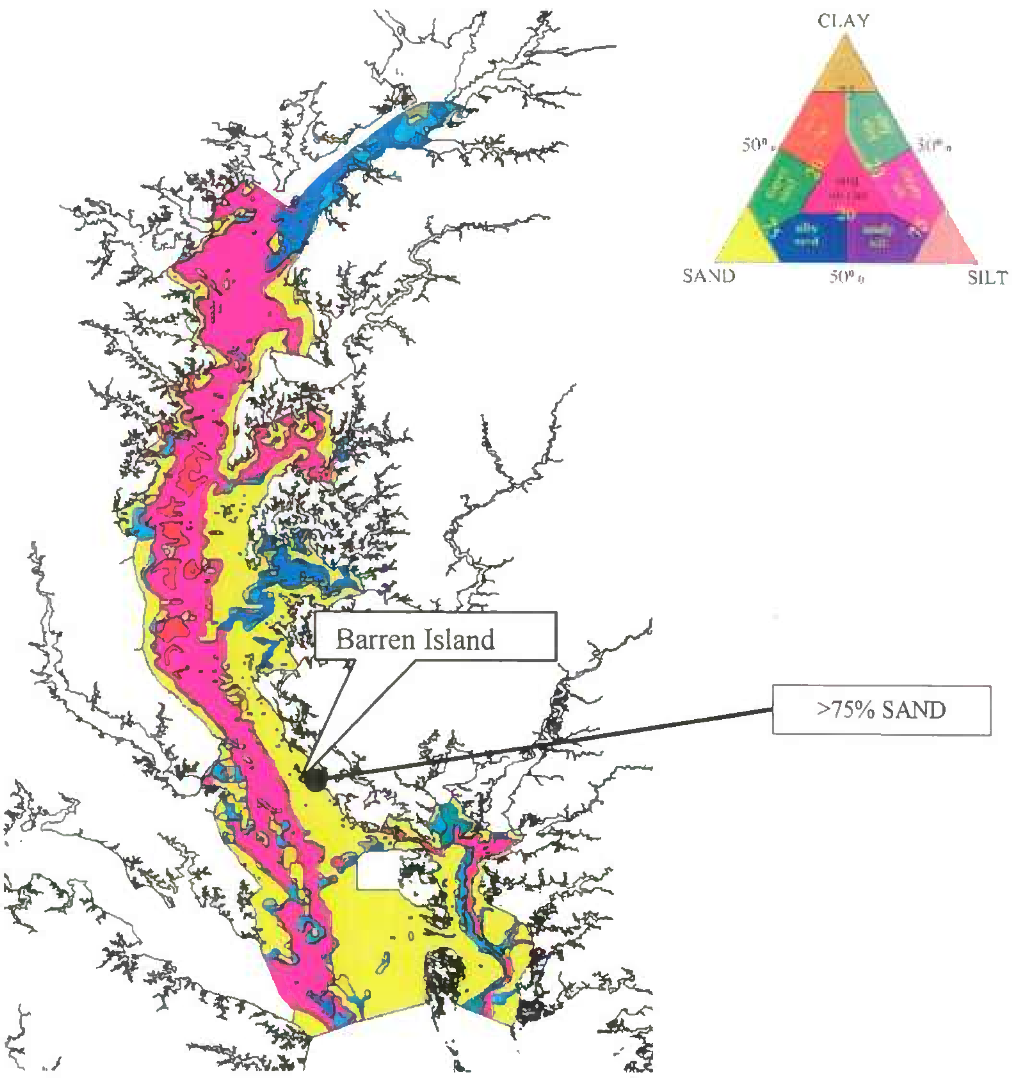
Figure 7. Boring Locations for Sediment Sampling Conducted in Proposed Project Area and Locations of Natural Oyster Bars



Note: 1" = 3000'

The surface sediment boring results are generally consistent with the expected sediment composition based on the Maryland Geological Survey distribution map of Chesapeake Sediments (Figure 8). This map indicated surface sediments in near Barren Island are typically sand, with areas of mixed silt, sand, and clay moving west from the island toward the channel.

Figure 8. Surface Sediments in the Chesapeake Bay



Note: Colors in map correlate to
Shephard's Diagram shown above.
Source: Excerpted from CEGP, 2001.

6. BIOLOGICAL RESOURCES

As discussed in the Habitat Description, Barren Island is exclusively used as ecological habitat, and serves as a satellite refuge for BNWR. Biological resources on the land and in the water surrounding the Island are diverse and abundant, although no baseline ecological survey has been conducted on Barren Island to the knowledge of the USFWS. A site reconnaissance visit to Barren Island was conducted on 10 October 2000 (see Appendix A) during which all observed species were recorded. The following sections detail the finfish, aquatic invertebrates, birds, wildlife, threatened and endangered species, and aquatic and terrestrial plants that are known to occur or could potentially occur on Barren Island.

6.1 Finfish

Numerous finfish species inhabit the mesohaline waters in the vicinity of Barren Island, and several of these species support valuable commercial and recreational fisheries in the Chesapeake Bay. No fish survey has been conducted in the vicinity of Barren Island or in the footprint of the proposed project. Table 11 lists the temporal distribution and relative abundance of 41 species of finfish that occur, or could potentially occur, in the vicinity of Barren Island. The information provided in this table has been adapted from the National Oceanographic Atmospheric Administration (NOAA) publication, *Distribution and Abundance of Fishes and Invertebrates in Mid-Atlantic Estuaries* (NOAA, 1994).

There have been no comprehensive surveys of finfish in the Barren Island area. However, surveys within several miles of Barren Island (see Section 6.2.2) and surveys by the Maryland Natural Resources Police (MNRP) have identified some of the species present in the Barren Island area. These include weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic croaker (*Micropogonias undulates*), summer flounder (*Paralychthys dentatus*), and spot (*Leiostomus xanthurus*). Additional species likely to be present include bluefish (*Pomatomus saltatrix*), hogchoker (*Trinectes maculatus*), sheepshead minnow (*Cyprinodon variegatus*) and fundulus (*Fundulus spp.*).

Under the Chesapeake Bay Program, six species of finfish are used as target species as part of monitoring programs in the Chesapeake Bay. The finfish used as "target" species include spotted seatrout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), Atlantic sturgeon (*Acipenser oxyrhynchus*), flounder (*Paralichthys dentatus*), and channel catfish (*Ictalurus punctatus*). This program is discussed in more detail in Section 6.2.2.

6.1.1 Essential fish habitat

Recognizing the importance of fish habitat to the productivity and sustainability of U.S. marine fisheries, Congress added new habitat conservation provisions to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), the federal law that governs U.S. marine fisheries management, in 1996. The re-named Magnuson-Stevens Act mandated the identification of Essential Fish Habitat (EFH) for managed species as well as measures to conserve and enhance the habitat necessary for all life cycles of fish. The Magnuson-Stevens Act requires cooperation among National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS), the Regional Fisheries Management Councils, fishing participants, Federal and state agencies, and others in achieving EFH protection, conservation, and enhancement.

Section 305(b)(2)-(4) of the Magnuson-Stevens Act outlines a process for NMFS and the Councils to comment on activities proposed by Federal action agencies that may adversely impact areas designated as EFH. Specifically, Federal action agencies are required to consult with NMFS on any action authorized, funded, or undertaken that may adversely impact EFH. NMFS provides recommendations to agencies for actions that would adversely affect EFH. These recommendations are advisory in nature.

Barren Island is located in an area designated as the Chesapeake Bay Mainstem. The section of the Mainstem in which Barren Island is located may provide EFH for nine species of fish, which are listed in Table 12. These nine species of fish include windowpane flounder (*Scopthalmus aquosus*), bluefish (*Pomatomus saltatrix*), Atlantic butterfish (*Peprilus triacanthus*), summer

Table 11. Temporal Distribution and Relative Abundance of Fish in the Chesapeake Bay
(Adapted from NOAA, 1994)

Common Name	Scientific Name	Life Stage	Salinity Zone T	M	S	Month J	F	M	A	M	J	J	A	S	O	N	D
Atlantic stingray	Dasyatis sabina	A		-----	-----						-----	-----	-----	-----	-----	-----	
		S															
		J		-----	-----						-----	-----	-----	-----	-----	-----	
		L															
		E															
Cownose ray	Rhinoptera bonansus	A		A	A					C	A	A	A	A	C		
		S															
		J		A	A					C	A	A	A	A	A	C	
		L															
		E															
Atlantic sturgeon	Acipenser oxyrhynchus	A		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		S															
		J		-----		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
		L															
		E															
American eel	Anguilla rostrata	A			C								C	C	C	C	
		S															
		J	C	A	C	A	A	A	A	A	A	A	A	A	A	A	A
		L			C	-----	-----	C	C	-----							
		E															
Blueback herring	Alosa aestivalis	A	C	A	A			A	A	A	A						
		S	C	-----				-----	C	C							
		J	C	C	C					C	C	C	C	C	C	C	-----
		L	C	-----				-----	C	C	C						
		E	C	-----				C	C	C							
Alewife	Alosa pseudoharengus	A	C	A	A		A	A	A	A							
		S	C	C				C	C	C							
		J	C	C	C		C	C	C	C	C	C	C	C	C	C	-----
		L	C	C				C	C	C							
		E	C	C				C	C	C							
American shad	Alosa sapidissima	A	-----	C	C		-----	C	C	C							
		S	-----	-----				-----	-----	-----							
		J	-----	-----	C					-----	-----	-----	-----	C	C	C	-----
		L	-----	-----				-----	-----	-----							
		E	-----	-----				-----	-----	-----							
Atlantic menhaden	Brevoortia tyrannus	A		HA	HA	C	C	C	C	A	HA	HA	HA	HA	HA	A	C
		S		C	C									C	C	C	
		J	HA	HA	HA	C	C	A	HA	HA	HA	HA	HA	HA	A	C	C
		L		C	HA	-----	C	A	HA	HA				C	C	C	
		E		C	C				-----	-----		-----	-----	C	C	C	
Atlantic herring	Clupea harengus	A		-----	C	C	C	C	C	C							C
		S															
		J			-----			-----	-----	-----							
		L															
		E															

Life Stage

A Adult
S Spawning Adult
J Juveniles
L Larvae
E Eggs

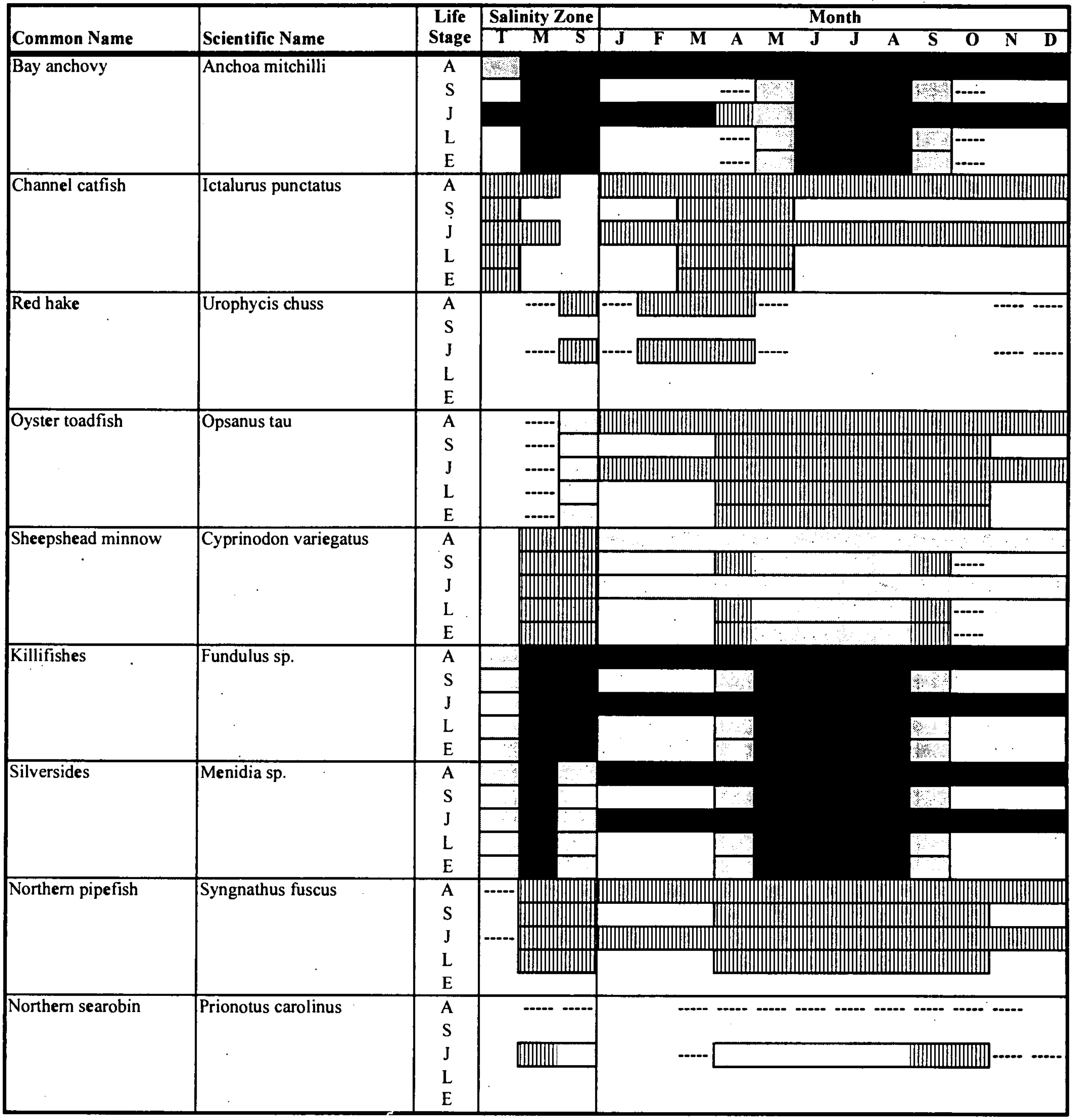
Salinity Zone

T Tidal
M Mixing
S Seawater

Relative Abundance

HA Highly abundant
A Abundant
C Common
----- Rare
Blank Not present

Table 11. Temporal Distribution and Relative Abundance of Fish in the Chesapeake Bay
(Adapted from NOAA, 1994)



Life Stage		Salinity Zone		Relative Abundance	
A	Adult	T	Tidal	(black)	Highly abundant
S	Spawning Adult	M	Mixing	(stippled)	Abundant
J	Juveniles	S	Seawater	|||||||	Common
L	Larvae			-----	Rare
E	Eggs			Blank	Not present

Table 11. Temporal Distribution and Relative Abundance of Fish in the Chesapeake Bay
(Adapted from NOAA, 1994)

Common Name	Scientific Name	Life Stage	Salinity Zone T	M	S	Month J	F	M	A	M	J	J	A	S	O	N	D
White perch	Morone americana	A															
		S															
		J															
		L															
		E															
Striped bass	Morone saxatilis	A															
		S															
		J															
		L															
		E															
Black sea bass	Centropristis striata	A															
		S															
		J															
		L															
		E															
Yellow perch	Perca flavescens	A															
		S															
		J															
		L															
		E															
Bluefish	Pomatomus saltatrix	A															
		S															
		J															
		L															
		E															
Pinfish	Lagodon rhomboides	A															
		S															
		J															
		L															
		E															
Scup	Stenotomus chrysops	A															
		S															
		J															
		L															
		E															
Spotted seatrout	Cynoscion nebulosus	A															
		S															
		J															
		L															
		E															
Weakfish	Cynoscion regalis	A															
		S															
		J															
		L															
		E															

Life Stage

A Adult
S Spawning Adult
J Juveniles
L Larvae
E Eggs

Salinity Zone

T Tidal
M Mixing
S Seawater

Relative Abundance

Highly abundant
Abundant
Common
----- Rare
Blank Not present

Table 11. Temporal Distribution and Relative Abundance of Fish in the Chesapeake Bay

(Adapted from NOAA, 1994)

Common Name	Scientific Name	Life Stage	Salinity Zone T	Salinity Zone M	Salinity Zone S	Month J	F	M	A	M	J	J	A	S	O	N	D
Spot	Leiostomus xanthurus	A		Abundant	Abundant				Common	Abundant	Abundant	Abundant	Abundant	Abundant	Common	Common	
		S															
		J	Common	Abundant	Abundant				Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Common	
		L															
		E															
Northern kingfish	Menticirrhus saxatilis	A		Rare	Rare					Rare	Rare	Rare	Rare	Rare	Rare	Rare	
		S															
		J		Rare	Rare					Rare	Rare	Rare	Rare	Rare	Rare	Rare	
		L		Rare	Rare						Rare	Rare	Rare	Rare			
		E															
Atlantic croaker	Micropogonias undulatus	A		Common	Rare	Rare	Rare	Rare	Rare	Common	Common	Common	Common	Common	Common	Common	Rare
		S															
		J	Rare	Abundant	Abundant	Common	Common	Common	Common	Abundant	Abundant	Abundant	Abundant	Abundant	Common	Rare	Rare
		L															
		E															
Black drum	Pogonias cromis	A		Common	Common				Common	Common	Common	Common	Common	Common	Common	Common	
		S			Common				Common	Common	Common						
		J		Common	Common				Common	Common	Common	Common	Common	Common	Common	Common	
		L			Common				Common	Common	Common						
		E			Common				Common	Common	Common						
Red drum	Sciaenops ocellatus	A		Common	Common					Common	Common	Common	Common	Common	Common		
		S															
		J		Common	Common					Common	Common	Common	Common	Common	Common	Common	
		L			Rare								Rare	Rare			
		E															
Mullets	Mugil sp.	A		Common	Common	Common	Common				Common	Common	Common	Common	Common	Common	Common
		S															
		J		Common	Common	Common	Common				Common	Common	Common	Common	Common	Common	Common
		L															
		E															
Tautog	Tautoga onitis	A		Rare	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common
		S		Rare	Common				Common	Common							
		J		Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common
		L		Rare	Common				Common	Common							
		E		Rare	Common				Common	Common							
Gobies	Gobiosoma sp.	A	Rare	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant
		S		Abundant	Abundant				Common	Abundant	Abundant	Abundant	Abundant	Rare	Rare		
		J	Rare	Abundant	Abundant					Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant	Abundant
		L	Abundant	Abundant	Abundant					Common	Abundant	Abundant	Abundant	Common	Rare		
		E	Abundant	Abundant	Abundant				Common	Abundant	Abundant	Abundant	Abundant	Rare	Rare		
Atlantic mackerel	Scomber scombrus	A		Rare	Rare	Rare	Rare	Rare									
		S															
		J		Rare	Rare	Rare	Rare	Rare	Rare							Rare	Rare
		L			Rare					Rare							
		E															

Life Stage

- A Adult
- S Spawning Adult
- J Juveniles
- L Larvae
- E Eggs

Salinity Zone

- T Tidal
- M Mixing
- S Seawater

Relative Abundance

- (solid black) Highly abundant
- (stippled) Abundant
- (vertical hatching) Common
- ----- Rare
- Blank Not present

Table 11. Temporal Distribution and Relative Abundance of Fish in the Chesapeake Bay

(Adapted from NOAA, 1994)

Common Name	Scientific Name	Life Stage	Salinity Zone T	Salinity Zone M	Salinity Zone S	Month J	F	M	A	M	J	J	A	S	O	N	D
Butterfish	Peprilus triacanthus	A		Common	Common				Rare	Common	Common	Common	Common	Common	Common	Common	
		S		Common	Common					Rare	Common	Common					
		J		Common	Common						Common	Common	Common	Common	Common		
		L		Common	Common						Rare	Common	Common				
		E		Common	Common					Rare	Common	Common					
Summer flounder	Paralichthys dentatus	A		Common	Common				Common	Common	Common	Common	Common	Common	Common	Rare	
		S															
		J		Common	Rare	Rare	Rare	Rare	Rare	Rare	Common	Common	Common	Common	Common	Common	Rare
		L		Common	Common	Common	Common	Common	Common								Rare
		E															
Windowpane flounder	Scophthalamus aquosus	A		Common	Common				Common	Common	Common	Common	Common	Common	Common		
		S															
		J		Common	Common	Rare	Rare	Rare	Common	Common	Common	Common	Common	Common	Common	Rare	Rare
		L			Rare			Rare	Rare	Rare	Rare						
		E															
Winter flounder	Pleuronectes americanus	A		Rare	Rare	Rare	Rare	Rare	Rare	Rare							Rare
		S		Rare		Rare	Rare	Rare	Rare	Rare							Rare
		J		Rare	Rare	Rare	Rare	Rare	Rare	Rare							Rare
		L		Rare		Rare	Rare	Rare	Rare	Rare							Rare
		E															
Hogchoker	Trinectes maculatus	A	Common	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant
		S		Highly abundant	Highly abundant					Abundant	Highly abundant	Highly abundant	Highly abundant	Abundant			
		J	Common	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant	Highly abundant
		L	Rare	Highly abundant	Highly abundant					Abundant	Highly abundant	Highly abundant	Highly abundant				
		E		Highly abundant	Highly abundant						Highly abundant	Highly abundant	Highly abundant				

Life Stage

- A Adult
- S Spawning Adult
- J Juveniles
- L Larvae
- E Eggs

Salinity Zone

- T Tidal
- M Mixing
- S Seawater

Relative Abundance

- (solid black) Highly abundant
- (stippled) Abundant
- (vertical bars) Common
- ----- Rare
- Blank Not present

flounder (*Paralicthys dentatus*), black sea bass (*Centropristus striata*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculates*), cobia (*Rachycentron canadum*), and red drum (*Sciaenops occelatus*). According to the Maryland Natural Resources Police (MNRP), summer flounder is the only one of these nine species of fish that is caught in nets deployed for commercial fishing in the area approximately one-quarter mile west of Barren Island.

Because the proposed environmental restoration areas are located in the Chesapeake Bay Mainstem, NMFS must be consulted for recommendations in order to determine potential impacts on EFH. A general analysis of impacts on EFH for the nine species is included in 13.2.1. Due to lack of specific information on species of finfish in the proposed environmental restoration area, interviews with commercial and recreational fishermen, plus site surveys during periods of peak use by fish, are recommended.

Table 12. Summary of Essential Fish Habitat in the Mainstem Chesapeake Bay

Species	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Windowpane flounder *(Scopthalmus aquosus)*			M,S	M,S	
Bluefish *(Pomatomus saltatrix)*			M,S	M,S	
Atlantic butterfish *(Peprilus triacanthus)*	M,S	M,S	M,S	M,S	
Summer flounder *(Paralicthys dentatus)*		M,S	M,S	M,S	
Black sea bass *(Centropristus striata)*			M,S	M,S	
King mackerel *(Scomberomorus cavalla)*	X	X	X	X	
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X	
Cobia *(Rachycentron canadum)*	X	X	X	X	
Red drum *(Sciaenops occelatus)*	X	X	X	X	

X = EFH has been designated for the given species and life stage.

S = The EFH designation for this species includes the seawater salinity zone of this bay or estuary (salinity > or = 25.0%).

M = The EFH designation for this species includes the mixing water/ brackish salinity zone of this bay or estuary (0.5% < salinity < 25.0%) (5 ppt to 25 ppt).

These EFH designations of estuaries and embayments are based on the NOAA Estuarine Living Marine Resources (ELMR) program.

The Highly Migratory Species' life stages that are summarized within the squares are broken down into neonates, juveniles, and adults. For these species there are no 'egg' designations, and neonates correspond to the heading larvae within each summary table.

6.2 Aquatic Invertebrates

6.2.1 Potential Species

Invertebrate species likely to be present in the shallow water habitats at Barren Island are listed in Table 13. As described in Section 3.1, shallow water habitats are comprised of the subtidal zone, which is the zone lying between mean low tide and the euphotic zone (depth of light penetration; approximately 9-10 feet). Shallow water habitats include regions of submerged aquatic vegetation, which are present along the eastern shoreline of Barren Island (see Section 6.6). These aquatic plant beds provide shelter and food for many species of crustaceans, mollusks, worms, and other invertebrates.

Invertebrate species likely to be present in the tidal flat habitats (i.e., the intertidal zone) are listed in Table 14. The intertidal zone is the region between mean low tide (MLT) and mean high tide (MHT). This area may be muddy (silt, clay, organic matter), sandy, or a mixture of these substrates.

Three key aquatic invertebrates present near Barren Island are blue crabs (*Callinectes sapidus*), American oysters (*Crassostrea virginica*) and soft shell clams (*Mya arenaria).* Each of these species is critical to local commercial fisheries, and are discussed in more detail in Section 7.1, Section 7.2, and Section 7.3, respectively.

Site specific surveys of benthic invertebrates in the vicinity of Barren Island were not found. The Maryland Chesapeake Bay Long-Term Benthic Monitoring and Assessment Program does not have a fixed sampling station near Barren Island. A benthic survey in the footprint of the proposed alignments is recommended to determine the species distribution and abundance for this region.

Table 13. Invertebrates Expected to Occur in Shallow Water Habitats at Barren Island

Common Name	Scientific Name
GASTROPODS	
Variable bittium	*Diastoma varium*
Convex slipper shell	*Crepidula convexa*
CRUSTACEANS	
Blue crabs	*Callinectes sapidus*
Eelgrass isopod	*Paracerceis caudata*
Tube-building amphipod	*Ampithoe longimana*
Common grass shrimp	*Palaemonetes pugio*
BIVALVES	
Brackish-water clam	*Rangia cuneata*
Soft-shelled clam	*Mya arenaria*
Hard clam	*Mercenaria mercenaria*
American oyster	*Crassostrea virginica*
EPIFAUNA	
Little gray barnacle	*Chthamalus fragilis*
Ivory barnacle	*Balanus eburneus*
Bay barnacle	*Balanus improvisus*
Ghost anemone	*Diadumene leucolena*
Feather hydroid	*Halocordyle disticha*
Whip mud worm	*Polydora ligni*
Sea nettle	*Chrysaora quinquecirrha*
Bent mussel	*Ischadium recurvum*
Sea squirt	*Molgula manhattensis*

Source: White, 1989.

Table 14. Invertebrates Expected to Occur in Tidal Flat Habitats on Barren Island

Common Name	Scientific Name
GASTROPODS	
Marsh periwinkle	*Littorina irrorata*
Common mud nassa	*Ilynassa obsoleta*
ARTHROPODS	
Saltmarsh amphipod	*Orchestia grillus*
Horseshoe crab	*Limulus polyphemus*
BIVALVES	
Baltic macoma clam	*Macoma balthica*
Soft-shelled clam	*Mya arenaria*
Hard clam	*Mercenaria mercenaria*
Stout razor clam	*Tagelus plebeius*
Common jackknife clam	*Ensis directus*
CRUSTACEANS	
Fiddler crabs	*Uca sp.*
Hermit crabs	*Pagurus sp.*
CNIDARIANS	
Burrowing anemone	*Edwardsia elegans*
POLYCHEATES	
Red ribbon worm	*Micrura leidyi*
Common clam worm	*Nereis succinea*
Red-gilled mud worm	*Scolecolepides viridis*
Glassy tube worm	*Spiochaetopterus oculatus*

Source: White, 1989.

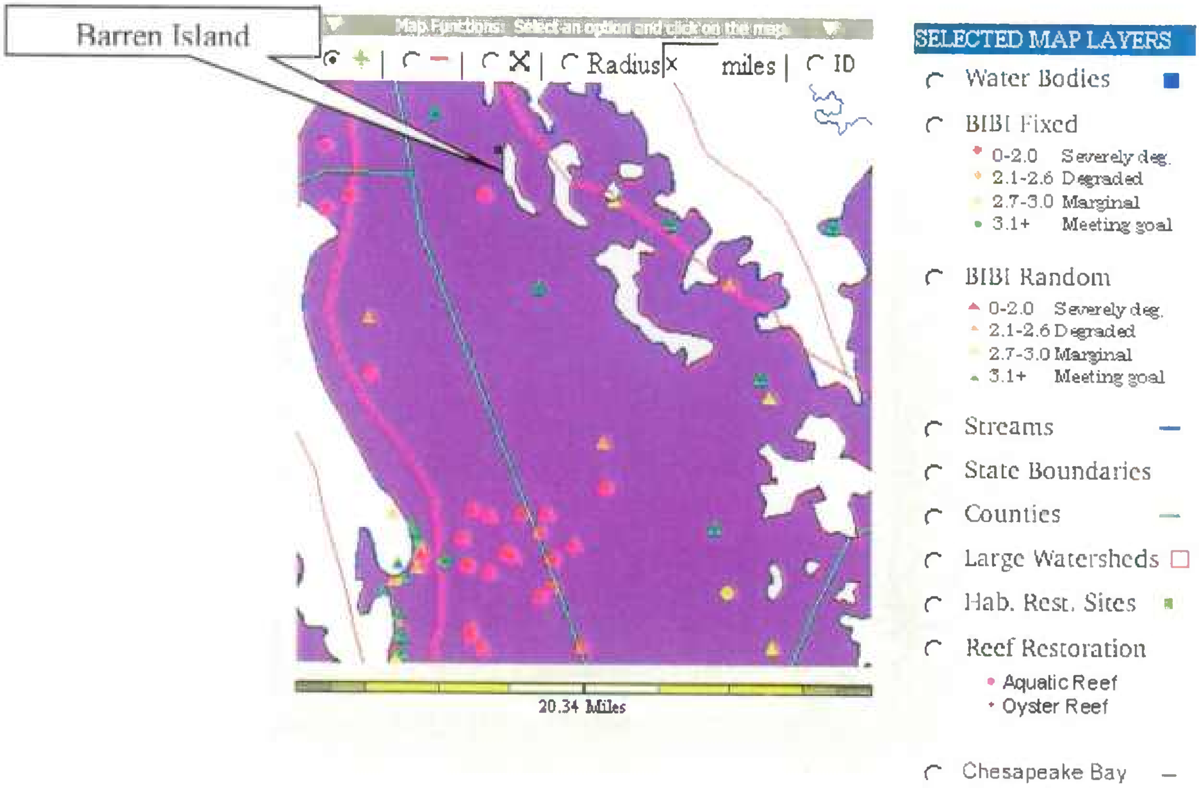
6.2.2 Indicator Species

Benthic organisms in the Chesapeake Bay are commonly used to evaluate the health of the Chesapeake Bay. Benthic samples in the vicinity of Barren Island have been collected in order to evaluate the health of the region. Data were evaluated using two different analysis approaches.

BIBI METHOD: The Benthic Index of Biotic Integrity (BIBI) is a commonly used measure of the biological integrity, general health, and quality of the benthic community in the Chesapeake Bay. The Chesapeake Bay Program's Bay Atlas indicated that several random BIBI sampling points were located around Barren Island, as shown in Figure 9 (CBP, 2001c). One random BIBI sampling point is located within, or very close to, the proposed 2,000 acre restoration boundary.

The average BIBI is determined by calculating the following: Shannon-Weiner Species Diversity Index, Total Species Abundance, Total Species Biomass, Percent Abundance of Pollution-Indicative Species, Percent Biomass of Pollution-Sensitive Species, Percent Abundance of Carnivore and Omnivores, and Percent Abundance of Deep Deposit Feeders. Each of these factors are assigned a value of 1, 3, or 5, with 5 being the most pristine sites, and 1 being the most degraded sites. These values are then averaged to compute the BIBI score. The sampling point in the proposed project footprint at Barren Island had a BIBI score between 0 and 2.0, indicating that the benthic community in this area is highly degraded. Further benthic sampling would be necessary to determine the quality of benthic habitat closer to Barren Island; and to confirm results of this initial analysis.

Figure 9. BIBI Sampling Locations and Results Map for the Barren Island Area



TARGET SPECIES METHOD: A second method of measuring the quality and integrity of a benthic community is to determine the presence and abundance of target aquatic species. The target species are identified to use as a "standard" for the evaluation of a benthic community. Benthic communities are rated based upon the number of these target species identified in an area, with the assumption that a higher number of target species indicates a healthier benthic community.

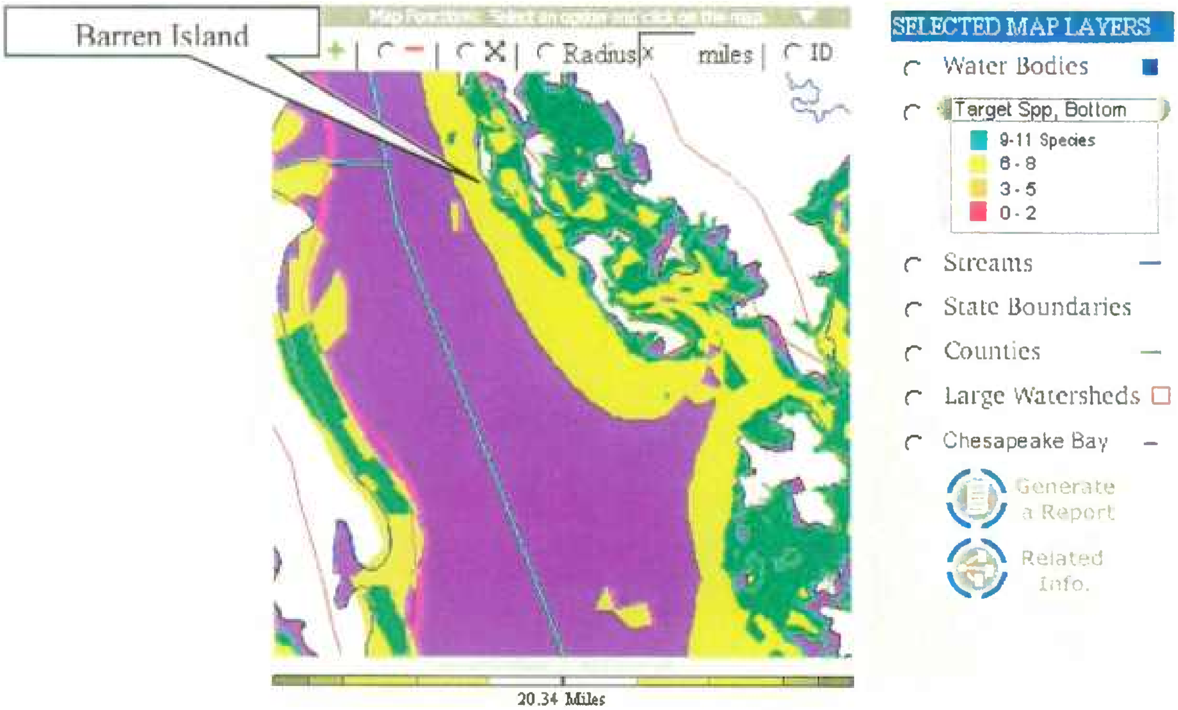
The Chesapeake Bay Program utilizes the following organisms as "target" species: blue crab (*Callinectes sapidus)*, spotted seatrout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), soft clam (*Mya arenaria*), Atlantic sturgeon (*Acipenser oxyrhynchus*), American oyster (*Crassostrea virginica)*, hard clam (*Mercenaria mercenaria)*, flounder (*Paralichthys dentatus*), post-larvae (PL) blue crab (*Callinectes sapidus*), and channel catfish (*Ictalurus punctatus*). In a 2-mile radius of Barren Island, there were 6 target species sampling locations. Table 15 provides a listing of target species found at these six sampling locations.

Table 15. Target Species at Six Sampling Locations within 2-miles of Barren Island
(0 = Species Absent; 1 = Species Present)

Station Location	Blue Crab	Spotted Seatrout	Spot	Croaker	Soft Clam	Sturgeon	Oyster	Flounder	Hard Clam	Crab PL	Catfish
1	1	0	1	1	1	1	0	1	1	0	1
2	1	1	1	1	1	1	0	1	1	1	1
3	1	0	1	1	1	1	1	1	1	0	1
4	1	0	1	1	1	1	1	1	1	0	1
5	1	1	1	1	1	1	1	1	1	1	1
6	1	0	1	1	1	1	0	1	1	0	1

Figure 10 graphically presents the number of target species identified in the Barren Island vicinity, which ranges from 6 to 8 (yellow areas) to 9 to 11 (green areas). Based on this data, it appears that the majority of the area around Barren Island is moderately healthy (6 to 8 target species), with pockets of areas that are quite healthy (9 to 11 species).

Figure 10. Number of Target Bottom Species in the Barren Island Area



The results of the BIBI and target species data appear to conflict with one another on the quality and integrity of the benthic community around Barren Island. It should be noted, however, that the BIBI score for the Barren Island area is based upon a single random sampling location, while six sampling points within 2-miles of Barren Island were used in the target species assessment. The results of the target species assessment may more accurately assess the benthic community in that area due to the larger and more representative sample set.

6.3 Birds

Barren Island provides valuable habitat for avian species. As mentioned in the introduction, Barren Island serves as a satellite refuge of the BNWR, and is an important nesting, nursery, and wintering area for colonial waterbirds, wading birds, and several Federally-listed and State-listed endangered species. The island is preferentially selected by migratory bird species because of its relative lack of human disturbance and predators (USACE, 1994).

A great blue heron (*Ardea herodias*) rookery is located on the south end of the Island, as well as a bald eagle nest (federally threatened; *Haliaeetus leucocephalus*). A brown pelican (*Pelecanus occidentalis*) nesting area is located on a small breakaway portion of Barren Island located approximately 500 yards to the south of the Island. + Brown pelicans are federally endangered in some areas of the US, but brown pelicans are not a federally-listed species on the U.S. Atlantic Coast (50 Federal Register 4938-4945) . Mr. David Brinker of the Wildlife & Heritage Service reports that 1,131 nesting pairs of waterbirds used the southern third of Barren Island to roost in 1999, as counted from an aerial survey (D. Brinker, MD DNR, personal communication, 2001). Of the 1,131 nesting pairs, 930 nesting pairs were blue herons, 200 pairs were incubating adult great egrets (*Ardea albus*), and 1 pair was snowy egrets (*Egretta thula*). An aerial photograph and survey was conducted in 2001; however, these data are not yet available for inclusion in this assessment.

Numerous other bird species frequent the Island, including the Least Tern (federally endangered; *Sterna antillarum*) and Black Skimmer (state endangered; *Rynchops niger*). Up to 80 nesting pairs of least terns historically used the island for breeding after a bare crown on the island was capped with shell cultch during a past restoration effort. *Spartina sp.* has since colonized the shell covered area, so least terns no longer nest on the Island, but this type of habitat could be included as part of the proposed project.

Table 16 lists the avian species known to occur on Barren Island. This table includes those species observed during the site reconnaissance, field notes from previous site visits (J. Gill, 1990), and the 15 avian species included in a previous Environmental Assessment of impacts on Barren Island (USACE, 1994).

Table 16. Avian Species Known to Occur on Barren Island

Common Name	Scientific Name	Special Status
Great Egret	*Ardea alba*	
BALD EAGLE	*Haliaeetus leucocephalus*	FT, MT
OSPREY	*Pandion haliaetus*	
Widgeon	*Anas americanas*	
American Black Duck	*Anas rubripes*	
Tundra Swan	*Cygnus columbianus*	
Glossy Ibis	*Plegadis falcinellus*	
American Oystercatcher	*Haematopus palliatus*	
Great Blue Heron	*Ardea herodias*	
Black Skimmer	*Rynchops niger*	MT
Least Tern	*Sterna antillarum*	FE, MT
Forester's Tern	*Sterna forsteri*	
Herring Gull	*Larus argentatus*	
Great black-backed Gull	*Larus marinus*	
Ring-billed Gull	*Larus delawarensis*	
Snowy Egret	*Egretta thula*	
Mute Swan	*Cygnus olor*	
Brown Pelican	*Pelecanus occidentalis*	
Mallard Duck	*Anas platyrhynchos*	
Bufflehead	*Becephala albeola*	
Merganser	*Mergus merganser*	
Common Goldeneye	*Bucephala clangula*	
Green Heron	*Butorides virescens*	
Willet	*Catoptrophorus semipalmatus*	
Double-Crested Cormorant	*Phalacrocorax auritus*	

FT = Federal threatened species.
FE = Federal endangered species.
MT= Maryland threatened species.
ME = Maryland endangered species.

Sources: Site Reconnaissance Report (Appendix A); Field Notes (J. Gill, 1990), and a previous EA (USACE, 1994).

In addition to the species listed in the table, many other birds have been observed in the vicinity of Barren Island. The National Audubon Society (NAS) has a Christmas Bird Count station located in southern Dorchester County, Maryland (circle identification: MDSD). A total of 166 bird species have been spotted in the MDSD 15-mile radius circle over the last 15 years, 136 of which have been sighted more than 1 time during the last 5 years (NAS, 2001). A list of the 136 species of birds recently sighted in southern Dorchester County during the Christmas Bird Count is located in Appendix A. The diversity of bird species in the area found in these Christmas counts are supported by the findings of an Environmental Assessment prepared for BNWR that noted that 257 species of birds occur on the refuge for part of the year, and an additional 25 species occasionally occur (BNWR, 1999).

In recent years, the population of mute swans (*Cygnus olor*) on Barren Island has grown at the expense of native tern and skimmer species, much to the concern of MD DNR. In the early 1990s, a large molting flock of mute swans caused a colony of least terns and black skimmers, both state-threatened species, to abandon their nesting site on Barren Island by trampling nests containing eggs and chicks. This was the only skimmer nesting colony in the Maryland portion of Chesapeake Bay. These swans also displaced nesting Forster's and common terns, declining species in Maryland (Hindman, 2001). In addition to displacing avian species, mute swan populations over-graze bay grasses in Maryland, eliminating habitats for crabs, fish, and other wetland dependent species. Maryland approved the killing of some of the Barren Island swans for the sake of the terns and skimmers, which caused considerable public outcry. The governor ordered a moratorium against killing any mute swan (Blankenship, 2000).

As a result of the moratorium, MD DNR established a Mute Swan Task Force to examine all aspects of the mute swan issue. Members of the Task Force included the Maryland Waterfowl Advisory Committee, the Humane Society of the United States, the U.S. Fish and Wildlife Service, Defenders of Wildlife, and the Maryland Wildlife Advisory Commission, as well as citizens, ecologists, waterfowl specialists and mute swan advocates. The Mute Swan Task Force summarized their findings in a report to MD DNR issued in January 2001 (MD DNR, 2001d). This report contains a comprehensive overview of mute swan information (e.g., legal status, natural history, population status, ecological impacts, management history, etc.), as well as the

Task Force's Management Recommendations. This report is available online (http://www.dnr.state.md.us/wildlife/mstfpc.html#msrecommend). The report prepared by the Mute Swan Task Force was open for public comment from January 2001 through March 1, 2001, and a summary of public comments was also prepared by the Task Force (http://www.dnr.state.md.us/wildlife/mscomments.html). The Task Force recommended that MD DNR maintain some population of mute swans in the Chesapeake Bay; however, MD DNR should maintain specific "swan free zones" to help control local impacts on bay grasses, and other native fish and wildlife habitat. Recommendations regarding the control of swans in "swan free zones," or where there are conflicts with humans, specify that nonlethal methods to exclude or remove swans be thoroughly exhausted before any lethal methods are employed.

6.4 Wildlife

Barren Island is known to support white-tailed deer (*Odocoileus virginianus*), diamondback terrapin (*Malaclemys terrapin terrapin*), redbelly turtle (*Pseudemys rubriventrus*), and various other terrestrial mammals, reptiles, and amphibians, although Refuge Manager John Gill indicated that the USFWS has not conducted any mammal or herpetological surveys on Barren Island to date. The Island also contains suitable habitat for the Delmarva Fox Squirrel (federally endangered; *Sciurus niger cinereus*), although the presence of this species has not been documented on the Island and no formal survey for these species has occurred. Table 17 contains a list of those mammal, reptile, and amphibian species that are known or expected to occur on Barren Island.

In addition to vertebrate species, Barren Island also provides excellent habitat for migrating and resident butterflies. Several species of butterflies, including one monarch butterfly (*Danaus plexippus*) were observed during the site reconnaissance. The USGS maintains a list of butterflies of Dorchester County Maryland (USGS, 2001). This list includes 6 swallowtails, 9 whites and sulfurs, 17 gossamer-winged butterflies, 19 brush-footed butterflies, and over 30 skipper butterflies. Although no butterfly survey has occurred on Barren Island, a number of these species are likely to occur on the Island.

Table 17. Wildlife Species Known or Expected to Occur on Barren Island[a]

Common Name	Scientific Name
Reptiles	
Northern diamondback terrapin*	*Malaclemys terrapin terrapin*
Eastern mud turtle*	*Kinosternon subrubrum subrubrum*
Eastern painted turtle	*Chrysemys picta picta*
Redbelly turtle	*Pseudemys rubriventris*
Mammals	
White-tailed deer*	*Odocoileus virginianus*
Raccoon*	*Procyon lotor*
River otter	*Lutra canadensis*
Muskrat	*Ondatra zibethicus*
Red fox	*Vulpes vulpes*
Meadow vole	*Microtus pennsylvanicus*

a = None of the species listed have a special status (i.e., endangered, threatened) at the Federal or State Levels.

* = Evidence of species observed during Site Reconnaissance Visit.

Sources: Site Reconnaissance Report (Appendix A); Field Notes (J. Gill, 1990), and a previous EA (USACE, 1994). Note that none of the species listed in this table have special status at the Federal or State levels.

6.5 Threatened and Endangered Species

No formal survey of threatened and endangered species has occurred on Barren Island to the knowledge of USFWS. As discussed previously, an adult Bald Eagle (federally threatened; *Haliaeetus leucocephalus*) and Bald Eagle nest were sited on the island. Suitable habitat for the Delmarva Fox Squirrel (federally endangered; *Sciurus niger cinereus)* and the Northeastern beach tiger beetle (federally threatened, *Cicindela dorsalis dorsalis*) were observed on the island. Habitat requirements for the Northeastern beach tiger beetle for the adult beetles and their larvae are wide, undisturbed, dynamic, fine sand beaches. Habitat of this type was observed on the northernmost portion of Barren Island, as shown in Photo 7 of Appendix A (Site Reconnaissance Report). Habitat requirements for the Delmarva Fox Squirrel are small stands of mature mixed hardwoods and pines that have relatively closed canopies, open understories, and a high

Report). Habitat requirements for the Delmarva Fox Squirrel are small stands of mature mixed hardwoods and pines that have relatively closed canopies, open understories, and a high proportion of forest edge. Habitat of this type was observed on the southern portion of Barren Island. The Least Tern (federally endangered; *Sterna antillarum*) and Black Skimmer (state endangered; *Rynchops niger*) are known to frequent the island. Sea turtles such as the endangered Atlantic loggerhead (*Caretta caretta*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), and leatherback sea turtle (*Dermochelys coriacea*), are occasionally found in the waters surrounding Barren Island, Bishops Head Point, and Spring Island (BNWR, 1999).

The federally- and state- endangered shortnose sturgeon (*Acipenser brevirostrum)* is also known to occur in vicinity of Barren Island in the Chesapeake Bay. A study investigating the distribution of sturgeon (both Atlantic sturgeon and shortnose sturgeon) in the Bay was initiated in 1996, whereby commercial fisherman were rewarded for reporting and holding live sturgeon caught as part of their fishing activities. After two years of monitoring (1996 through 1998), 29 shortnose sturgeon had been captured in the Chesapeake Bay. The majority of the reported catches (25 of 29 catches) occurred in the upper bay, near the Susquehanna River and C&D Canal. One catch was reported just north of Barren Island, approximately halfway between the Little Choptank and the Honga Rivers. Although the catch information presented in this study is biased towards commercial fishing locations, this study indicates that the federally endangered shortnose sturgeon occurs in the vicinity of Barren Island (Welsh et al., 1999).

Several species in Need of Conservation (MD list) also occur on BNWR and could potentially occur on Barren Island: black rail (*Laterallus jamaicensis*), Henslow's sparrow (*Ammodramus henslowii*), sedge wren (*Cistothorus platensis*), northern harrier (*Circus cyaneus*), and rare skipper (*Problema bulenta*) (BNRW, 1999).

6.6 Submerged Aquatic Vegetation

Beds of submerged aquatic vegetation (SAV) have been documented on the south and east side of Barren Island by the Virginia Institute of Marine Science (VIMS), as shown in Figure 11. Dense beds of SAV were observed to the east and south of Barren Island during the Site Reconnaissance on 10 October 2001 (Appendix A).

Based upon the average salinity in the proximity of Barren Island (mesohaline habitat), 10 common bay grasses could potentially occur in the vicinity of Barren Island. Table 18 lists the common species of SAV that occur in mesohaline waters. Refuge Manager John Gill indicated that widgeon grass (*Ruppia maritima*) dominates SAV beds in the area. Widgeon grass dominance was evident during the Site Reconnaissance.

Table 18. Species of Submerged Aquatic Vegetation that Occur in Mesohaline Waters

Common Name	Scientific Name	Salinity Range
Common waterweed, Elodea	*Elodea canadensis*	0-10 ppt
Coontail, Horwort	*Ceratophyllum demersum*	0-10 ppt
Eelgrass	*Zostera marina*	10-35 ppt
Eurasian watermilfoil, Milfoil	*Myriophyllum spicatum*	0-15 ppt
Horned pondweed	*Zannichellia palustris*	0-20 ppt
Redhead grass	*Potamogeton perfoliatus*	0-15 ppt
Sago pondweed	*Stuckenia pectinatus*	0-20 ppt
Sea lettuce	*Ulva lactuca*	10-25 ppt
Widgeon grass*	*Ruppia maritima*	0-35 ppt
Wild celery	*Vallisneria americana*	0-10 ppt

* = Dominant species in vicinity of Barren Island.

Source: CBF, 2001.

Submerged aquatic vegetation is a critical part of the Chesapeake Bay ecosystem. Not only do SAV beds provide habitat and food for fish, waterfowl and benthic species, SAV improves water quality by oxygenating bay waters. Of particular importance to commercial fisheries, SAV provides essential habitat for juvenile blue crabs. Research has shown that that the density of juvenile blue crabs is 30 times greater in grass beds than in unvegetated areas of the Bay (MD DNR, 2001a).

Changes in the distribution and composition of SAV beds throughout the Chesapeake Bay have been monitored by VIMS, the Chesapeake Bay Program, and other initiatives. GIS data for SAV available from VIMS provides SAV beds and densities on an annual basis, as well as provides limited identification of SAV species. The information and mapping data from the VIMS SAV Monitoring Project Reports and the on-line SAV GIS data for this report have been combined, and Figure 11 presents the distribution of SAV beds around Barren Island on an annual basis from 1991 to 2000.

A review of the SAV bed data from 1991 through 2000 confirms that there are currently no, nor have there been during that time period, any SAV beds within either of the proposed alignments. SAV beds are located to the east, north, and south of Barren Island. To the east and south, these beds are shown to be immediately adjacent to Barren Island in the most recent SAV maps (1999 and 2000).

Comparing the SAV data for the ten-year period of 1991 through 2000, there is a marked increase in density and extent of SAV beds in Tar Bay north and west of Barren Island between 1991 and 1992. In 1993, the SAV beds in this area reduced in size and density, and between 1994 and 1996 SAV beds are completely absent in this area. It is possible that the absence of SAV beds in this area is due to the lack of mapping for these years, although this possibility was not confirmed. In 1997, SAV occurs on the eastern side of Tar Bay; SAV is non-existent in 1998, and occurs in Tar Bay again in 1999. The 2000 data indicate a significant recovery in both size and density of the SAV beds in Tar Bay. All of the SAV beds observed around Barren Island during the site visit were comprised of widgeon grass (*Ruppia maritima)*.

In the VIMS classification system, each SAV bed is identified with a unique one or two letter designation (A, B, C, ..., AA, BA, CA,...). In addition, a density classification is assigned. The density classification refers to percent crown cover as identified in aerial photographs, and is presented as 0-10%; 10-40%; 40-70%; and 70-100% cover. These densities are presented on Figure 11. In addition, the species composition of a few SAV beds is identified to species using ground surveying during any given year. Three species have been predominantly found in the Barren Island area, and these species are (from most predominant to least predominant): widgeon grass (*Ruppia maritima*), eelgrass (*Zostera marina*), and horned pondweed (*Zannichellia palustris*). Species identification on Figure 11 is presented as two-letter codes:

- Rm = Widgeon Grass (*Ruppia maritima*)
- Zm = Eelgrass (*Zostera marina*)
- Zp = Horned Pondweed (*Zannichellia palustris*)

Note that the VIMS SAV Monitoring Project Reports and SAV GIS data provide SAV bed maps by USGS Quadrangle, as well as by Chesapeake Bay Program (CBP) segment. WESTON derived the SAV information for this report from the USGS Quadrangle data. The USGS Quadrangles of concern are the Barren Island, MD (SAV Map #72) and the Honga, MD (SAV Map #73) quadrangles. VIMS SAV Monitoring Project Report data in this format are available for 1994 through 2000, although the SAV maps for 1994, 1995, and 1996 do not include the Barren Island Quadrangle. It is assumed that SAV beds on the Barren Island quadrangle, if any, were not mapped or recorded for the years of 1994, 1995, and 1996. GIS SAV data are available for the entire Chesapeake Bay extending into the 1980s. GIS SAV data from 1991 through 2000 was utilized to supplement the SAV Monitoring Project Report maps.

Impacts of the proposed project on biological resources will be discussed in more detail in Section 13.2 (Potential Impacts on Biological Resources). The proposed project is expected to provide long-term protection of existing SAV beds south and east of Barren Island, and provide additional wave shadow around Barren Island.

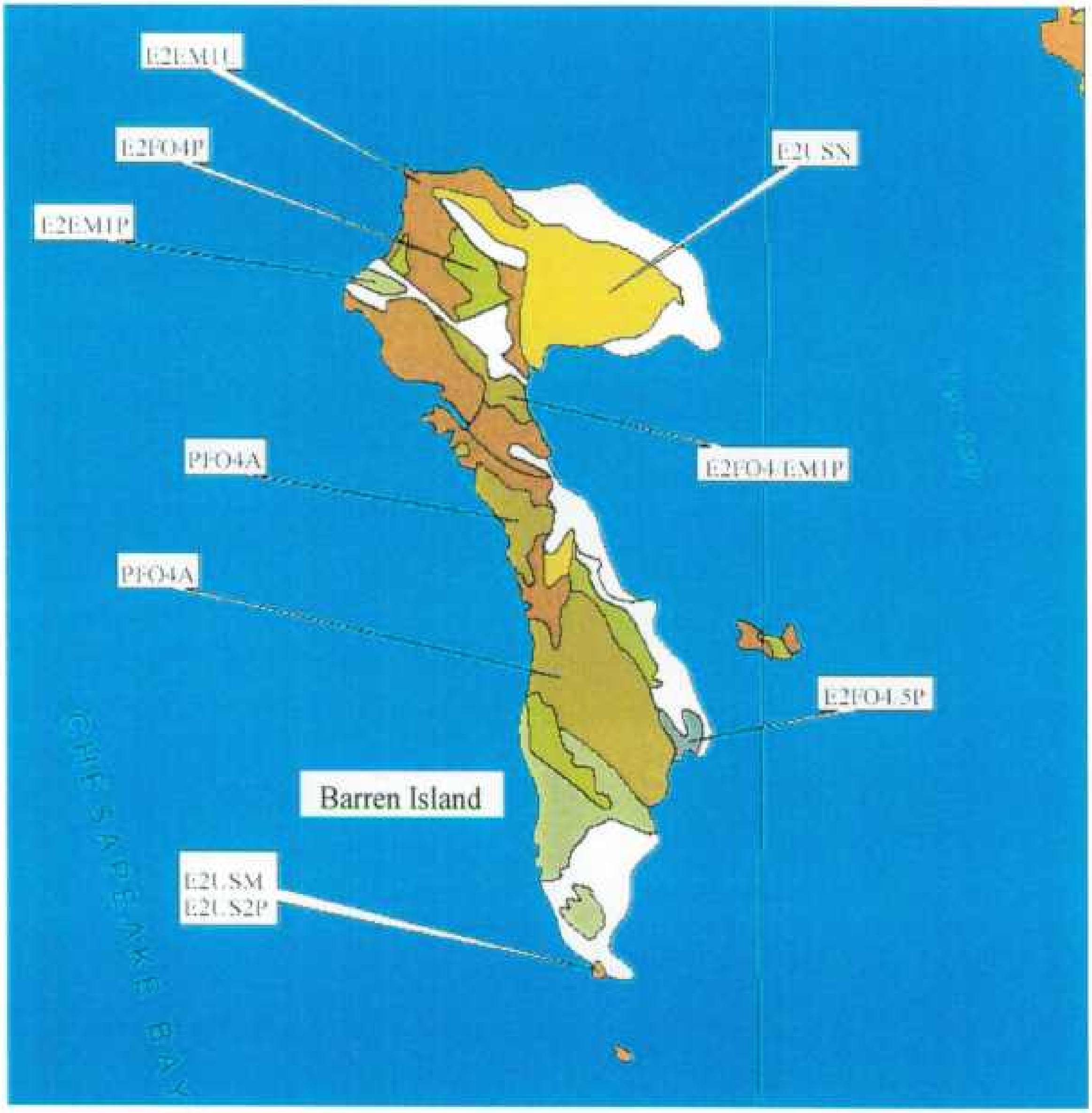
6.7 Estuarine Wetlands

WESTON® consulted the United States National Wetlands Inventory (NWI) maps for the Barren Island area (Barren Island and Honga, MD, quadrangles), in order to determine wetland types present on the island. NWI maps indicate that both estuarine and palustrine wetlands are present on Barren Island, as shown in Figure 12. The base map for Barren Island in Figure 12 is based on a 1974 USGS quadrangle, and the NWI photo was taken in 1981. The white areas along the shoreline in this figure (i.e., areas without wetland designations), are likely areas that eroded between the time the USGS quad was prepared and the photo was taken. Wetlands designations on the NWI map follow Cowardin et al., 1979.

The types of habitat that comprise these wetland areas on the NWI map include high quality tracts of salt marshes, and to a lesser extent brackish bay marsh. The salt marshes are dominated by a few species of emergent, salt-tolerant grasses (*Spartina sp.*), although other species of herbaceous plants may be present. Brackish bay marshes contain a wider array of plant species. Table 19 lists the species of plants expected to occur in the estuarine wetlands on Barren Island.

Field observations of the various wetland types on Barren Island were compared to the NWI map following the site reconnaissance visit. In general, the types of wetlands delineated by the NWI concur with observations made during the field visit. However, a formal habitat survey (i.e., delineation of habitat types) and an examination of the soils (a typical component of a wetlands evaluation) were not performed during the site visit. Therefore, it is not possible to evaluate the accuracy of the boundaries of the various wetland types. However, the succession of various wetland types observed on the island is generally consistent with the NWI map. A few discrepancies between the NWI map and existing conditions were noted. First, forested areas on Barren Island NWI map are designated as palustrine forest (PF04A); however, it appeared that at least some of these areas are not wetland forest. Second, the sandy beach that occurred on the northern portion of Barren Island is included as wetland on the NWI map, rather than as a non-vegetated area. This discrepancy is due to the age of the NWI map. The dredged material placement activity on Barren Island occurred in the mid-1990s, which was well after the NWI photo was taken in 1981. Third, the actual width of Barren Island, particularly in the central region, is much more narrow now than on the NWI map due to the high erosion rates.

Figure 12. National Wetlands Inventory of Barren Island



LEGEND	Source: Cowardin et al. (1979)
E2EM1U	E2EM1U - Estuarine, Intertidal, Emergent, Persistent, Unkown
E2EM1P	E2EM1P – Estuarine, Intertidal, Emergent, Persistent, Irregularly Flooded
E2FO4P	E2FO4P – Estuarine, Intertidal, Forrested, Persistent, Needle-leaved Evergreen, Irregularly Flooded
E2FO4	E2FO4 - Estuarine, Intertidal, Forrested, Persistent, Needle-leaved Evergreen
E2FO5P	E2FO5P – Estuarine, Intertidal, Forrested, Persistent, Dead, Irregularly Flooded
E2USM	E2USM – Estuarine, Intertidal, Unconsolidated Shore, Irregularly Exposed
E2USN	E2USN – Estuarine, Intertidal, Unconsolidated Shore, Regularly Flooded
E2US2P	E2US2P – Estuarine, Intertidal, Unconsolidated Shore, Sand, Irregularly Flooded
PFO4A	PFO4A – Palustrine, Forrested, Needle-leaved Evergreen, Temporarily Flooded

Table 19. Wetland Plants that Occur or are Expected to Occur on Barren Island

Common Name	Scientific Name	Habitats
	GRASSES	
Saltmarsh cordgrass	*Spartina alterniflora*	B, S
Saltmeadow hay	*Spartina patens*	B, S
Switchgrass	*Panicum virgatum*	B
Saltgrass, Spike grass	*Distichlis spicata*	B, S
Big cordgrass	*Spartina cynosuroides*	B
Common reed	*Phragmites australis*	B
Walter's millet	*Echinochloa walteri*	B
Giant foxtail	*Setaria faberi*	B
	RUSHES	
Black needlerush	*Juncus roemerianus*	B, S
	SEDGES	
Three-square	*Scirpus americanus*	B
Saltmarsh bulrush	*Scirpus robustus*	B
Saltmarsh fimbristylis	*Fimbristylis castanea*	S
	OTHER HERBACEOUS PLANTS	
Seaside goldenrod	*Solidago semipervirens*	B
Narrow-leaved cattail	*Typha angustifolia*	B
Saltmarsh fleabane	*Pluchea purpurascens*	B
Marsh hibiscus	*Hibiscus moscheutos*	B
Saltmarsh aster	*Aster tenuifolius*	S
Sea lavender	*Limonium carolinianum*	S
Slender glasswort	*Salicornia europaea*	S
Smartweed	*Polygonum spp.*	B
Duckweed	*Lemna spp.*	B

Table 19. Wetland Plants that Occur or are Expected to Occur on Barren Island (continued)

SHRUBS		
Groundsel tree	*Baccharis halimifolia*	B, S
Wax myrtle	*Myrica cerifera*	B
Marsh elder	*Iva frutescens*	B, S
Sea oxeye	*Borrichia frutescens*	S

S = Salt Marsh   B = Brackish Bay Marsh
Sources: Mitsch and Gosselink, 1993; CBP, 2001a; White, 1989

Estuarine wetlands are important to the Bay ecosystem because they remove and retain nutrients, provide food and habitat for finfish, shellfish, shorebirds, wading birds, and several mammals. Several commercially important fish and shellfish depend on estuarine wetlands, including striped bass, menhaden, flounder, oysters, and blue crabs. Low salt marshes are regularly flooded, and are dominated by saltmarsh cordgrass (*Spartina alterniflora*). Low marshes provide habitat for juvenile fish and a variety of invertebrates including shrimp, fiddler crabs, marsh crabs, marsh periwinkle, and Atlantic ribbed mussel. High marshes are salt marsh habitats that flood irregularly due to strong winds or exceptionally high tides. The most common plant species found in high marshes is black needlerush (*Juncus roemerianus)*.

6.8 Forested Areas

An estimated 65-70% of Barren Island consists of forested areas (J. Gill, USFWS, personal communication, 2001). The canopy is dominated by loblolly pine (*Pinus taeda*), with smaller portions of other deciduous and coniferous trees and shrubs. Table 20 provides a list of trees and shrubs that occur or are expected to occur on Barren Island.

Table 20. Common Trees and Shrubs that Occur or are Expected to Occur on Barren Island

Common Name	Scientific Name
TREES	
Loblolly pine*	*Pinus taeda*
American holly	*Ilex opaca*
Green ash	*Fraxinus pennsylvanica*
River birch	*Betula nigra*
Black gum	*Nyssa sylvatica*
Sweet gum	*Liquidambar styraciflua*
Red maple	*Acer rubrum*
Sycamore	*Platanus occidentalis*
Hackberry	*Celtis occidentalis*
Sweetbay magnolia	*Magnolia virginiana*
Black willow	*Salix nigra*
Pin oak	*Quercus palustris*
Willow oak	*Quercus phellos*
Black locust	*Robinia pseudo-acacia*
Common persimmon	*Diospyros virginiana*
Sumac	*Rhus spp.*

Table 20. Common Trees and Shrubs that Occur or are Expected to Occur on Barren Island (continued)

SHRUBS/VINES	
Common greenbriar	*Smilax rotundifolia*
Poison ivy	*Toxicodendron radicans*
Bayberry	*Myrica pensylvanica*
Japanese honeysuckle	*Lonicera japonica*
Trumpet creeper	*Campsis radicans*
Raspberry	*Rubus spp.*
Pokeberry	*Phytolacca americana*
Southern arrowwood	*Viburnum dentatum*
Winterberry	*Ilex verticillata*
Spicebush	*Lindera benzoin*
Buttonbush	*Cephalanthus occidentalis*
Red chokeberry	*Aronia arbutifolia*
Serviceberry	*Amelanchier alnifolia*

* Dominant Species

7. COMMERCIAL FISHERIES

The area in the vicinity of Barren Island supports commercial fishing for three species of shellfish (blue crabs, softshell clams, and oysters) and numerous species of finfish. The distribution and abundance of these resources are described in the following four sections. Data on the landings of commercial fisheries were obtained from MD DNR Fisheries, and are also provided in the following four sections. Note that the majority of these landings data are based on the entire Chesapeake Bay because MD DNR considers the mainstem of the Bay a single 'zone'. Specific data for landings in the vicinity of Barren Island (Zone 129) are only available for oysters and soft shell clams (C. Lewis, MD DNR Shellfish Division, personal communication, 2001).

7.1 Blue Crabs

The commercial harvesting of blue crabs (*Callinectes sapidus*) is vital to the life and culture of the Chesapeake Bay region. The Chesapeake Bay is the nation's largest source of blue crabs, supplying up to one-third of the total national harvest. Table 21 lists the annual harvest from the mainstem of the Chesapeake Bay in pounds and in dollars of both hard shell and soft shell blue crabs from 1990 to 2000. The annual harvest of blue crabs (hard shell) has declined over the last years from a high of 55 million pounds in 1993 to a low of 18 million pounds in 2000. The annual harvest of soft shell crabs has remained relatively steady over this period. Note that the data provided in Table 21 are for all of the Chesapeake Bay in Maryland, and are not specific for the area near Barren Island. Specific harvest information for the footprint of the proposed project was not available (C. Lewis, MD DNR Shellfish Division, personal communication, 2001).

The Hillsboro Office of the Maryland Natural Resources Police (MNRP) regularly patrols the waters of Dorchester County. This agency was contacted regarding the level of commercial fishing activity in the vicinity of proposed project. Corporal Randy Bowman, the officer that patrols the area including Barren Island, indicated that crab pots lines are regularly deployed on the west side of the island, from approximately 100 yards offshore to the navigation channel. Crabbing occurs during the spring, summer, and fall in the area that is colloquially called 'Barren

Island Grounds' (Corp. Bowman, Maryland Natural Resources Police, personal communication, 2001). The alignments for the proposed project will reduce the size of the Barren Island Grounds crabbing area.

Table 21. Annual Commercial Harvest of Shellfish from the Chesapeake Bay

Year	Blue Crab, Hard		Blue Crab, Soft		Soft Clam		Oyster	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
1990	45,127,840	19,048,509	1,548,196	4,290,411	2,130,961	9,031,987	2,843,504	10,582,433
1991	46,787,344	18,408,435	1,831,018	4,331,100	1,700,978	5,394,833	2,332,092	7,385,923
1992	29,405,559	16,036,646	1,202,981	2,948,887	357,815	1,891,200	1,259,270	4,080,956
1993	55,013,117	29,724,251	1,815,965	4,992,641	1,042,191	4,590,454	519,271	1,444,458
1994	40,723,882	33,940,134	1,582,313	5,215,885	448,632	3,008,355	817,205	2,630,101
1995	39,546,771	34,354,161	1,633,801	4,628,190	447,957	2,492,406	1,312,264	3,511,979
1996	35,918,828	25,228,432	1,782,581	7,634,489	319,434	1,476,422	882,942	2,733,671
1997	38,664,142	29,547,134	1,495,733	6,864,191	252,231	1,680,477	1,506,372	4,704,581
1998	24,385,601	24,125,225	1,234,533	5,738,940	217,702	1,454,098	2,390,513	7,423,784
1999	30,085,914	26,022,596	1,484,121	7,734,516	148,161	1,011,631	2,438,894	6,888,274
2000	18,875,234	21,230,871	1,363,638	7,050,447	162,512	975,787	2,365,051	7,153,952

Source: MD DNR, 2001b; Commercial Harvest Fisheries Database

7.2 Oysters

Commercial harvesting of oysters (*Crassostrea virginica)* has been critical to the culture and economy of the Chesapeake Bay region. Oystering was the most valuable commercial fishery in the Bay until the mid-1980s when it was overtaken by crabbing. Oysters also have tremendous ecological value by providing habitat for numerous other organisms and by purifying Bay water as they filter it for food. Current oyster populations in the Bay are estimated to be only 1% of populations present a century ago due to heavy harvest, loss of habitat, pollution, and disease.

The Maryland Department of Natural Resources Fisheries Service was contacted and Maryland Natural Oyster Bar Charts were used to determine whether any natural oyster bars (NOBs) were located within the proposed footprint of the proposed project. Based upon this review, it was determined that two NOBs (NOB 23-2 and NOB 23-4) are in areas adjacent to the proposed dike alignment (MD DNR, 1961). NOB 23-2 is located to the north and NOB 23-4 to the east of both proposed alignments. The location of the NOBs relative to the two proposed alignments are shown in Figure 7. The specific productivity of individual oyster beds is not available; however, oyster harvest data (in bushels) from this region (MD DNR Zone 129) is available and listed in Table 22. Since 1990 the greatest number of bushels harvested was in 1998, and has decreased in 1999 and 2000. Oystering is not permitted in Tar Bay or the Honga River.

Table 22. Oyster Landings Data in Zone 129

Year	Bushels Harvested
1990	6500
1991	4161
1992	902
1993	1
1994	495
1995	1245
1996	291
1997	2354
1998	7618
1999	5015
2000	2089

Source: C. Lewis, 2001.

Information regarding the health of these specific NOBs is not available since these NOBs have not been sampled within the last 5 years (E. Campbell, MD DNR Shellfish Division, personal communication, 2001). Oyster bar surveys are conducted by MD DNR on an annual basis in the fall, and evaluate the disease levels and spat set (recruitment of larvae) of approximately 300 -

400 different bars. Mr. Eric Campbell, Biologist, DNR Shellfish Division, reviewed all oyster survey information available for the last 5 years. He determined that no specific survey information, i.e., collections specifically from NOBs 23-2 and 23-4, had been conducted in the last 5 years for, or for other NOBs in the vicinity of Barren Island. However, Mr. Campbell noted that oysters in this area of the Bay have been heavily infected with two oyster parasites, Dermo (*Perkinsus marinus*) and MSX (*Haplosporidium nelsoni*). It is likely that any potential populations on NOB 23-2 and NOB 23-4 are remnant populations. Mr. Campbell stated that NOBs 23-2 and 23-4 are "definitely impacted" by disease. The two parasites that infect oysters are lethal within the first two years of life. MSX thrives in higher salinity brought on by dry years. Dermo tolerates low salinity, and therefore is the more damaging to the oyster population in this region (CBP, 2001a).

In addition to the information provided by the MD DNR Shellfish Division, Mr. Roy Scott, Oyster Biologist, Shellfish Division, MD DNR, was also contacted. Mr. Scott conducts the oyster surveys for MD DNR, and he confirmed that no surveys from NOB 23-2 and 23-4 have occurred recently. He added that the lack of surveys is because no oyster harvesting has occurred in the Barren Island area for decades because oysters are not present in commercial quantities. Roy Scott stated that this area has not been productive for decades; however, oyster cultch is likely present in both areas.

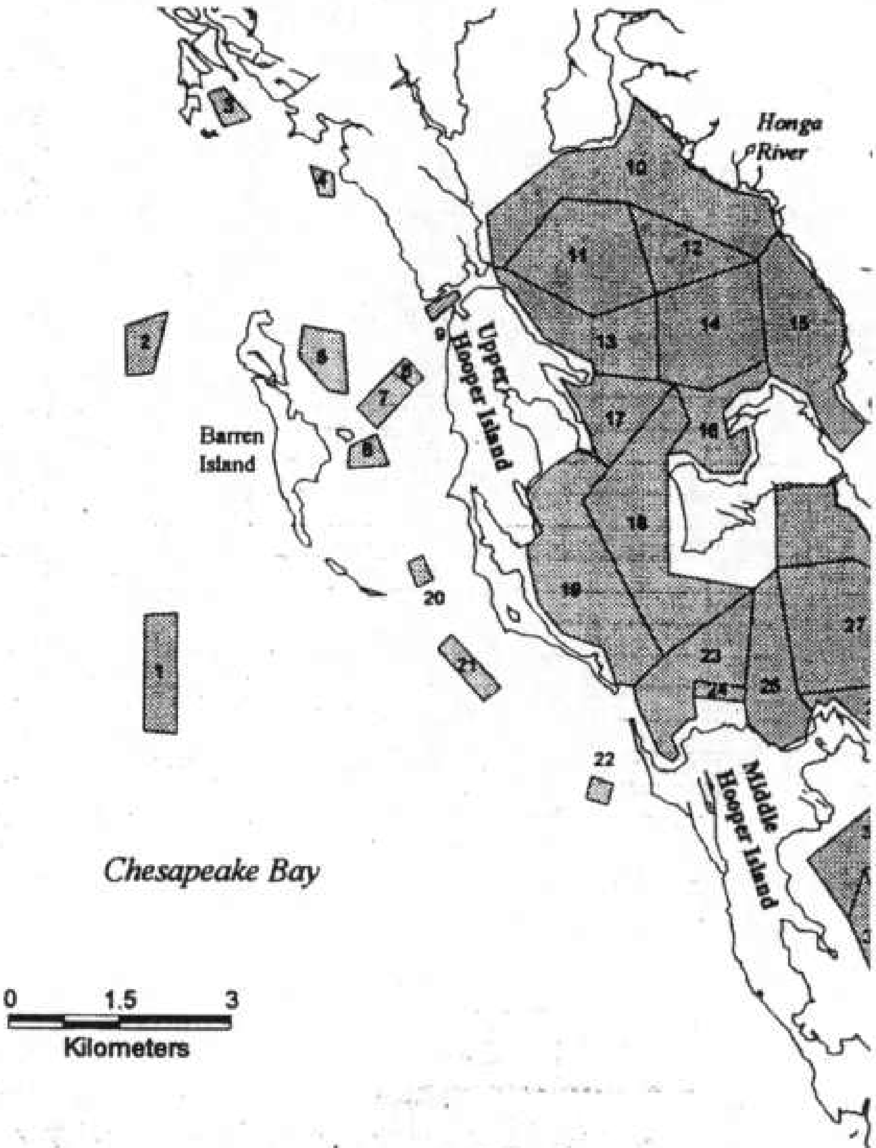
In addition to the numbered NOBs, several traditional oyster bars are located in the vicinity of Barren Island. Five oyster beds are located to the east of Barren Island in Tar Bay, and two oyster bars are located in the Chesapeake Bay to the northwest and southwest of the island, as shown in Figure 13. Shaded areas indicate the locations of traditional oyster bars. The traditional oyster bars are located outside of both proposed dike alignments. To differentiate between NOBs and traditional oyster bars, NOBs are legal bar boundaries, whereas traditional oyster bars are the historical location of oysters. Clamming vessels are not permitted within NOB boundaries. Note that traditional oyster bars are locations of historic oyster bars that are not protected by the State of Maryland. These areas served as suitable oyster habitat in the past, and could potentially serve as oyster habitat in the future if the hydrologic and/or water quality conditions permitted.

Table 23. Traditional Oyster Bars in the Vicinity of Barren Island

Number (see Figure 13)	Barname	Barcode
1	New Discovery	DOSND0
2	Stone Pile	DOSSP0
5	Great Bay	TAGB0
6	Possum Island	TABPI0
7	Tar Bay	TABTB0
8	Dry Rock	TABDR0
20	White Wood	TABWW0

Source: MD DNR, 1997.

Figure 13. Traditional Oyster Bars in the Vicinity of Barren Island – Historical Locations



Source: Map E-23, a NOB chart, reprinted with permission from MD DNR Fisheries Service (MD DNR, 1997).

7.3 Soft Shell Clams

Soft shell clams (*Mya arenaria*) are a significant fishery in the mesohaline regions of the Chesapeake Bay. Soft shell clams occur only in relatively shallow, sandy portions of the Chesapeake Bay. Commercial harvest of soft shell clams for the last 10 years in the Chesapeake Bay is listed in Table 21. Harvest of soft shell clams has varied widely over this time period, ranging from a low of 148,161 pounds in 1999 to a high of 2,130,961 in 1990. Specific soft shell clam harvest information for the vicinity near Barren Island (Zone 129) indicated that no soft shell clams were collected in this area for the last decade (C. Lewis, MD DNR Shellfish Division, personal communication, 2001).

The Maryland Natural Resources Police indicated that no clamming occurs in the footprint of the proposed project. The closest clamming activity is for soft shell clams, and is located south of the Island, north of Ferry Bridge (Corp. Bowman, Maryland Natural Resources Police, personal communication, 2001). Clamming is not permitted in Tar Bay or the Honga River.

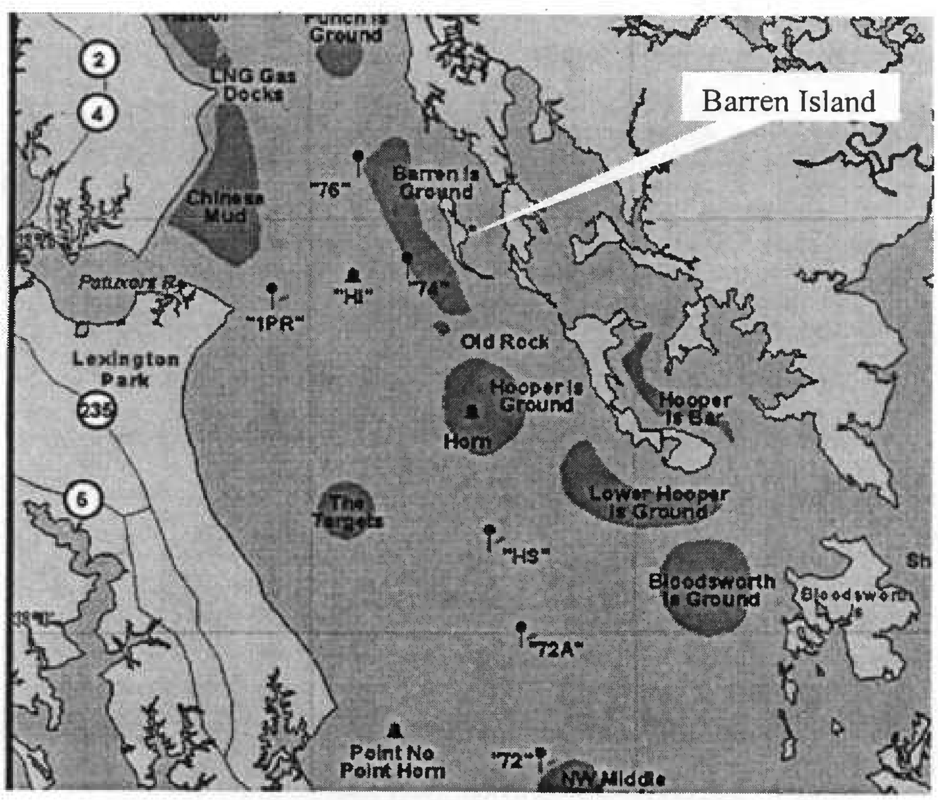
Information on the health and productivity of soft shell clams in the vicinity of Barren Island is not available. Eric Campbell, Biologist, MD DNR Shellfish Division, reviewed all soft shell clam survey information available for the last 5 years. He determined that no specific survey information on the health and/or productivity of soft shell clams in the vicinity of Barren Island is available (E. Campbell, MD DNR Shellfish Division, personal communication, 2001).

7.4 Finfish

Although specific commercial harvests for Barren Island area were not available, Table 24 lists the commercial harvest for the Chesapeake Bay for the last 11 years for 13 commercially important finfish species. From 1990 through 1995 catfish and menhaden were generally the most abundant species caught in terms of both poundage and value. However, starting in 1993 the poundage and value of striped bass has increased and was the most valuable species from 1995 through 2000.

The MNRP indicated that 4 pound nets for commercial fishing are regularly deployed on the west side of Barren Island, approximately one-quarter mile offshore of the island in the area locally called 'Barren Island Grounds'. MNRP estimated that there are 8 potential pound nets sites in this stretch, although only 4 nets have been deployed during the last 4 to 5 years. Pound nets in this vicinity catch weakfish (*Cynoscion regalis*), Atlantic menhaden (*Brevoortia tyrannus*), striped bass (*Marone saxatilis*), Atlantic croaker (*Micropogonias undulates*), and summer flounder (*Paralychthys dentatus*). Nets are deployed north to south, and range in length from 300 to 500 yards (500 yards is the maximum permitted length). Trotlines and eel pots are occasionally sited in Tar Bay (Corp. Bowman, Maryland Natural Resources Police, personal communication, 2001). The location of Barren Island Grounds in shown in Figure 14. Both of the proposed alignments will be sited in the southern half of the Barren Island Grounds (compare Figures 3 and 14).

Figure 14. Barren Island Grounds – Commercial Fishing Area



Source: MD DNR, Fishing Report (MD DNR 2001c).

Table 24. Annual Commercial Harvest of Finfish from the Chesapeake Bay

Year	Alewife		Blue Fish		Catfish		Croaker	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
1990	178,256	39,013	134,520	31,072	1,771,640	601,961	1,544	1,180
1991	139,363	22,760	75,500	15,385	1,675,008	641,729	2,163	2,730
1992	218,554	22,645	37,018	10,789	1,777,523	676,037	6,939	4,102
1993	145,005	24,380	19,019	10,682	1,240,944	454,351	80,138	53,463
1994	95,940	5,180	27,798	8,290	1,994,579	824,133	150,712	97,330
1995	134,319	13,802	28,472	13,959	1,990,448	1,596,601	450,694	246,505
1996	134,575	15,450	27,908	8,113	2,502,419	1,378,410	643,306	238,361
1997	193,326	34,134	42,239	14,051	1,814,756	785,347	933,401	324,429
1998	150,098	16,368	66,802	21,525	2,234,065	962,009	807,117	306,550
1999	98,282	8,122	92,157	25,342	2,175,057	749,401	645,635	213,494
2000	141,881	12,575	35,362	7,713	1,268,948	553,991	723,146	250,840

Year	Eel		Summer Flounder		Menhaden		Weakfish	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
1990	154,623	266,333	6,508	14,818	1,603,157	147,213	34,009	40,897
1991	272,340	481,381	8,856	11,295	2,972,753	1,009,162	15,159	15,953
1992	219,561	389,645	30,408	49,175	1,711,432	164,876	17,350	17,155
1993	229,970	236,274	17,730	33,821	2,257,254	234,348	27,099	26,098
1994	281,917	391,856	18,508	31,511	2,189,736	750,682	29,580	34,926
1995	248,047	562,288	18,404	35,801	4,081,148	414,853	21,836	26,242
1996	360,162	124,529	41,071	72,273	3,731,672	367,294	18,597	21,443
1997	309,444	157,340	25,890	56,265	3,317,600	322,498	18,295	13,544
1998	264,848	387,567	34,892	74,353	2,624,443	245,218	78,241	50,930
1999	256,544	385,781	27,157	59,684	4,343,450	353,362	76,478	53,892
2000	207,168	217,575	49,989	88,461	3,842,897	466,611	68,640	32,153

Table 24. Annual Commercial Harvest of Finfish from the Chesapeake Bay (continued)

Year	Shad		Spot		Striped Bass	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
1990	23,185	7,629	99,833	79,007	17,820	36,529
1991	210	70	68,344	38,536	127,860	250,244
1992	10,394	4,228	128,944	42,181	597,156	1,046,102
1993	Neg.	Neg	73,717	43,523	947,138	1,574,350
1994	Neg.	Neg.	95,796	57,266	918,778	1,601,390
1995	10,424	5,422	122,204	51,573	1,043,832	1,571,276
1996	8,750	4,652	63,896	35,512	1,573,655	2,555,628
1997	58,827	13,628	65,846	39,587	2,118,759	2,922,060
1998	33,170	7,113	127,137	53,866	2,426,634	3,166,084
1999	2,000	940	80,425	36,665	2,274,781	3,558,496
2000	3,615	996	98,018	48,278	2,261,284	3,457,231

Neg = Neglible harvest of shad occurred during these years.

Year	White Perch		Yellow Perch	
	Pounds	Dollars	Pounds	Dollars
1990	824,636	383,479	82,050	63,310
1991	603,276	610,354	67,179	47,702
1992	801,285	1,401,528	45,162	36,905
1993	928,709	698,609	78,373	43,383
1994	953,343	747,187	69,868	68,207
1995	1,157,227	901,486	83,394	67,235
1996	1,514,044	905,709	55,961	40,701
1997	2,129,715	929,282	104,861	147,201
1998	1,371,528	843,064	135,986	186,013
1999	1,518,643	759,212	203,057	343,588
2000	1,863,362	901,459	103,726	172,882

8. RECREATIONAL RESOURCES

Barren Island is not open to the public for recreation. A special permit is required to access the Island, consequently the proposed action will not affect access to or recreational resources on the island. As discussed in the previous section, the fishing grounds locally called 'Barren Island Grounds' are located to the west of the island. Both proposed alignments are located within the Barren Island Grounds.

During the Site Reconnaissance, evidence of trespassing was evident on both the north and south ends of the island, including dog tracks and beverage containers. No fences or other physical barriers are present to restrict access to the island.

9. HISTORIC AND CULTURAL RESOURCES

The Maryland Historical Trust was contacted to determine whether any sites of historical or archaeological significance are present on Barren Island. The Maryland Historical Trust indicated via letter that no historical, cultural, or archaeological sites are present on the island that would be impacted by the proposed project. Correspondence from this agency is included in Appendix C. In addition, no listings for Barren Island were found on the National Register of Historic Places on the Maryland Historical Trust web site (www.marylandhistoricaltrust.net).

Pre-colonial inhabitation or use of the island by Native Americans is known to have occurred, as evidenced by the arrowheads and midden piles that have been found on the island in the past (J. Gill, USFWS, personal communication, 2001). In colonial times, Barren Island was inhabited, and the last family is believed to have left in the early 1900s. In the 1930s, the land was privately owned and was the site of a hunting club. During this period, Barren Island served as a hunting ground for sportsmen. A colonial-era cemetery is located on the western-central portion of the Island, which is currently eroding into the Chesapeake Bay. The proposed project could potentially afford protection to the cemetery and other historic and cultural resources by reducing or halting further erosion of Barren Island.

10. NAVIGATION

The proposed project area [i.e., the Barren Island habitat restoration area footprints (both the 1,000 acre and 2,000 acre proposals)] lies east of the main shipping channel in the Chesapeake Bay. The proposed environmental restoration areas range in depth from approximately 3 to 12 feet deep, which makes this area too shallow for commercial shipping. It is likely that this area is utilized by small, private vessels including fishing, recreational, and sail boats. Small commercial fisherman and crab-boats also navigate through this area, although this traffic is anticipated to be light due to the shallow depths.

11. AESTHETICS/NOISE

Currently Barren Island is currently uninhabited, and there are no structures on the island, with the exception of the ruins of the 1930s hunting lodge. "Noise" on Barren Island is typically limited to natural sources such as birds, wildlife, wind, and waves. Anthropogenic noise from passing recreational boats and fishing boats could potentially occur at the island, although these noises were not evident during the site reconnaissance (Appendix A).

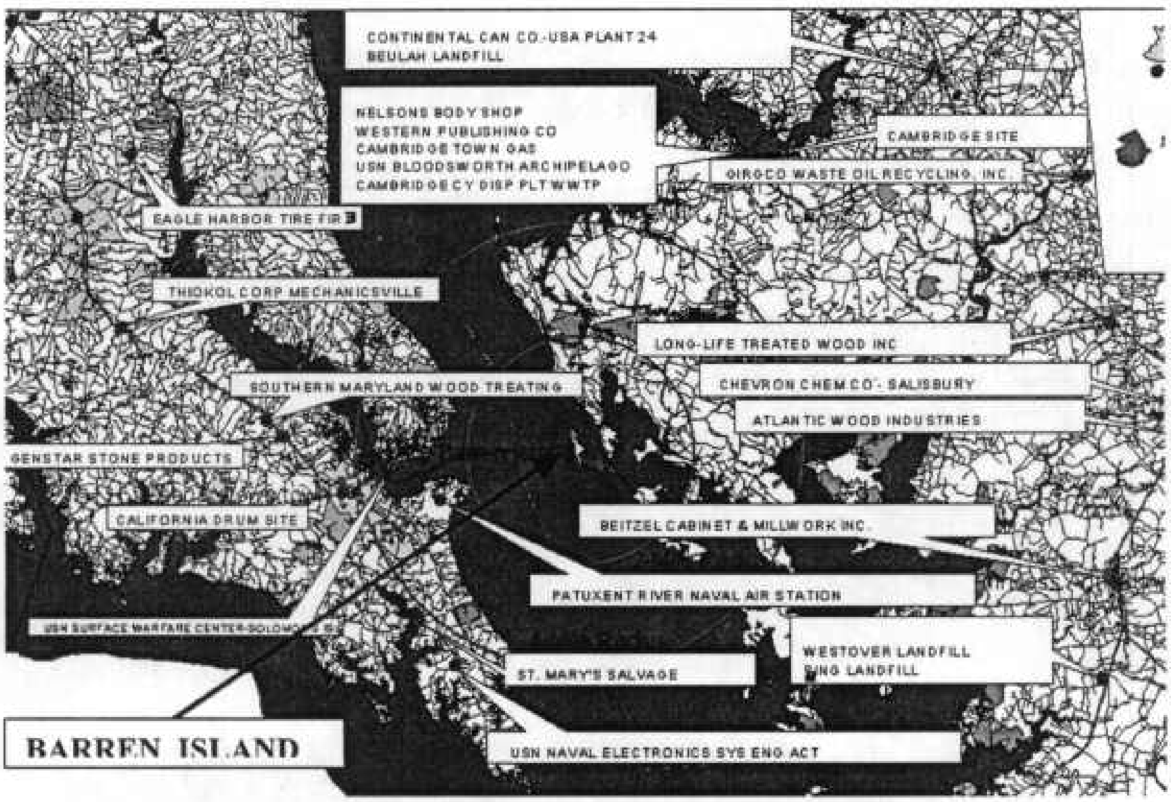
The viewshed from the island to the north and west is the Bay, with the Maryland's eastern and western shores visible across the Bay. To the east, Upper Hoopers Island lies approximately ½ to ¾ miles east, and is easily seen from the shoreline. Upper Hoopers Island is inhabited, and private homes and docking areas are visible. To the south, a small remnant island that was formerly a part of Barren Island, is prominent. This small island (unnamed) lies approximately 500 yards south of Barren Island.

12. CERCLA LIABILITY

No research to date has indicated that any hazardous, toxic, or radioactive substances exist within or in the vicinity of the proposed project area. The lack of degraded areas near Barren Island supports this finding. No liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) would be associated with the site.

A review of U.S. EPA Region III CERCLA Sites within a 2-mile radius of Barren Island indicated that no CERCLA sites are present (USEPA Region III, no date). Within a 4-mile radius of Barren Island, two CERCLA sites were identified: the Patuxent River Naval Air Station, located approximately 2-1/2 miles west of Barren Island; and the USN Surface Warfare Center - Solomon's Island, located approximately 3 miles west of Barren Island. Figure 15 graphically presents these two CERCLA sites, as well as several other CERCLA sites outside of the 4-mile radius, in relation to Barren Island.

Figure 15. CERCLA Sites in the Vicinity of Barren Island



Source: USEPA Region III, no date.

In addition, an on-line search of the EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) was performed on 17 December

2001 (USEPA, 2001a). This search identified three CERCLA facilities/sites in Dorchester County, MD (see Appendix D): Cambridge Town Gas, Eastern Maryland Wood Treating, and USN Bloodsworth Archipelago. All of these sites are located outside of the 4-mile radius from Barren Island, and are depicted on Figure 15 with the exception of Eastern Maryland Woodtreating, which is located east of the mapped area in Dorchester County.

WESTON reviewed the information available from EPA's on-line database for the two facilities located within 4 miles of Barren Island. Both of these sites are located across the Chesapeake Bay and west of Barren Island, and are not considered to be significant to the proposed dike alignments (see Appendix D). Note that data regarding the USN Surface Warfare Center - Solomon's Island site was not available from EPA sources. It is probable that this site is so old that no reasonably attainable information exists for this site.

There are no known areas of waste disposal or storage on Barren Island. The USFWS removed several fuel tanks from the hunting lodge area in the 1990's. These tanks were associated with electrical power generation at the lodge, and were removed completely.

The Chesapeake Bay Program publishes a map titled "Status of Chemical Contaminants on Living Resources in the Chesapeake Bay's Tidal Rivers" (CBP, 2001d), which indicates regions of the Bay that have been impacted by chemical contamination. This map indicates that waters in the vicinity of Barren Island have had historically low levels of chemical contamination.

13. POTENTIAL IMPACTS

The following subsections discuss some of the expected positive and negative impacts that would be caused by the proposed habitat restoration and beneficial reuse project. This impact assessment is based on the information on resources and environmental conditions presented in the previous section.

13.1 Water and Sediment Quality

Short-term impacts on water quality and sediments are expected during both dike construction and the placement of dredged materials. Both of these activities may result in short-term increases in TSS levels and turbidity, and possibly increased sedimentation in the surrounding area. As in the case of the Poplar Island Environmental Restoration Project (PIERP), water quality based restrictions on construction activities would be expected to control and limit these types of impacts. Furthermore, discharge limits similar to those used at PIERP would be expected to control and minimize potential chemical and nutrient impacts during operation.

The dredged material proposed as fill for the habitat restoration project is expected to be uncontaminated, and no adverse impacts to sediment quality are expected from placement activities. As with PIERP, chemical analyses of sediments will be performed on materials prior to placement in the habitat restoration project. Although these sediments will be slightly different in grain size than the local sediments and will alter the substrate within the project footprint, negative sediment quality impacts in the surrounding area are not expected.

During placement activities, there is potential for elevated nutrient levels or pH changes in the water discharged, however water quality monitoring requirements and permitted discharge levels are expected to be similar to those at PIERP. All discharge will be strictly monitored for compliance with permit levels to control potential impacts.

In the long-term, the proposed project is expected to improve water quality in the vicinity of the proposed project. If the project is successful at reducing the rate of shoreline erosion at Barren

Island, then long-term TSS levels in the waters around Barren Island would likely decrease due to the lessened erosion on the remnant island. Lower TSS will serve to protect and maintain water quality in the surrounding shallow water habitat including the benthos and SAV.

13.2 Biological Resources and Critical Areas

Impacts on terrestrial biological resources during the construction phase are expected to be small because the majority of the activities will be conducted in the water. Because the proposed alignments do not directly tie into Barren Island, there will be no loss of vegetation or habitat on the island itself. Some terrestrial species, particularly nesting birds, will likely avoid the western and southern shores of the island during construction activities. This impact will be short-term, lasting only during the construction and, to a lesser extent, placement phases. If the construction phase occurs during the late spring and early summer, the potential impact on nesting birds will be higher than at other times of the year because nests will already be established and eggs or young will be present. Construction activities earlier in the year could discourage nesting along the western and southern shoreline as well as on the small remnant island to the south of Barren Island where the brown pelicans nest. Construction activities later in the year will displace adults but will not impact juvenile birds that have already left the nest. It is expected that Alignment #2 will require a longer construction period, have a longer placement period, and, therefore, have a larger impact on these areas.

Great blue herons (*Ardea herodias*) lay eggs in March and April, incubate the eggs for one month, and fledglings leave the next by early July. Brown pelican (*Pelecanus occidentalis*) lays eggs from late winter to early spring, and incubates the eggs for 30 days. Bald eagles (*Haliaeetus leucocephalus)* lay eggs between January and March, incubate the eggs for 35 days, and the fledglings leave the next in 10 to 12 weeks. It is recommended that construction activities associated with the proposed project follow the schedule implemented for the Poplar Island Habitat Restoration Project in order minimize impacts to nesting waterbirds that use Barren Island and the small remnant island to the south.

Because the dike systems will not actually tie into Barren Island, there is not expected to be a significant impact on other terrestrial habitats. It is possible that increased turbidity could potentially impact some of the low marsh areas on the western shore of Barren Island by increasing sedimentation in these areas. This impact should be monitored closely during construction of the dike system and placement of the dredged material.

Construction of the dike system and subsequent placement of dredged material will replace shallow water habitat with upland and marsh habitats within the selected alignment footprint. These effects will be permanent. Alignment #1 will bury 1,000 acres of shallow water habitat and Alignment #2 will bury 2,000 acres of shallow water habitat. The benthic communities and aquatic habitat have not, to date, been adequately assessed with regard to ecological value. As a result, it is impossible to quantify the effect of burying these areas. However, the existing benthic habitat in the proposed project area is of low quality. Benthic habitat will be created in marsh habitat construction by the proposed action. This habitat will replace some of the lost shallow water benthic habitat. The constructed tidal marsh areas will provide habitat for wildlife that utilize these systems and increase the area of salt marsh systems in the area.

The proposed alignments are in a portion of the Barren Island Grounds (see Figure 14), which are used commercially for finfish and blue crab harvests. The proposed alignments will result in a permanent reduction of the Barren Island Grounds. However, there are larger and much more valuable shallow water areas around Barren Island, and the impact of the proposed project is not expected to be significant. Further assessment of the use of this area by commercial and recreational fishermen is suggested to verify these findings.

Because the proposed alignments do not tie into Barren Island, the placement of dredged material will not destroy the western shoreline habitats on Barren Island. In fact, additional shoreline habitat will be created along the entire outer boundary of the dike system, effectively increasing the shoreline habitat by approximately 20,000 linear feet for Alignment #1 and 28,000 linear feet for Alignment #2. Although this habitat will be different than the current habitat found along the western edge of the Island, it will provide additional habitat for shoreline species. Currently, the western shoreline is eroding quite rapidly. The addition of either proposed alignment will reduce or eliminate this erosion. In addition, both proposed alignments will augment the current habitat by providing a tidal flat habitat area between Barren Island and the dike alignment.

In addition, the proposed project would provide additional wave shadow around Barren Island, which would increase the potential SAV habitat in the area and could protect existing habitat. Increasing SAV habitat around Barren Island would contribute to the Chesapeake Bay Program's overall goal to increase SAV beds in the Bay. The proposed project would provide additional nesting and feeding habitat for a wide variety of waterfowl, and would likely contribute to local fish habitat through increasing SAV beds. These positive impacts are expected to outweigh the negative impact of reducing the size of local productive crabbing areas.

Most of Barren Island and its surrounding habitats (e.g., SAVs, shallow water, intertidal wetland, bird nesting areas, threatened and endangered species) would be considered Critical Areas. Impacts from the proposed environmental restoration would be primarily limited to shallow water areas. Indirect impacts from the construction and placement of dredged material could be minimized by using similar timing and techniques employed as part of the Poplar Island Habitat Restoration Project.

It should be noted that since Barren Island is owned by USFWS it is not directly subject to Maryland Critical Area regulations because it is not a private holding. However, the Coastal Zone Management Act (CZMA) of 1972 gives states the ability to require federal agencies to carry out activities within the coastal zone in a manner consistent with the state coastal program's policies. This will include consideration of the Critical Area regulations and programs for the state and Dorchester County (R. Serey, MD DNR Critical Area Commission, personal communication).

13.2.1 Essential Fish Habitat

Barren Island is located in an area that may provide EFH for nine species of fish. These include windowpane flounder (*Scopthalmus aquosus*), bluefish (*Pomatomus saltatrix*), Atlantic butterfish (*Peprilus triacanthus*), summer flounder (*Paralicthys dentatus*), black sea bass (*Centropristus striata*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculates*), cobia (*Rachycentron canadum*), and red drum (*Sciaenops occelatus*) (Table 12). A summary of EFH and general habitat parameters, as prepared by NMFS, for each of these species is found in Appendix E. A summary of those stages most likely to be impacted (if any) from the proposed environmental restoration project follows.

- Windowpane flounder - Juveniles and adults are expected in the project area, generally from March through November. This species is found in areas with substrates of mud or fine grained sand and is a bottom feeder.

- Bluefish - Juveniles and adult bluefish are present in the Bay and project area from April to October. The adults are strong swimmers and not bottom feeders. Juveniles generally utilize shallower waters than adults.

- Atlantic butterfish - Utilize deeper waters than the proposed project area and is not likely to be impacted.

- Summer flounder - The juveniles and adults migrate into the project area during the late spring and summer months, and are bottom feeders. Habitat includes shallow water and a sandy substrate, but also includes muddy substrates. This species also occurs in areas designated as Habitat Area of Particular Concern (HAPC), which include all native species of macroalgae, seagrasses, freshwater and tidal macrophytes in any size bed as well as loose aggregations.

- Black sea bass - Juveniles are anticipated to be in the project area during the spring and summer. The preferred habitat is rough bottom, shellfish and eelgrass beds and man-made structures in sandy-shelly areas.

- King mackerel and Spanish mackerel do not enter the Bay up to the project area location. Similarly, Cobia are generally limited to the southern portion of the Bay and would not be impacted from the proposed environmental restoration.

- Red drum - Larvae are found in low salinity areas associated with estuarine wetlands, including SAVs. The adults travel in large schools as far north as the Patuxent River, which is located directly east of Barren Island. Habitat for adults and older juveniles include shallow bay bottoms and oyster reef substrates. Red drum juveniles are expected to be in the project area from September through November. Adults are present in both the spring and fall. These species are bottom feeders.

The Atlantic butterfish, king mackerel, Spanish mackerel, and cobia are not anticipated to be in the project area and would not be impacted. Black sea bass (juveniles) may be in the project area, but the proposed project footprints do not contain preferred habitat for this species. It may use adjacent areas such as the oyster beds and SAV. The remaining species, windowpane flounder (juveniles and adults), bluefish (juveniles), summer flounder (juveniles and adults), and red drum (adults and juveniles), may utilize the proposed environmental restoration area for at least a portion of the year. Summer flounder (adults and juveniles) and bluefish (juveniles) may be the species of most concern for the project.

The proposed environmental restoration will convert an area of shallow water and substrates ranging from mixed silty sand to clayey silt and silty clay to a mixture of marsh and upland habitat. The loss of this habitat will reduce the size of the Barren Island Grounds and available fish habitat, primarily for those species that are bottom feeders (e.g., summer flounder). Water-column species would be less impacted from the loss of habitat. The quality of benthic habitat is this case is considered low. Note that Habitat Areas of Potential Concern (HAPC), particularly SAV beds that are critical to early life stages of many finfish, may benefit as a result of the proposed project.

Because the proposed environmental restoration areas are located in area of designated EFH, NMFS will need to be consulted for recommendations in order to determine potential impacts on EFH. Due to a lack of information on fish utilization of the project area, it is recommended that further studies of the area be conducted, including interviews of local commercial and recreational fishermen, and field surveys during the months when fish are generally expected to be most abundant in the area.

13.2.2 Commercial fishery

The two alignments for the proposed project do not directly impact either of the two NOBs in the vicinity of Barren Island. Increased sedimentation resulting from construction activities may potentially impact these oyster beds. The impact of potential increased sedimentation on the overall oyster productivity in the Bay is not expected to be significant. Fisheries statistics from MD DNR indicate that soft shell clamming does not occur in the vicinity of Barren Island; therefore, there will be no impacts to clamming by the proposed project.

Placement of the dike system and subsequent placement of dredged material will result in a reduction of crabbing areas within the selected alignment. These effects will be permanent. It is expected that Alignment #1 will result in the loss of 1,000 acres of commercial blue crab fishing grounds, and Alignment #2 will result in the loss of 2,000-acres of commercial blue crab fishing grounds. These areas are currently considered productive based upon conversations with local MNDP, and from the visual observations of >30 crab pots near Barren Island during the Site Reconnaissance. There is currently no way to accurately assess the productivity of these crabbing areas without conducting personal interviews with local waterman; therefore, it is impossible to adequately determine the economic and ecological impact of the loss of these crab areas.

MNRP have confirmed that commercial fishing of menhaden, rockfish, and summer flounder is conducted west of Barren Island, presumably in the footprint area of the proposed alignments on Barren Island Grounds. As with commercial blue crab fishing, there is no way to accurately assess the productivity of these fishing areas without conducting personal interviews with local waterman. Therefore, it is impossible to adequately determine the economic and ecological impact of burying these fisheries. The overall impact of the project on Bay commercial fishing is not expected to be significant.

Additional information is needed to confirm the extent and productivity of commercial crabbing, oystering, and fishing around Barren Island in order to more accurately assess both the economic and ecologic impact of the proposed project.

13.3 Recreational Resources

Recreational fishing and boating that occurs within the proposed project areas will be permanently displaced as the result of this action. It is anticipated that these activities will resume around Barren Island when the project is completed, and will ultimately be enhanced by island reconstruction and the creation of marsh habitat. Because Barren Island is a Wildlife Refuge and its access is restricted by USFWS permit only, no other impact on recreational activities is expected. USFWS has considered opening Barren Island to the public for kayak tours and similar activities, but no formal proposals have been made. It is likely that the proposed project would enhance the ability of Barren Island to support and maintain this type of recreational activity by increasing available habitat and providing additional refuge areas for sensitive species. Increasing the human recreational activities around Barren Island in a controlled, constructive manner could ultimately raise the public awareness and involvement with conservation and habitat restoration in the Chesapeake Bay and positively impact similar, future projects.

13.4 Historical Resources

Maryland Historical Trust has determined that no areas of historical, cultural, or archaeological significance will be affected by the proposed project. There are no known areas of historical significance within the proposed project areas.

According to the USFWS, arrow points and other artifacts have been found on Barren Island. In addition, there is a cemetery currently eroding along the southwestern portion of the island. The historical significance of the cemetery and artifacts are currently unknown. Although it is not anticipated that the proposed project would negatively impact any of the areas on Barren Island, a formal consultation with the Maryland Historic Trust should be conducted as part of this project.

13.5 Other Impacts

There are no known areas of waste disposal or storage on Barren Island. The USFWS did remove several fuel tanks from the hunting lodge area in the 1990's. These tanks were associated with electrical power generation at the lodge, and they were removed completely. Based upon conversations with Refuge Manage John Gill, there does not appear to be any CERCLA liability issues on Barren Island.

Barren Island is uninhabited, and lies approximately 1 mile from the closest inhabited areas (Hooper's Island). The noise resulting from activities associated with the proposed project are not expected to significantly impact these areas. Noise from construction may impact nesting birds and other wildlife as previously discussed in this report; however, these impacts are expected to be short-term.

Because the proposed project will be located on the western side of Barren Island and will include habitat similar to that currently present on the Island, the impact on the viewscape from the Eastern Shore is expected to be negligible. Barren Island is too far from the Western Shore to impact the viewscape from that direction.

Although groundwater impact is always a concern with the placement of dredged material, the clays and silt sediments underlying the project area are expected to provide adequate protection of groundwater resources. In addition, the dredge material proposed for use on this project is expected to be of good quality and is not expected to pose a significant threat to groundwater.

During construction activities, the local barge and tug traffic will increase around Barren Island. This increased traffic will have a minor impact on overall shipping traffic in the area. This effect is not expected to be significant, although it will be slightly greater for Alignment #2 because of the increased size and length of construction period.

13.6 Previous Environmental Assessments

Environmental Assessments were completed in 1971, 1977, 1981, 1984, 1988, and 1994 to address maintenance dredging in the Federal navigation channel and disposal operations related to this maintenance dredging. Each of these Environmental Assessments resulted in Findings of No Significant Impact (FONSIs). Given the similarity of each of these channel maintenance projects and the age of some of these reports (>20 years), the most pertinent and recent assessment was selected for review. In 1994, the Environmental Assessment addressed the maintenance dredging of approximately 5.8 miles of the federal navigation channel resulting in the removal of approximately 103,000 cubic yards of material. This particular Environmental Assessment was selected for review because the dredged material from this project was placed on Barren Island to create habitat (geotextile tube project). This report reviewed the existing environmental conditions on Barren Island, and these conditions were incorporated into the relevant sections of this report. A FONSI was issued for this project on July 4, 1994 (USACE, 1994).

13.7 Overall Assessment

Additional studies of the shallow water habitat around Barren Island are needed to accurately assess the overall impact of the proposed project, particularly with regard to crabbing productivity, commercial fishing, and the benthic community habitat. The overall assessment that follows assumes that these studies would indicate that impacts on these resources would not be significant, or would be outweighed by the positive impacts of the project. In addition, it is assumed that the proposed project would be designed in close coordination with natural resource trustees, particularly the USFWS, in order to create a needed, beneficial, and successful habitat restoration at Barren Island. In order to provide the positive impact described in this report, it is imperative that the proposed project be designed for the purposes of habitat restoration and preservation.

Based upon the currently available information, WESTON believes that the overall impact of an environmental restoration project at Barren Island would be positive. This type of project would provide significant erosion protection for Barren Island. In addition, the proposed project could protect and possibly provide additional wave shadow around Barren Island, which would increase the potential SAV habitat in the area. Increasing SAV habitat around Barren Island would contribute to the Chesapeake Bay Program's overall goal to increase SAV beds in the Bay. The proposed project would provide additional nesting and feeding habitat for a wide variety of waterfowl, and would likely contribute to local fish habitat through increasing SAV beds and areas of intertidal marsh and mud flats. These positive impacts are expected to outweigh the negative impacts of reducing the size of local productive crabbing areas and short-term water quality impacts.

14. ADDITIONAL STUDY NEEDS

The following additional study needs are recommended prior to the implementation of the proposed project:

1) Interview local watermen in the region to assess the commercial and recreational value of the proposed alignments to fisheries.

2) Conduct an ecological survey of the shallow water habitat in the footprint of the proposed project.

3) Contact National Marine Fisheries Service regarding Essential Fish Habitat after the proposed alignment for the project has been selected.

4) Consult with USFWS, MDNR, and other appropriate agencies regarding the proposed project, impacts, and permitting requirements.

5) Although not an additional study need, a surface water quality monitoring program should be prepared prior to the onset of the proposed project. Monitoring parameters should at a minimum include DO, TSS, and nutrients.

15. REFERENCES

ACRE (Applied Coastal Research and Engineering, Inc.). 2001. *Coastal Engineering Feasibility Study for Barren Island, Maryland – DRAFT.* Prepared for Gahagan & Bryant Associates, Inc. September 2001.

Blama, R.N., S.D. Garbarino, J. Gill, and M.C. Landin. 1995. "Shoreline Stabilization and Wetland Restoration at Barren Island and Historic Smith Island, Chesapeake Bay, Maryland: Innovative Geotextile Tube Technology." *Proceedings of the National Interagency Workshop on Wetlands: Technology Advances for Wetland Science.* April 5-7, 1995, New Orleans, Louisiana. Available online: http://www.wes.army.mil/el/workshop/contents.html (Section RE15).

Blankenship, Karl. 2000. "Beauty & the Beast: Foreign swan poses management questions for Bay." *Bay Journal* 10(3). May 2000. Article available online: http://www.bayjournal.com/00-05/swans.htm.

BNWR (Blackwater National Wildlife Refuge). 1999. Environmental Assessment Prepared for the Management Conflicts Associated with Non-migratory (Resident) Canada Geese – DRAFT. Prepared for the United States Fish and Wildlife Service. Available online: http://blackwater.fws.gov/rcg.html.

Bowman, Corporal Randy. 2001. Personal Communication with Cecelia Youngblood Oswald (WESTON) regarding commercial fishing near Barren Island, October 9, 2001. Corporal Bowman is the patrolling officer near Barren Island for the Maryland Natural Resources Police, Hillsboro Office.

Brinker, David. 2001. Personal Communication with Cecelia Youngblood Oswald (WESTON) regarding the results of the 1999 nesting bird census on Barren Island, October 15, 2001. David Brinker works for the Wildlife & Heritage Service of MD DNR, and noted that the bird count programs used to be funded as the Maryland Colonial Waterbird Program.

Campbell, Eric. 2001. Personal Communication with Cecelia Y. Oswald (WESTON) regarding the results of a database search on oyster health data in the vicinity of Barren Island. October 18, 2001. Eric Campbell is Biologist in the MD DNR Shellfish Division.

CBF (Chesapeake Bay Foundation). 2001. *Chesapeake Bay Foundation Guide to Underwater Grasses.* Available for download online: http://www.cbf.org/resources/pubs/index.htm#sav.

CBP (Chesapeake Bay Program). 2001a. Chesapeake Bay Program: America's Premier Watershed Restoration Program Web Page. Accessed August, September 2001. Online: http://www.chesapeakebay.net/index.htm.

CBP (Chesapeake Bay Program). 2001b. Chesapeake Bay Program Water Quality Database (1984 to Present). Available Online: http://www.chesapeakebay.net/wquality.htm.

CBP (Chesapeake Bay Program). 2001c. Bay Atlas: Online Interactive Charting and Mapping Tool. Online: http://www.chesapeakebay.net (select 'Bay Atlas' icon).

CBP (Chesapeake Bay Program). 2001d. *Toxics Reduction in the Chesapeake Bay Region in 2000.* Available online: http://www.chesapeakebay.net/pubs/toxics-00.pdf.

CBP (Chesapeake Bay Program). 2001e. Water Quality: Tidal Rivers and Main Bay. Available Online: http://www.chesapeakebay.net/status/WQcrntcond.cfm?subjectarea=TIDAL (Select station CB5.2, then select the 'Dissolved Oxygen' parameter).

CEGP (Coastal and Estuarine Geology Program). 2001. *Chesapeake Bay Sediment Distribution.* Online: http://www.mgs.md.gov/coastal/sedpageold2.html.

Cowardin, L.W., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish & Wildlife Service Publication FWS/OBS-79/31, Washington, D.C. 103 pp.

DOER (Dredging Operations and Environmental Research). 2000. *Improved Methods for Correlating Turbidity and Suspended Solids Monitoring.* Prepared for the US Army Corps of Engineers. ERDC TN-DOER-E8. June 2000. 11 pgs.

Drummond, D.D. 2001. Abstract of *Hydrogeology of the Coastal Plain Aquifer System in Queen Anne's and Talbot Counties, Maryland, with Emphasis on Water-Supply Potential and Brackish Water Intrusion in the Aquia Aquifer*. Maryland Geological Survey. Report of Investigations No. 72 (R.I. 72).

E2CR (Engineering Consultation Construction Remediation, Inc.). 2001. *Geotechnical Feasibility Study for Barren Island, Chesapeake Bay, MD.* December 2001.

Gelenter, David. 1990. University of Maryland's Center for Global Change. Unpublished report under contract to the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, Maryland. Provided by John Gill, USFWS.

Gill, John. 2001. Personal Communication. October 10, 2001. John Gill is Refuge Manager of Chesapeake Island Refuges, including Barren Island, for the USFWS.

Gill, John. 1990. Unpublished Field Notes from Site Visit to Barren Island on February 21, 1990.

Hindman, Larry. 2001. Mute Swans: Beautiful but Controversial Birds. ***Maryland Department of Natural Resources, Wildlife and Heritage Division.*** Online: http://www.dnr.state.md.us/wildlife/muteswans.html. Accessed September 21, 2001.

Lewis, Connie. 2001. Personal Communication with Cecelia Y. Oswald (WESTON). Connie Lewis is the Project Leader of Fisheries Statistics for MD DNR. Ms. Lewis also supplied oyster landings data for the last decade for Zone 129.

Mitsch, W.J. and J. G. Gosselink. 1993. "Chapter 8: Tidal Salt Marshes." *Wetlands*. Van Nostrand Reinhold, New York, New York. Second edition. 722 pgs.

MD DNR (Maryland Department of Natural Resources). 2001a. Importance of Bay Grass. Chesapeake Bay Web Page. Accessed September 2001.
Online: http://www.dnr.state.md.us/bay/sav/importance.html

MD DNR (Maryland Department of Natural Resources). 2001b. Maryland Commercial Fisheries: Commercial Chesapeake Bay Harvest Data 1975 – 2000 for Selected Species. Available online: http://www.dnr.state.md.us/fisheries/commercial/chbayharvest.htm

MD DNR (Maryland Department of Natural Resources). 2001c. Current Chesapeake Bay & Tributaries Fishing Reports. Accessed September, October 2001. Available Online: http://www.dnr.state.md.us/fisheries/fishingreport/chesapeake.html.

MD DNR (Maryland Department of Natural Resources). 2001d. *Mute Swans - Population Status, Impacts On Native Wildlife and People, and Management Needs In Maryland.* Prepared by the Mute Swan Task Force. January 2001. Available online: http://www.dnr.state.md.us/wildlife/mstfpc.html#msrecommend.

MD DNR (Maryland Department of Natural Resources). 1997. *Maryland's Historic Oyster Bottom: A Geographic Representation of the Traditional Named Oyster Bars.* MD DNR Fisheries Service. October 1997. Map in text reprinted with permission of Kelly Greenhawk of MD DNR.

MD DNR (Maryland Department of Natural Resources). 1961. Natural Oyster Bars in Maryland, Chart No. 23.

MDE (Maryland Department of the Environment). 2001. *Water Resources of Maryland.* Available online: http://www.mde.state.md.us/wetlands/wwr/MDResources.htm

NAS (National Audobon Society). 2001. Christmas Bird Count Database. Available online: http://birdsource.cornell.edu/cbc/.

NOAA (National Oceanic and Atmospheric Administration). 1994. *Distribution and Abundance of Fishes and Invertebrates in Mid-Atlantic Estuaries*. Estuarine Living Marine Resources Program. March 1994. 280 pgs.

Roe, Jaime. 2001. "Effort to Restore Barren Island is Underway." *The Mariner*. June 19, 2001.

Scott, Roy. 2001. Personal Communication with Cecelia Y. Oswald (WESTON). October 19, 2001. Mr. Scott is the Oyster Biologist within MD DNR Shellfish Division that conducts oyster bar surveys.

Serey, Ren. 2001. Personal Communication with Barry J. Dubinski (WESTON) regarding the applicability of the Critical Area Act to the proposed environmental restoration in the vicinity of Barren Island. December 20, 2001. Ren Serey is a staffpeson in the MD DNR Critical Area Commission.

Shepard, F.P., 1954, Nomenclature based on sand-silt-clay ratios: Journal of Sedimentary Petrology, v. 24, p. 151-158.

USACE (United States Army Corps of Engineers). 1994. *Environmental Assessment: Maintenance Dredging, Honga River and Tar Bay Navigation Channel, Dorchester County, Maryland.* USACE Baltimore District. June 1994.

USEPA, 2001a. *Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Database*. Available Online: http://www.epa.gov/enviro/html/cerclis/cerclis_query.html. Accessed 17 December 2001.

USEPA, 2001b. "EPA Superfund Sites." EPA Webpage, Accessed 17 December 2001. Available online: http://www.epa.gov/superfund/sites/index.htm.

USEPA Region III (United States Environmental Protection Agency). No date. *Inland Area Contingency Plan (DE, MD, WV, and D.C.)* CDROM. No Date.

USGS (United States Geological Survey). 2001. Butterflies of Dorchester County, Maryland. Accessed October, 2001. Online: http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/chklist/states/counties/md_19.htm

USGS (United States Geological Survey). 1998. *The Chesapeake Bay: Geologic Product of Rising Sea Levels.* Fact Sheet 102-98. US Department of the Interior. October 1998. Available Online: http://pubs.usgs.gov/factsheet/fs102-98/.

USGS (United States Geological Survey). 1997. *USGS Groundwater Atlas of the United States:Delaware, Maryland, New Jersey, Pennsylvania, North Carolina, Virginia, West Virginia.* HA-730L. Available online: http://capp.water.usgs.gov/gwa/ch_l/index.html.

Welsh, Stewart A., Jorgen E. Skjeveland, and Michael F. Mangold. 1999. A Progress Report of Investigations and Research on Atlantic and Shortnose Sturgeon in Maryland Waters of the Chesapeake Bay (1996 – 1998). Prepared by the U.S. Fish and Wildlife Service, Maryland Fisheries Resource Office. 15 June 1999.

White, C.P. 1989. *Chesapeake Bay: A Field Guide*. Tidewater Publishers: Centreville, Maryland. 212 pgs.

APPENDIX A

SITE RECONNAISSANCE REPORT

Barren Island Site Reconnaissance

Introduction

Roy F. Weston (WESTON®) has been contracted by Maryland Environmental Services (MES) to prepare a Preliminary Assessment of Environmental Conditions for Barren Island for the Barren Island Beneficial Reuse and Habitat Restoration project proposed by the Maryland Port Authority. The project would consist of the construction of a separate armored sand dike area west of the island, which would be backfilled with maintenance dredge material from a channel in the Chesapeake Bay. The purpose of the project is to curtail the extensive erosion currently occurring on the west side of the island. The purpose of the site reconnaissance was to evaluate the resources on the island that could potentially be impacted by the proposed project. This site reconnaissance report supplements additional investigations related to the proposed project.

Site Location

Barren Island is a satellite refuge for Blackwater National Wildlife Refuge (BNWR), and is owned by the United States Fish and Wildlife Service (USFWS). Barren Island is located on the southwestern side of Dorchester County, Maryland (see Figure 1 - Site location map). The island is approximately 180 acres in size. The 2-mile long west shoreline is currently eroding at an estimated rate of 10-14 feet per year, which translates to an approximate loss of 2.4 to 3.4 acres per year. Historical records indicate that 450 acres have eroded over 325 years, which correlates an average rate of 0.7 acres per year (Gelenter, 1990).

Site Visit

The site visit to Barren Island occurred on 10 October 2001, and was led by USFWS representative, John Gill, Refuge Manager for the Chesapeake Island Refuges Program for the USFWS. Three WESTON personnel, Robert McGlade, Cecelia Youngblood Oswald, and Emily Dyson, participated in the site visit that initiated at the USFWS office located near Cambridge, Dorchester County, Maryland. WESTON reviewed the USFWS files pertaining to Barren Island and obtained copies of the documents relevant to the proposed project, including historical land size information, land ownership history, and one set of field notes from a previous site visit. After completing the file review, WESTON personnel and Refuge Manager John Gill departed for a 4-hour field reconnaissance of Barren Island.

The shoreline of Barren Island was reconnoitered by boat, with the exception of a region on the east side of the island where shallow water and dense submerged aquatic vegetation restricted boat access. The north and south sides of the island were accessed by foot, and a qualitative examination of the types of habitat, species diversity, and species abundance was conducted. The natural resources encountered on the island are described in the following sections. Photographs from the reconnaissance are provided following this description.

Land Use

Currently, land use on Barren Island is entirely devoted to ecological habitat. Barren Island is uninhabited, and access to Barren Island is restricted to permit use only from USFWS. Some evidence of trespassing was evident on both the north and south ends of the island, including dog tracks and beverage containers in upland areas. No fences or other physical barriers are present to restrict access to the island.

Pre-colonial inhabitation or use of the island by Native Americans is known to have occurred, as evidenced by the arrowheads and midden piles that have been found on the island in the past. In colonial times, Barren Island was inhabited, and the last family is believed to have left in the early 1900s. In the 1930s, the land was privately owned and was the site of a hunting club. During this period, Barren Island served as a hunting ground for sportsmen.

General Observations

The island has approximately four miles of shoreline, consisting of low salt marsh, high salt marsh, sandy beaches, mud flats, and eroding woodlands. Upland areas on the island consist of approximately 65-70% woodland, with the remaining areas consisting of salt marsh and small ponds. Small pockets of salt pans and low salinity wetland areas were also present.

Topography of the island is very flat, as is typical on Bay islands, with the elevation ranging from 0 feet to an estimated 6 feet above mean high tide (MHT) (Photo 1).

The viewshed from the island to the north and west is the Bay, with Maryland's eastern and western shores visible across the Bay. To the east, Upper Hoopers Island lies approximately ½ to ¾ miles east, and is easily seen from the shoreline. Upper Hoopers Island is inhabited, and private homes and docking areas are visible. To the south, a small remnant island that was formerly a part of Barren Island, is prominent. This small island (unnamed) lies approximately 500 yards south of Barren Island (Photos 17 and 23).

Barren Island can be divided into three sections: the north end, the mid-area marsh (approximately 50 yards), and the south end. The mid-area marsh was not accessible because of shallow water and dense submerged aquatic vegetation. Observations specific to the north and south ends are detailed in the following two sections.

North End Reconnaissance

Of the two parts of the island visited by WESTON, human impact was more prevalent in the north than in the south. The remains of the hunting lodge from the 1930s was present on the north tip of the island (Photos 2 and 3). This lodge succumbed to erosion and crumbled into the Bay in the early 1990s, and is now a pile of rubble (Photo 7). A deteriorated wooden bulkhead that has long been breached lies offshore from the remains of the lodge, and now serves as a popular perching spot for double-crested cormorants (*Phalacrocorax auritus*) and various gulls (Photo 3). Behind the lodge to the south, the footprint of an old boathouse and associated canal, filled in with dredged materials by USACE in the mid-1990s, is present. Refuge Manager Gill also pointed out the location of an old grass runway that was operational at the same time as the hunting lodge (Photo 10).

The types of habitat observed on the north end of the island include low salt marsh, high salt marsh, sandy beaches, mud flats, and eroding woodlands (Photos 5 and 7). Small pockets of salt pans and low salinity wetland areas are also present (Photos 8 and 9). Woodland area was present towards the center of the north end. The shoreline marsh areas gradually transitioned into upland forest (Photo 6). John Gill noted that the approximately 30-foot wide unvegetated sandy beach on the northern tip of the island (located behind the geotextile tubes) could potentially serve as habitat for the federally threatened northeastern tiger beach beetle (*Cicindela dorsalis dorsalis*) habitat, although no survey for these organisms has been conducted to date (Photo 7).

Two recent shoreline/habitat restoration activities have occurred on the north end of Barren Island that were visible during the site visit: 1) the 1994 geotextile tube project; and 2) the 1999/2000 geotextile tube project. One of the 1994 geotextile tubes, now submerged, was visible above the waterline. This 1994 tube is located just inside of the 1999/2000 geotextile tubes that were installed outside the original tube configuration. The 1999/2000 tubes are still in place, with one tube breach obvious toward the northern tip of the island (Photo 4). The sandy dredge material pumped in behind the 1999/2000 tubes is still in place (Photo 7). John Gill pointed out the approximately 10 acre marsh planted by volunteers of various organizations, including the National Aquarium of Baltimore. The health and plant density of the newly planted marsh was surprisingly good. After only 1 season of growth, many of the grasses had seeded (unusual occurrence for new plantings) and a ponded area contained small fish (1-2 inch in length, species unknown) (Photo 5).

John Gill noted that he was extremely pleased with the plant colonization rates and species types present in this dredge spoils area, particularly compared with plants present in the canal and boathouse areas backfilled with dredge material in the mid 1990s. The canal and boathouse areas are dominated by the invasive wetland plant *Phragmites sp.*, whereas the recent dredge spoils area is dominated by *Spartina sp.* The difference between these two areas is a relatively minor elevation change. The canal and boathouse areas were filled too high, and consequently are too dry for *Spartina sp.* to thrive. The evidence that a minor elevation difference can drastically affect the success of habitat restoration project strongly suggests that USFWS staff or other biological specialists should be present during the construction phase as well as the planting phase of any restoration project.

A list of flora and fauna observed during the site visit is provided in a subsequent section. No species were encountered in the northern end that were not seen in the southern end.

South End Reconnaissance

The south island did not contain evidence of previous human inhabitation. No obvious remains of dwellings or other anthropogenic structures were present. John Gill did point out that a cemetery is located on the southwest side of the island and is eroding into the Bay. The cemetery was not visited.

Low and high salt marsh areas were present on the southwest end of the island. On the southeast side, a large forested area abutted the Bay, and a 1 to 3 foot eroded bank was present in places (Photo 13). Downed trees were present in the water and along the edges of the shoreline. The forest was dominated by loblolly pine (*Pinus taeda*). Portions of the forest were mature, with some of the largest loblolly pines exceeding 2' dbh (diameter at breast height) (Photos 14 through 16).

The mature portions of the southern forest serve as a great blue heron (*Ardea herodias*) rookery. Although not nesting season during the visit, evidence of the rookery was prevalent. Many heron nests were visible in the tree canopy, and pale blue-green eggshell fragments were present on the forest floor (Photo 21). This mature forest area also contained an active bald eagle's nest, which was observed during the site visit (Photo 18). A bald eagle (*Haliaeetus leucocephalus*) was also sited during the visit. The eagle was perched on a tree on the southwest side of the island (Photo 22). A brown pelican was also sited just offshore of Barren Island, and John Gill noted that brown pelicans (*Pelecanus occidentalis*) are known to nest in the small remnant island to the south of Barren Island (Photo 23). It is possible that pelicans nest on Barren Island as well, although no evidence of a brown pelican nest was found.

In addition to egg shells, two turtle shells, one small bird nest, and two deer skulls were found in the southern end of the island. Beds of submerged aquatic vegetation (SAV), predominantly widgeon grass (*Ruppia maritima*), were located in the shallow waters on the south and east sides of the island (Photo 16). The east side of the island was inaccessible due to shallow waters and heavy seagrass. All SAV is located on the leeward side (in the 'shadow') of Barren Island and the small remnant island. Wave action is too great on the west side of the island to permit SAV growth.

One final note, little underbrush was present in some areas of the mature forest (Photo 19). John Gill noted that these open areas would be prime Delmarva fox squirrel (*Sciurus niger cinereus*) habitat, although these animals are not known to occur on the island. Delmarva fox squirrels are very common in Dorchester County, particularly in BNWR.

Island Vegetation

Similar plant species were present on both the north and south sides of the island. The dominant low salt marsh plant is *Spartina alterniflora*, and the dominant high salt marsh plant is *Spartina patens*. The dominant overstory plant in the mixed coniferous/deciduous forest is loblolly pine, with greenbriar (*Smilax rotundifolia*), American Holly (*Ilex opaca*), and poison ivy (*Toxicodendron radicans*) commonly present in the understory. Table 1 lists the plant species that were observed on the north and south ends of Barren Island during the field reconnaissance. This list is not a complete list of all plant species on the island. A baseline ecological survey would be required to generate a comprehensive list of plant diversity.

Island Wildlife

Similar faunal species were present on both the north and south sides of the island. Table 2 lists the faunal species observed on Barren Island during the site visit. This list is not a complete list of all faunal species on the island. A baseline ecological survey would be required to generate a comprehensive list of animal diversity.

Numerous species of birds, including one bald eagle, were observed on the island. Evidence of white-tailed deer inhabitation, including tracks, scats, skulls, and a browse line in the forest was present. One white-tailed deer was sited on the south end of the island. Evidence of raccoons (scat) was found on both the north and south ends of the island. Dog tracks were also prevalent, although these are likely the pets of trespassers. J. Gill reported finding evidence of muskrat (*Ondatra zibethicus*), red fox (*Vulpes vulpes*), and river otter (*Lutra canadensis*) during past visits.

No live reptiles or amphibians were observed during the site visit, although shells of two turtle species were found: Northern diamondback terrapin (*Malaclemys terrapin terrapin*) and Eastern mud turtle (*Kinosternon subrubrum subrubrum*). J. Gill reported that he had seen eastern painted turtles (*Chrysemys picta picta*) and red bellied turtles (*Pseudemys rubriventris*) at Barren Island during past site visits. According to the USFWS, no formal herpetological survey has been performed on Barren Island to date.

The most prevalent invertebrate species observed were fiddler crabs (*Uca spp.*). Shells and remains of blue crabs (*Callinectes sapidus*), oysters (*Crassostrea virginica*), horseshoe crabs (*Limulus polyphemus*) and other shellfish and benthic organisms were scattered on the shoreline among the plant debris. Several species of butterflies, including one monarch butterfly (*Danaus plexippus*), were observed on Barren Island. John Gill noted that Barren Island serves as excellent habitat for migrating species of butterflies, although he did not list any specific species. According to the USFWS, no formal ecological survey for invertebrate species has been performed on Barren Island to date.

Aquatic Flora and Fauna

Numerous SAV beds were located to the south and east of the island, which were predominantly comprised of widgeon grass (*Ruppia maritima*). J. Gill noted that eel grass (*Zostera marina)* is also common in the Tar Bay area, although none was observed in the water or on the shoreline. As noted above, oyster shells and remains of blue crabs and horseshoe crabs were scattered on the shoreline. Numerous crab pots were observed in the water to the north of Barren Island. Both horseshoe crabs and blue crabs are known to feed in the shallows around Barren Island, although this activity was not observed. J. Gill noted that he fished recreationally in Tar Bay and often caught speckled seatrout (*Cynoscion nebulosus*). Several small ponded areas were present around the island, and these ponds contained small fish (Photos 8, 9, 11, and 20). J. Gill suggested that the fish may be mosquitofish (*Gambusia affinis*), although he was not certain of this field identification.

Upon return to the dock area, WESTON observed several commercial crab boats unloading the day's catch of blue crab. One boat contained at least 35 bushels of crab. The exact location where these crabs were caught is not known, although it is reasonable to assume it was in the vicinity of Barren Island, possibly where crab pots were observed in the water north of the island.

USFWS does not own any of the shallow water habitat offshore of Barren Island. Consequently, it does not perform offshore monitoring or surveys.

References

Gelenter, David. 1990. University of Maryland's Center for Global Change. Unpublished report under contract to the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, Maryland. Provided by John Gill, USFWS.

Gill, John. 1990. Unpublished Field Notes from Site Visit to Barren Island on February 21, 1990.

Contact Information

Contact information for personnel that participated in this site reconnaissance effort is provided below.

John Gill
Refuge Manager
Chesapeake Island Refuges
Chesapeake Marshlands National Wildlife Refuge Complex
2145 Key Wallace Drive
Cambridge, MD 21613
410.228.2692

Cecelia Y. Oswald
Project Scientist
Roy F. Weston, Inc.
1400 Weston Way
P.O. Box 2653
West Chester, PA 19462
610.701.3486

Robert McGlade
Sr. Project Scientist
Roy F. Weston, Inc.
1400 Weston Way
P.O. Box 2653
West Chester, PA 19462
610.701.3133

Emily Dyson
Sr. Project Leader
Roy F. Weston, Inc.
1395 Piccard Drive
Rockville, Maryland 20850
301.208.6828

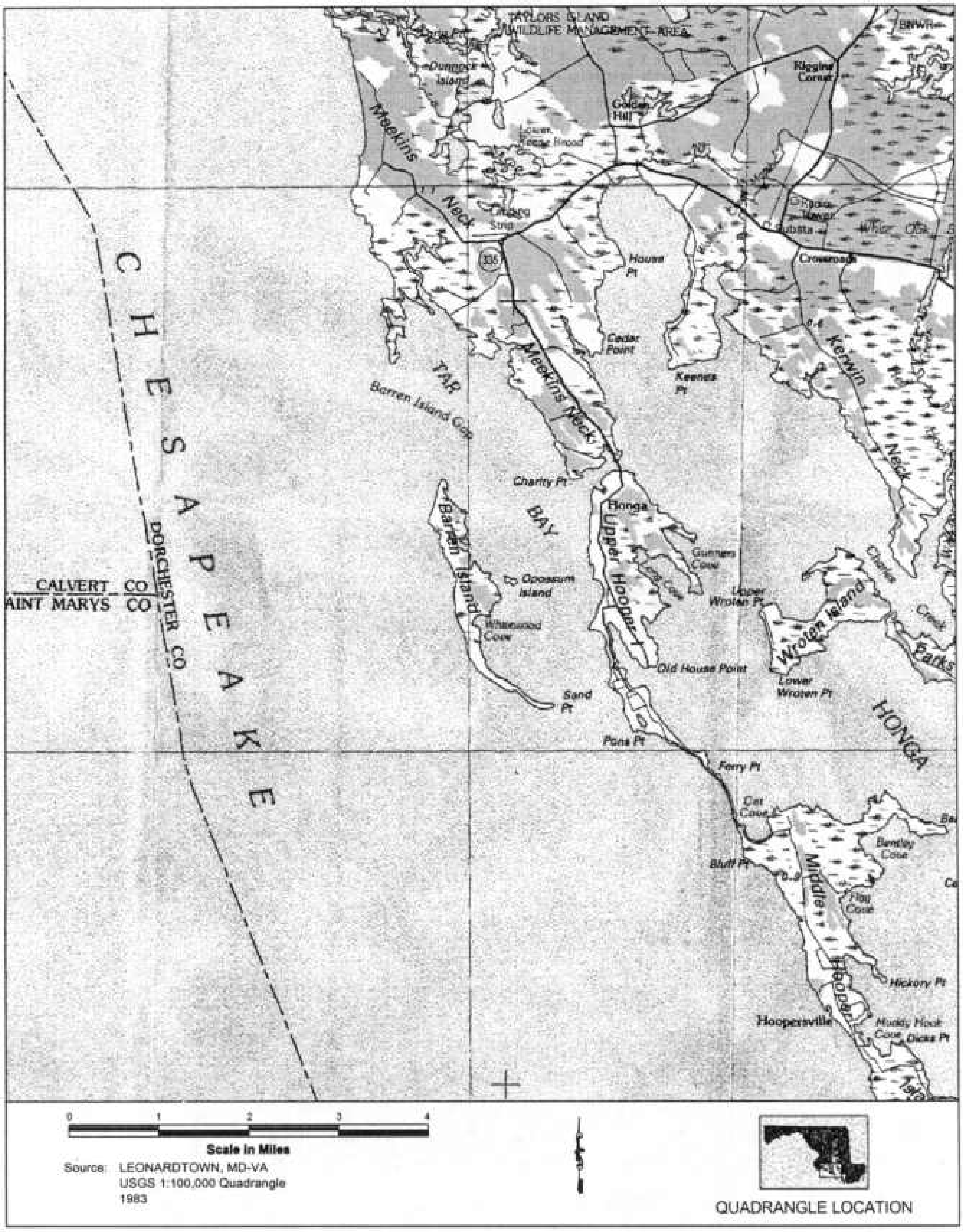


FIGURE 1 BARREN ISLAND LOCATION MAP
CHESAPEAKE BAY
DORCHESTER COUNTY, MARYLAND

Table 1. Flora Observed on Barren Island

Common Name	Scientific Name
Submerged Aquatic Vegetation	
Widgeon Grass	*Ruppia maritima*
Salt Marsh/Wetland Species	
Saltmarsh cordgrass	*Spartina alterniflora*
Saltmeadow cordgrass	*Spartina patens*
Saltgrass	*Distichlis spicata*
Black needlerush	*Juncus roemerianus*
Slender glasswort	*Salicornia europaea*
Saltmarsh fleabane	*Pluchea purpurascens*
Seaside goldenrod	*Solidago sepervirens*
Big cordgrass	*Spartina cynosuroides*
Switchgrass	*Panicum virgatum*
Common threesquare	*Scirpus americanus*
Smartweed	*Polygonum spp.*
Giant foxtail	*Setaria faberi*
Duckweed	*Lemna spp.*
Narrow-leaved cattail	*Typha angustifolia*
Common reed	*Phragmites australis*
Walter's millet	*Echinochloa walteri*
Marsh elder	*Iva frutescens*
Groundsel tree	*Baccharis halimifolia*
Marsh hibiscus	*Hibiscus moscheutos*
Upland Species	
Loblolly pine	*Pinus taeda*
American holly	*Ilex opaca*
Common greenbriar	*Smilax rotundifolia*
Poison Ivy	*Toxicodendron radicans*
Trumpet Creeper	*Campsis radicans*
Bayberry	*Myrica pensylvanica*
Oak	*Quercus spp.*
Common Persimmon	*Diospyros virginiana*
Eastern red cedar*	*Juniperus virginiana*
Raspberry*	*Rubus spp.*
Pokeberry	*Phytolacca americana*
Sumac	*Rhus spp.*
Japanese honeysuckle*	*Lonicera japonica*
Black locust*	*Robinia pseudo-acacia*

* = Species observed by J. Gill during 1990 Field Survey (Gill, 1990); species was not observed on 10 October 2001.

Table 2. Fauna Observed on Barren Island

Common Name	Scientific Name
Birds	
Herring gull	*Larus argentatus*
Great black-backed gull	*Larus marinus*
Ring-billed gull	*Larus delawarensis*
Double-crested cormorant	*Phalacrocorax auritus*
Bald eagle (adult)	*Haliaeetus leucocephalus*
Great blue heron	*Ardea herodias*
American black duck	*Anas rubripes*
Snowy egret	*Egretta thula*
Osprey (nest only)	*Pandion haliaetus*
Mute swan	*Cygnus olor*
Brown pelican	*Pelecanus occidentalis*
Mallard duck*	*Anas platyrhynchos*
Tundra swans*	*Cygnus columbianus*
Bufflehead*	*Bucephala albeola*
Merganser*	*Mergus merganser*
Common goldeneye*	*Bucephala clangula*
Owl* (scat/cast only)	Unidentified species
Reptiles	
Northern diamondback terrapin (shell only)	Malaclemys terrapin terrapin
Eastern mud turtle (shell only)	*Kinosternon subrubrum subrubrum*
Eastern painted turtle*	*Chrysemys picta picta*
Red belly turtle*	*Pseudemys rubriventris*
Mammals	
White-tailed deer	*Odocoileus virginianus*
Raccoon (scats only)	*Procyon lotor*
River otter* (sign only)	*Lutra canadensis*
Muskrat*	*Ondatra zibethicus*
Red fox* (sign only)	*Vulpes vulpes*
Invertebrates	
Fiddler crabs	*Uca spp.*
Blue crabs	*Callinectes sapidus*
Marsh periwinkle*	*Littorina irrorata*
Coffee bean snail*	unknown
Horseshoe crabs (shell only)	*Limulus polyphemus*
American oysters (shell only)	*Crassostrea virginica*
Barnacles (on piling offshore)	not identified

* = Species observed by J. Gill during 1990 Field Survey (Gill, 1990); species was not observed on 10 October 2001.

APPENDIX B

CHRISTMAS BIRD COUNT RESULTS

Appendix B.
Bird Species Present in Dorchester County, Maryland

Common Loon	Merlin	Brown Creeper
Pied-billed Grebe	Peregrine Falcon	Carolina Wren
Horned Grebe	Ring-necked Pheasant	House Wren
Double-crested Cormorant	Wild Turkey	Winter Wren
American Bittern	Northern Bobwhite	Sedge Wren
Great Blue Heron (Blue form)	King Rail	Marsh Wren
Great Egret	Virginia Rail	Golden-crowned Kinglet
Black-crowned Night-Heron	American Coot	Ruby-crowned Kinglet
Tundra Swan	Killdeer	Eastern Bluebird
Trumpeter Swan	Greater Yellowlegs	Hermit Thrush
Mute Swan	Lesser Yellowlegs	American Robin
Snow Goose	Western Sandpiper	Gray Catbird
Ross's Goose	Dunlin	Northern Mockingbird
Canada Goose	Long-billed Dowitcher	Brown Thrasher
Wood Duck	dowitcher sp.	American Pipit
American Green-winged Teal	Common Snipe	Cedar Waxwing
American Black Duck	American Woodcock	European Starling
Mallard	Ring-billed Gull	Yellow-rumped (Myrtle) Warbler
Northern Pintail	Herring Gull	Pine Warbler
Blue-winged Teal	Great Black-backed Gull	Common Yellowthroat
Northern Shoveler	Rock Dove	Northern Cardinal
Gadwall	Mourning Dove	Eastern Towhee
American Wigeon	Barn Owl	American Tree Sparrow
Canvasback	Eastern Screech-Owl	Chipping Sparrow
Redhead	Great Horned Owl	Field Sparrow
Ring-necked Duck	Short-eared Owl	Vesper Sparrow
Lesser Scaup	Belted Kingfisher	Savannah Sparrow (form?)
scaup sp.	Red-headed Woodpecker	Seaside Sparrow
Common Goldeneye	Red-bellied Woodpecker	Fox Sparrow
Bufflehead	Yellow-bellied Sapsucker	Song Sparrow
Hooded Merganser	Downy Woodpecker	Swamp Sparrow
Common Merganser	Hairy Woodpecker	White-throated Sparrow
Red-breasted Merganser	Northern (Yellow-shafted) Flicker	White-crowned Sparrow
merganser sp.	Pileated Woodpecker	Dark-eyed (Slate-colored) Junco
Ruddy Duck	Eastern Phoebe	Red-winged Blackbird
Black Vulture	Horned Lark	Eastern Meadowlark
Turkey Vulture	Blue Jay	Rusty Blackbird
Bald Eagle	American Crow	Boat-tailed Grackle
Northern Harrier	Fish Crow	Common Grackle
Sharp-shinned Hawk	crow sp.	Brown-headed Cowbird
Cooper's Hawk	Carolina Chickadee	Purple Finch
Red-shouldered Hawk	Tufted Titmouse	House Finch
Red-tailed Hawk	Red-breasted Nuthatch	American Goldfinch
Rough-legged Hawk	White-breasted Nuthatch	House Sparrow
Golden Eagle	Brown-headed Nuthatch	Eastern Rufous-sided Towhee
American Kestrel		

Source : National Audubon Society. *Audobon Christmas Bird Count Results 1995-2000.* http://birdsource.cornell.edu/cbc. Accessed 10/01

APPENDIX C

CORRESPONDENCE

F
CE

WESTON
MANAGERS DESIGNERS/CONSULTANTS

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

CDS/SRB

RECEIVED
AUG

20010316?

August 24, 2001

Ms. Elizabeth Cole
Maryland Historic Trust
Department of Housing and Development
100 Community Place
Crownsville, MD 21032

Barren Island
Arch. — no/e.
(1A)
9/10/01

Re: Information Act Request

Dear Ms. Cole:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting a review of the historic, cultural or archaeological significance of the referenced property.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

A review of MHT files and your submittal indicates that this project is unlikely to affect significant historic and archeological properties.

Gary Shaffer — 9-18-01

Office of Preservation Services
Maryland Historical Trust — Date

IA
9/17
SRB

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway • Baltimore Maryland 21224
(410) 631-3000 • 1-800-633-6101 • http:// www. mde. state. md. us

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

September 12, 2001

Ms. Emily F. Dyson
Roy F. Weston, Inc.
1395 Piccard Drive
Suite 200
Rockville MD 20850

RE: Tracking Number: 2001-05906
Request Received August 31, 2001

MISCELLANEOUS

Dear Ms. Dyson:

The Maryland Department of the Environment (MDE) received your recent request for information under the Public Information Act (PIA).

After conducting a thorough search of our files, the Waste Management Administration has no records responsive to your request. There were no charges incurred as a result of this search.

When requesting information regarding this request, please cite the tracking number referenced above. If you have any questions, please call me at (410) 631-3314.

Sincerely,

Maria Stephens

Maria Stephens
PIA Liaison
Waste Management Administration

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Mr. Donald Mauldin
Public Information Act Coordinator
Maryland Department of the Environment
2500 Broening Highway
Baltimore, Maryland, 21224

Re: Information Act Request

Dear Mr. Mauldin:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any general environmental information concerning Barren Island that MDE may possess.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON
MANAGERS DESIGNERS/CONSULTANTS

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Mr. J. Rodney Little
State Historic Preservation Officer
Maryland Historic Trust
45 Calvert Street
Fourth Floor
Annapolis, MD 21401

Re: Information Act Request

Dear Mr. Little:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any historic and cultural resource information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Thomas C. Voltaggio
Deputy Regional Administrator
U.S. Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107

Re: Information Act Request

Dear Mr. Voltaggio:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any general environmental information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON MANAGERS DESIGNERS/CONSULTANTS
Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Mr. Gary Setzer
Program Manager
Water Management and Administration
Maryland Department of the Environment
2500 Broening Highway
Baltimore, Maryland, 21224

Re: Information Act Request

Dear Mr. Setzer:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any water resource information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON
MANAGERS DESIGNERS/CONSULTANTS
Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Ms. Susan Langley
State Underwater Archaeologist
Division of Historical and Cultural Programs
100 Community Place
Crownsville, MD 21032

Re: Information Act Request

Dear Ms. Langley:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any underwater archaeological information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON
MANAGERS DESIGNERS/CONSULTANTS

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Mr. Richard B. Hughes
Chief of the Office of Archeology
Division of Historical and Cultural Programs
100 Community Place
Crownsville, MD 21032

Re: Information Act Request

Dear Mr. Hughes:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any general archeological information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON
MANAGERS DESIGNERS/CONSULTANTS

Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Rich Takacs
Mid-Atlantic Restoration Coordinator
NOAA Restoration Center
410 Severn Ave., Suite 107A
Annapolis, MD 21403

Re: Information Act Request

Dear Mr. Takacs:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting any national marine fisheries information concerning Barren Island.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

WESTON
MANAGERS DESIGNERS/CONSULTANTS
Roy F. Weston, Inc.
Suite 200
1395 Piccard Drive
Rockville, Maryland 20850-4391
301-208-6800 • Fax 301-208-6801
www.rfweston.com

August 24, 2001

Ms. Elizabeth Cole
Maryland Historic Trust
Department of Housing and Development
100 Community Place
Crownsville, MD 21032

Re: Information Act Request

Dear Ms. Cole:

Roy F. Weston, Inc. (WESTON) is currently preparing an Environmental Conditions Report as part of the Conceptual Study for Barren Island located in the Chesapeake Bay, in Dorchester County, Maryland (vicinity map enclosed). The study will evaluate the potential of using Barren Island as a large-scale beneficial use and habitat restoration site on the order of 1000 to 2000 acres using dredged material. In order to properly assess these properties, I am requesting a review of the historic, cultural or archaeological significance of the referenced property.

If the property information provided is not sufficient to conduct an accurate file search, or if you have any questions, please contact me at (301) 208-6828. Please forward the results of the record search to my office at the address listed above. Thank you for your assistance.

Sincerely,

Emily F. Dyson

Emily F. Dyson
Senior Project Leader

Enclosure

APPENDIX D

CERCLA SITES IN THE VICINITY OF BARREN ISLAND

PATUXENT RIVER NAVAL AIR STATION

Information on the Patuxent River Naval Air Station site was identified and retrieved on 17 December 2001 from the U.S. EPA Region III website at http://www.epa.gov/reg3hwmd/super/index.htm.

The information is as follows:

Patuxent River Naval Air Station
Maryland
EPA ID# MD7170024536
EPA Region 3
St. Mary's County
Cedar Point
5th Congressional District

Current Site Status

EPA and the Navy signed the federal facility agreement (FFA), which outlines the work for the environmental cleanup in December 2000.

EPA and the Navy with state concurrence signed the record of decision (ROD) for operable unit one (OU1) for Fishing Point Landfill and the Landfill Behind the Rifle Range. The landfill will be closed and used for limited recreational reuse. The remedial action (RA), a soil cover at the landfills began in the Spring of 2000. Construction is almost complete. A pre-final inspection was conducted on May 22, 2001. The final construction inspection for OU1 at Site 6 (Bohneyard) was also conducted on May 22, 2001. A concrete fuel tanker trunk parking lot was constructed at the Bohneyard, a former drum staging area. Reuse if the CERCLA site will save the Navy significant amount of money in its daily operations. Approximately 23-acres of land will be available for future redevelopment as a result of the fuel tanker consolidation in the vicinity of the taxiway, runways and fuel storage area.

Site Description

The Naval Air Station Patuxent River is located in St. Mary's County, Maryland is a 6,400-acre facility located at the confluence of the Patuxent River and the Chesapeake Bay on a peninsula known as Cedar Point. The Navy facility is located next to the city of Lexington Park which has a population of about 13,000. There are approximately 17,500 military, civilian, contractors and nonappropriated fund personnel that work at the Naval Air Station on a normal day. That number has grown with the influx of workers from the base realignment and closure (BRAC) activities from other Navy installations in 1998.

Surface water on the facility is contaminated as a result of the operations of the Fishing Point, the Former Sanitary, and the Current Sanitary Landfills—and from a portion of the site known as the Pesticide Control Rinse Area. From 1960 to 1974, the Fishing Point Landfill (a filled wetland area) received solid and hazardous wastes such as sewage treatment plant sludge, cesspool wastes, spent oil absorbents, paints, antifreeze, solvents, thinners, pesticides, and photo lab wastes. In 1974, the Navy began depositing these wastes in the Former Sanitary Landfill and, in 1980, began using the Current Sanitary Landfill, which remained open until September 1994. The Former and Current Sanitary Landfills cover a total of 16½ acres. The Pesticide Control Shop Rinse Area generated 300 to 400 gallons of rinsate per day from 1962 until the late 1970s. Two fishing areas on the site, Pond 3 and Pine Hill Run, are located in the surface water runoff pathway of the Pesticide Shop. Pine Hill Run flows into the Chesapeake Bay. The State of Maryland issued a fish advisory for the ponds on the base. The town of Lexington Park directly borders and is up gradient from the base.

Site Responsibility
The site is being addressed through Federal actions.
NPL Listing History
Proposed Date: 01/18/94
Final Date: 05/31/94

Threats and Contaminants

The soil and surface water are contaminated with sludge, cesspool wastes, oil absorbents, paints, antifreeze, solvents, thinners, photo lab wastes, hospital wastes, and asbestos. In addition, the soil and sediments are contaminated with pesticides, including DDT and chlordane. The wetlands located along the southern and northern borders of Fishing Point were used for shell fishing and fishing. The Chesapeake Bay supports recreational and fishing activities.

Cleanup Progress

Actual Construction Underway

Previously in January 1994, to prevent further erosion of Fishing Point Landfill into the Patuxent River, the Navy completed reclamation of the north shoreline. Sand was transported in and barriers were constructed in the river. An early action at Site 24 (Dry Well) was conducted in March 1996. Wastes from electroplating operations and soil around the dry well as well as the dry well were removed. The removal is not complete because construction trailers were in the way.

A Record of Decision (ROD) was signed July 29, 1996, for the Former Sanitary Landfill Site for operable unit one (OU 1). The ROD required that the landfill be capped with an impermeable liner; upgrade of the leachate collection system; and installation of a landfill gas collection system with a filter and flare. The Remedial Design (RD) was approved July 31, 1996 and construction began August 6, 1996. Construction was complete as of March 25, 1997. The site is in its long-term monitoring phase.

In an area next to the Former Sanitary Landfill, the Navy in conjunction with EPA, FWS and MDE constructed an impermeable cap over clean soil. A 40x60-ft. test plot was planted with shallow rooted native shrubbery (sumac, bayberry, and blueberry). The plot is being evaluated *for root growth to determine if similar plants can be used as vegetative cover at landfills to reduce the long-term operations and maintenance cost.*

In October 1996, a soil and drum removal was conducted at Site 34 (Former Drum Disposal Area and Borrow Pit). Approximately 3,000 cubic yards of contaminated soil were removed along with 111 full drums and 29 crushed drums. The soil and crushed drums were sent for disposal in December 1997. The full drums were, over packed, staged, characterized and disposed of in March 1998. The area was graded and revegetated. The RI/FS continues at the site.

The Navy and EPA signed a ROD for Site 17 (Pesticide Shop) on Dec. 16, 1998 with state concurrence. Excavation of soil that posed a risk to humans began on Dec. 18, 1999. The Navy completed a soil toxicity and bioaccumulation test as required by the ROD. Approximately 3,108 tons of soil was sent to be incinerated off site. The excavation stopped on March 15, 1999 due to realization that it appeared that there was more contaminated soil at the site than originally anticipated. As a result, additional analytical data was collected. Based upon this data, the Navy in conjunction with EPA and in consultation with MDE decided to Amend the original ROD. The ROD should be signed by June 2001 and the remedial action should resume the Summer of 2001.

The Navy and EPA signed a ROD with State concurrence for Sites 6 and 6A (Bohneyard Area) on September 29, 1999. The ROD selected various soil covers for reuse of the site. The base will construct a fuel tanker truck parking lot on approx. 3-acres of Site 6. As a result, fuel operations will be consolidated in one central location. The perimeter of the parking lot will be covered with a gravel/soil cover and then be vegetated. Site 6A will continue to be used as a temporary staging and storage area but will be covered with asphalt. As a result of the fuel consolidating operations, approximately 23-acres of land will be available for future reuse and redevelopment on base.

On February 8, 2000, EPA and the Navy signed the record of decision (ROD) with state concurrence for operable unit one (OU1) Fishing Point Landfill and the Landfill Behind the Rifle Range. A soil cover will be constructed over the landfills. Partnering efforts resulted in the state accepting a variance to its solid waste landfill closure regulations. The Navy is expected to save an estimated $4.3 million by not constructing a RCRA Subtitle D (impermeable liner) over the landfills. The remedial design (RD) was accepted by EPA on February 14, 2000. Construction began Spring 2000. The Navy stock piled approximately 60,000 cubic yards of soil from various construction activities on base. Using this soil will save the Navy an additional $800,000. In addition, the Navy will save about $750,000 for the shoreline stabilization component in the remedy as a result of efforts by EPA, the Navy, MDE, and the Biological Technical Assistance Team (BTAG) consisting of members of EPA, the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration (NOAA). In addition, the soil borrow area is being used as a experimental effort to create top soil by using Class A sludge (composted biosolids).

A Rod Amendment is expected to be signed for Site 17(Pesticide Shop) in June or July 2001. The ROD selects partial excavation and off site incineration and disposal.

APPENDIX E

SUMMARY OF ESSENTIAL FISH HABITAT (EFH) AND GENERAL HABITAT PARAMETERS FOR FEDERALLY MANAGED SPECIES

Source: Material included in this Appendix is excerpted directly from the National Marine Fisheries Service (NMFS) *Guide to Essential Fish Habitat Descriptions* (NMFS, 2001)

Note: The EFH designation applies to nine of the fish provided in the Appendix.

- Windowpane flounder
- Bluefish
- Atlantic butterfish
- Summer flounder
- Black sea bass
- King mackerel
- Spanish mackerel
- Cobia
- Red drum

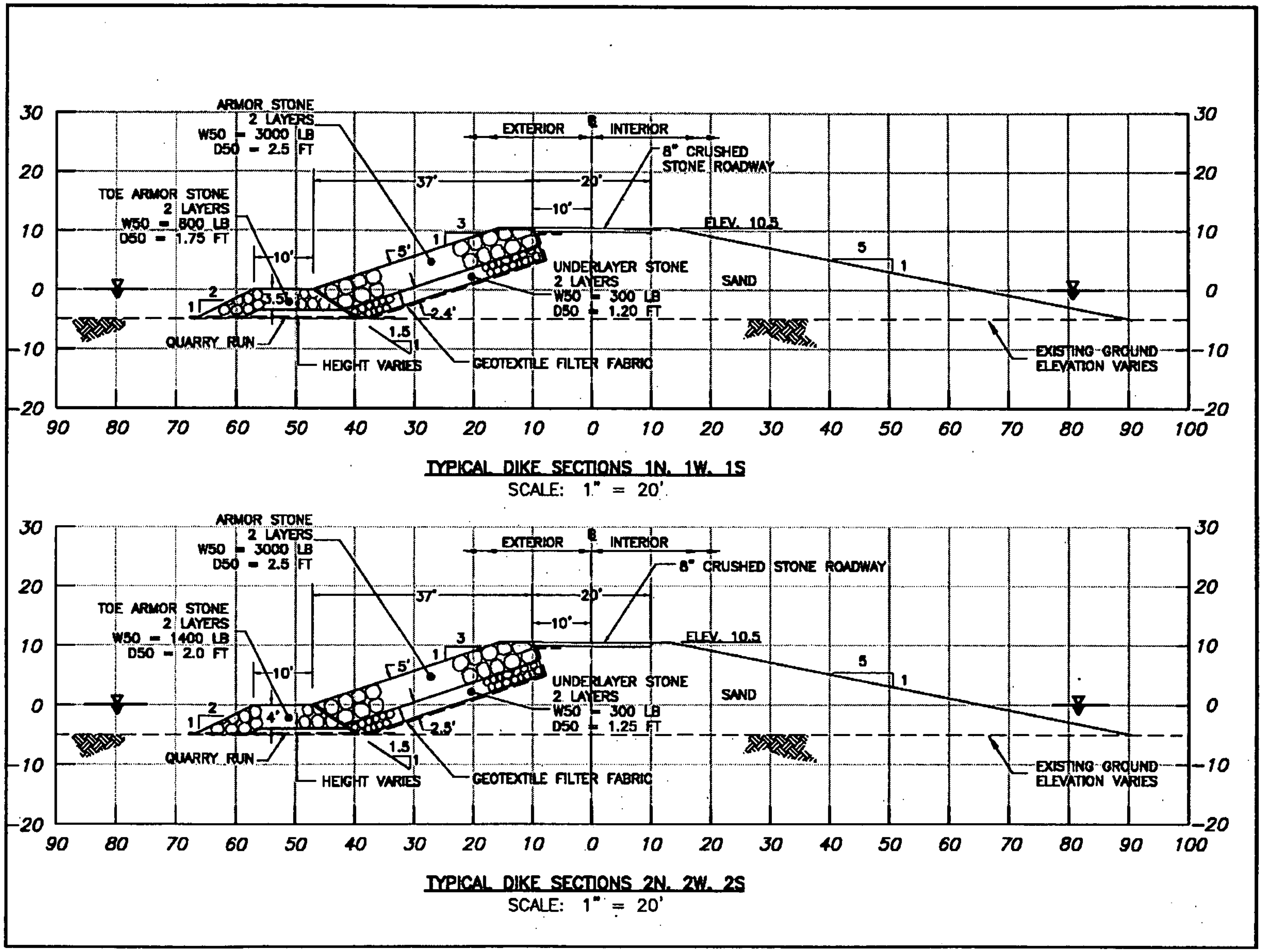
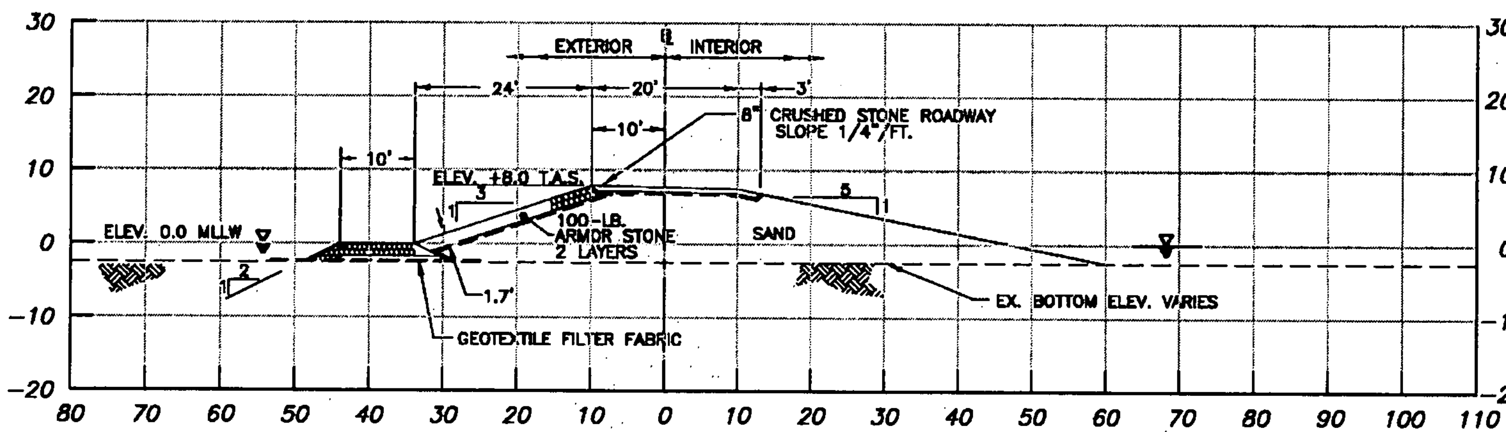


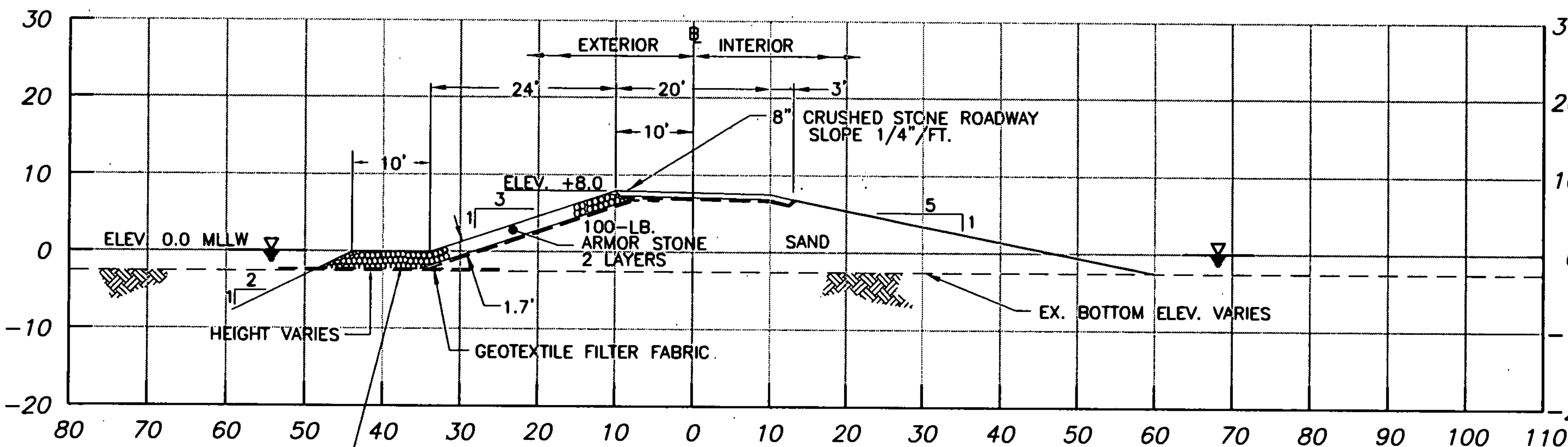
Figure 15: Barren Island Typical North, West, and South Dike Sections for Alignments 1 and 2.



TYPICAL DIKE SECTION 1E & 2E
SCALE: 1" = 20'

Figure 16: Barren Island Typical East Dike Sections for Alignments 1 and 2.

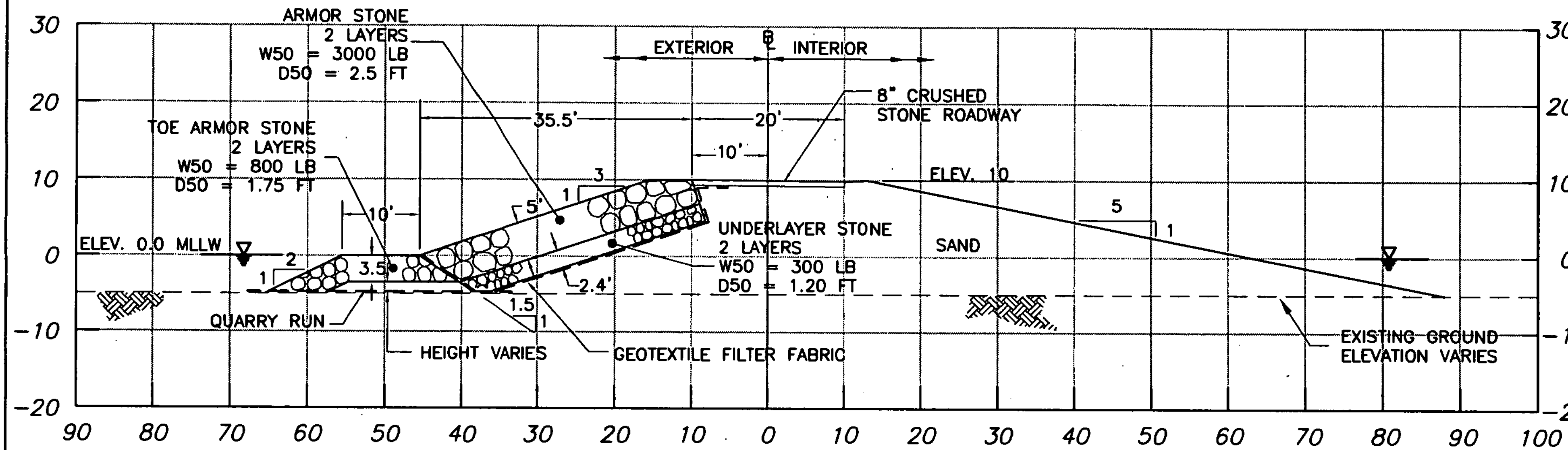
FIGURE No. 7 – BARREN ISLAND TYPICAL DIKE SECTIONS



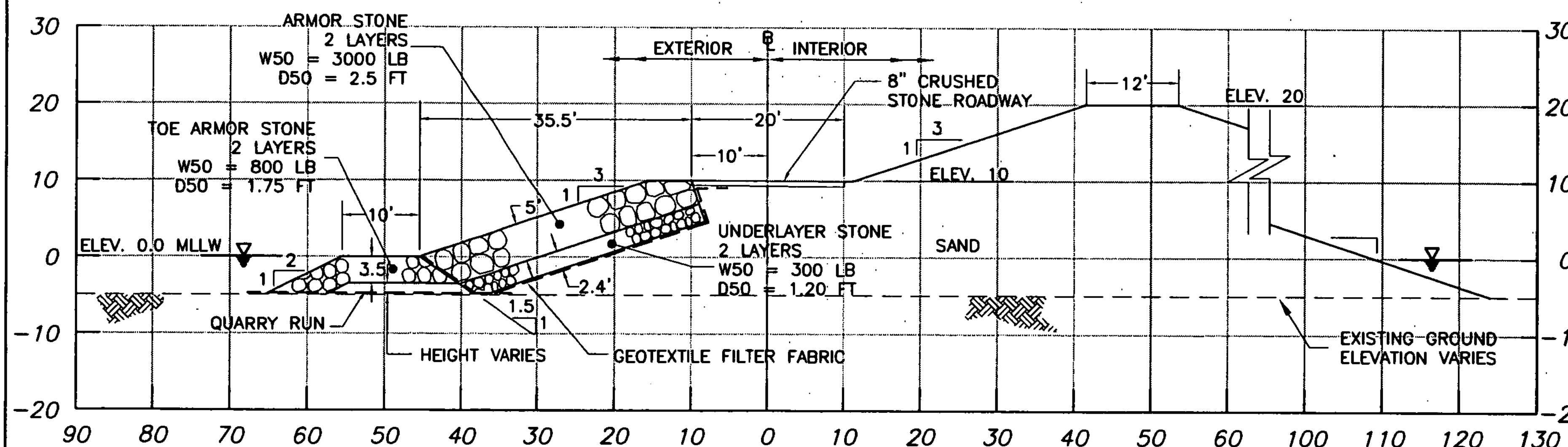
TYPICAL DIKE SECTION 1
SCALE: 1" = 20'

NOTE:
MINIMUM THICKNESS OF TOE ARMOR STONE SHALL BE 2.5'. IF BOTTOM ELEVATION IS BELOW –2.5', FILL WITH ADDITIONAL ARMOR STONE. IF BOTTOM ELEVATION IS ABOVE –2.5', EXCAVATE TO –2.5'.

FIGURE No. 8 – BARREN ISLAND TYPICAL DIKE SECTIONS

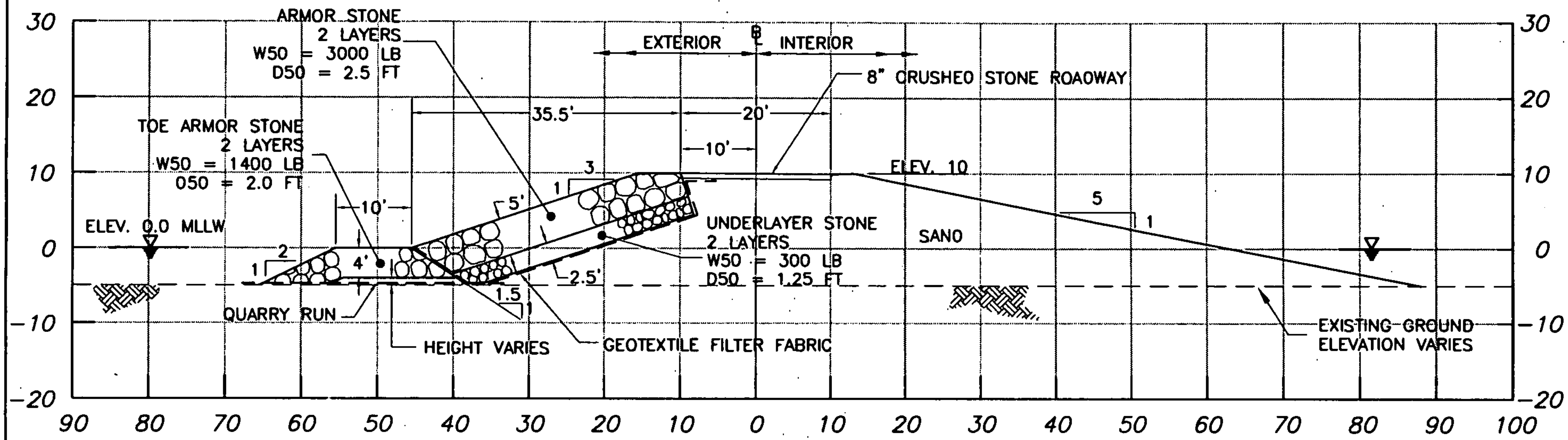


TYPICAL DIKE SECTION 2A
SCALE: 1" = 20'



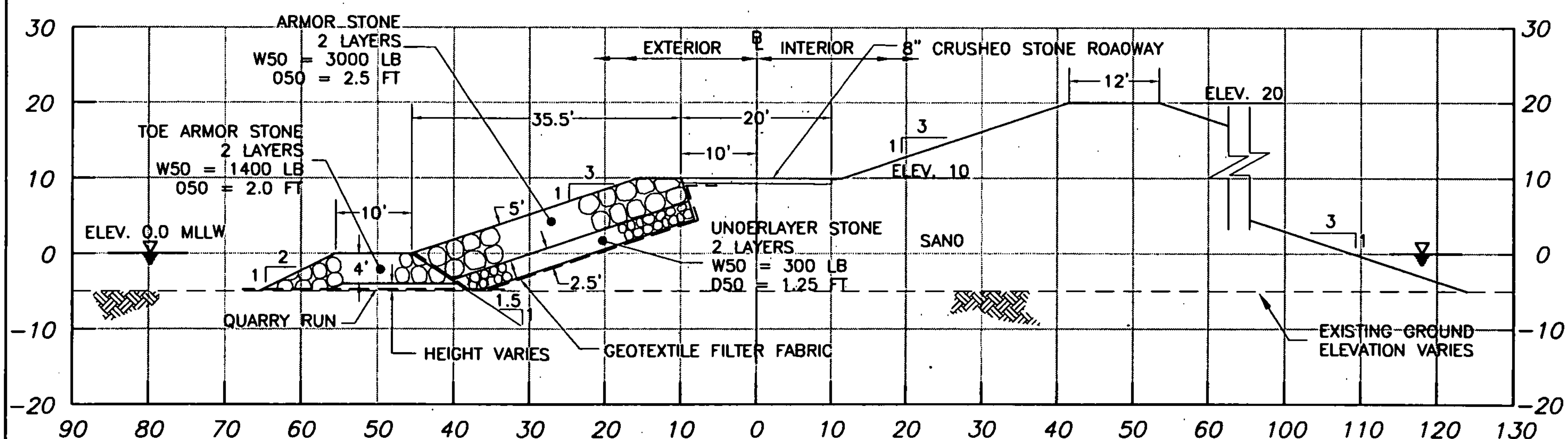
TYPICAL DIKE SECTION 2B
SCALE: 1" = 20'

FIGURE No. 9 – BARREN ISLAND TYPICAL DIKE SECTIONS



TYPICAL DIKE SECTION 2C

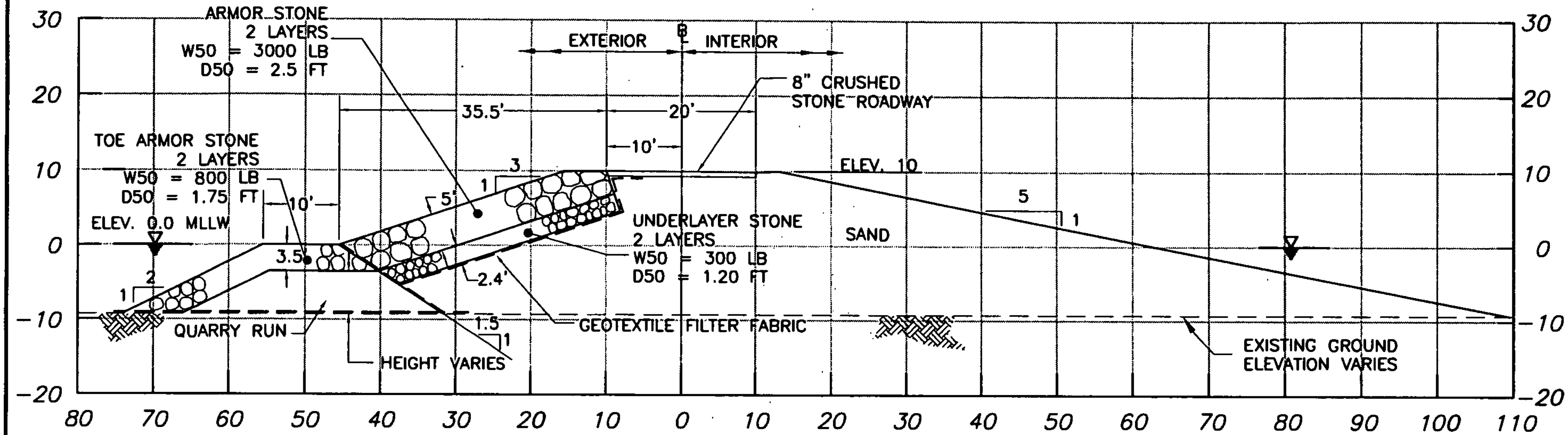
SCALE: 1" = 20'



TYPICAL DIKE SECTION 2D

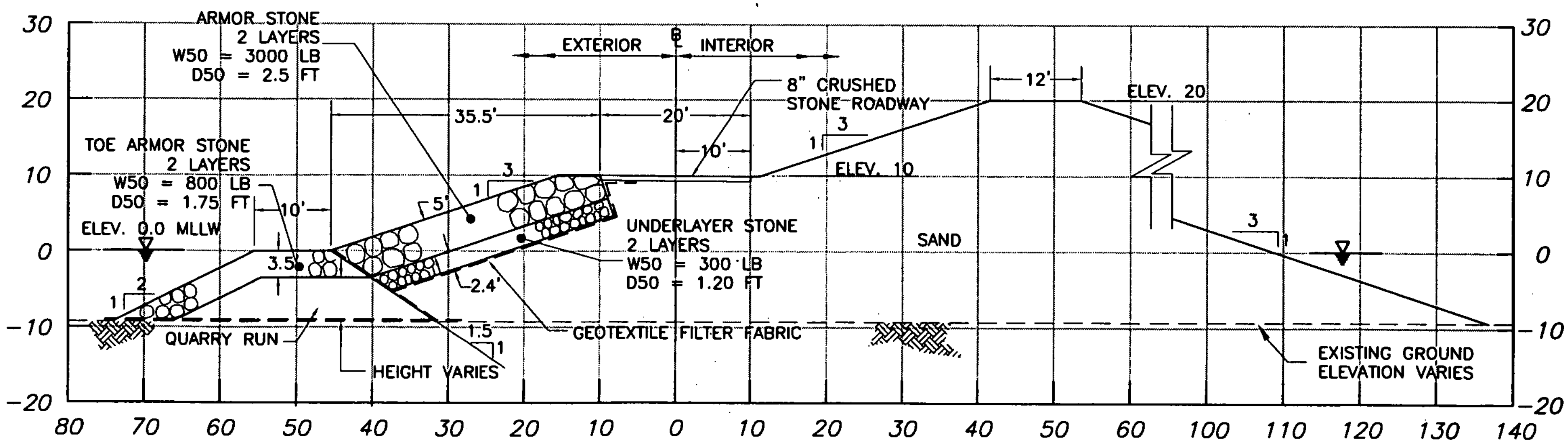
SCALE: 1" = 20'

FIGURE No. 10 – BARREN ISLAND TYPICAL DIKE SECTIONS



TYPICAL DIKE SECTION 3A

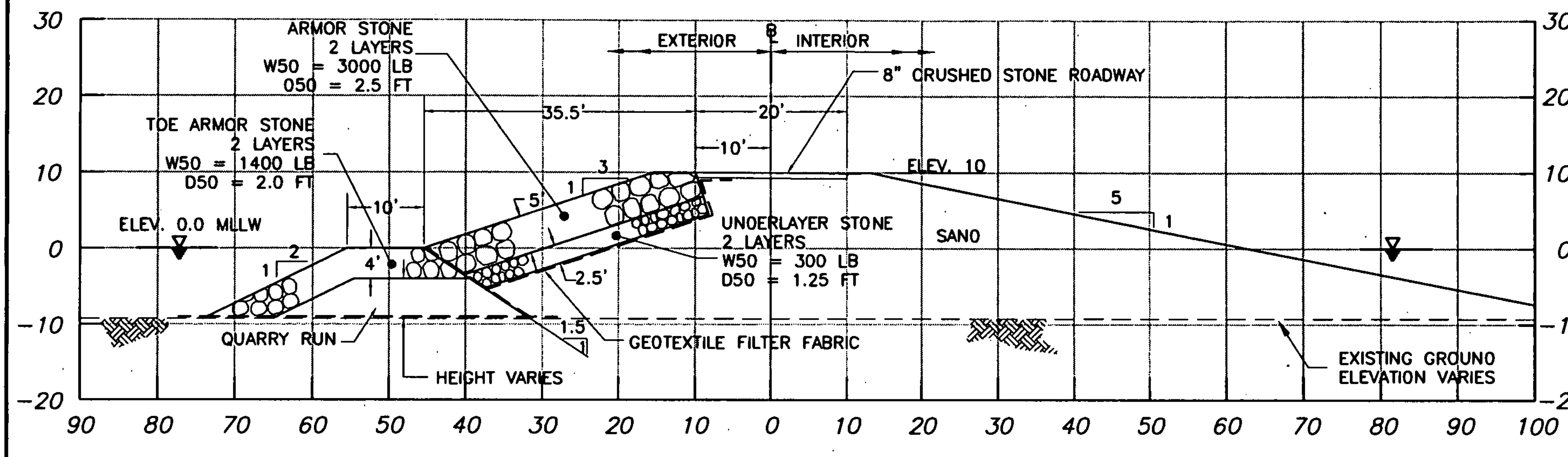
SCALE: 1" = 20'



TYPICAL DIKE SECTION 3B

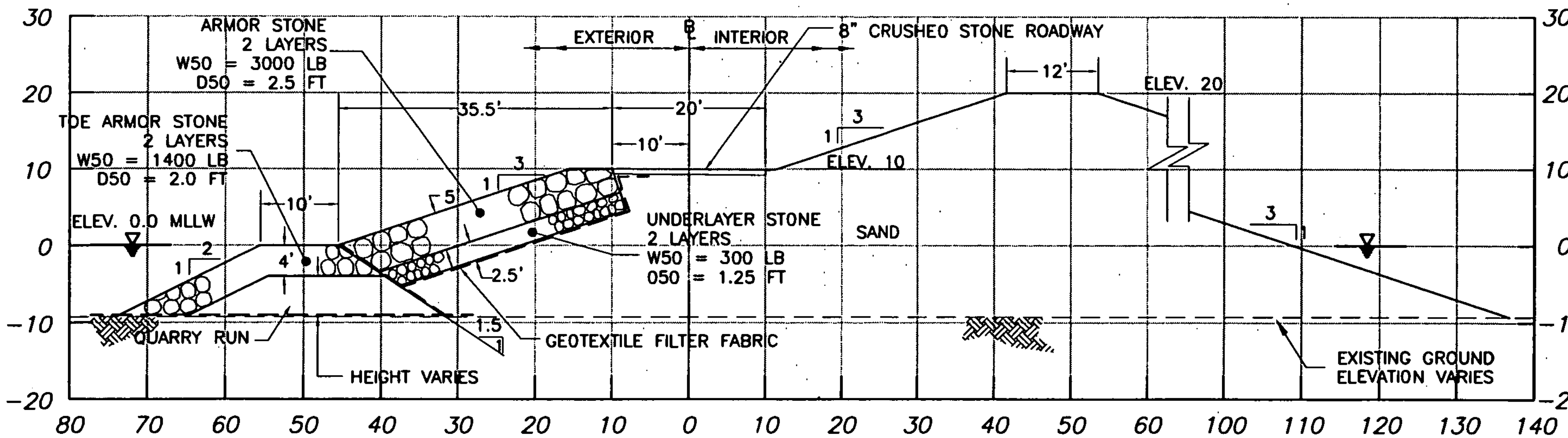
SCALE: 1" = 20'

FIGURE No. 11 – BARREN ISLAND TYPICAL DIKE SECTIONS



TYPICAL DIKE SECTION 3C

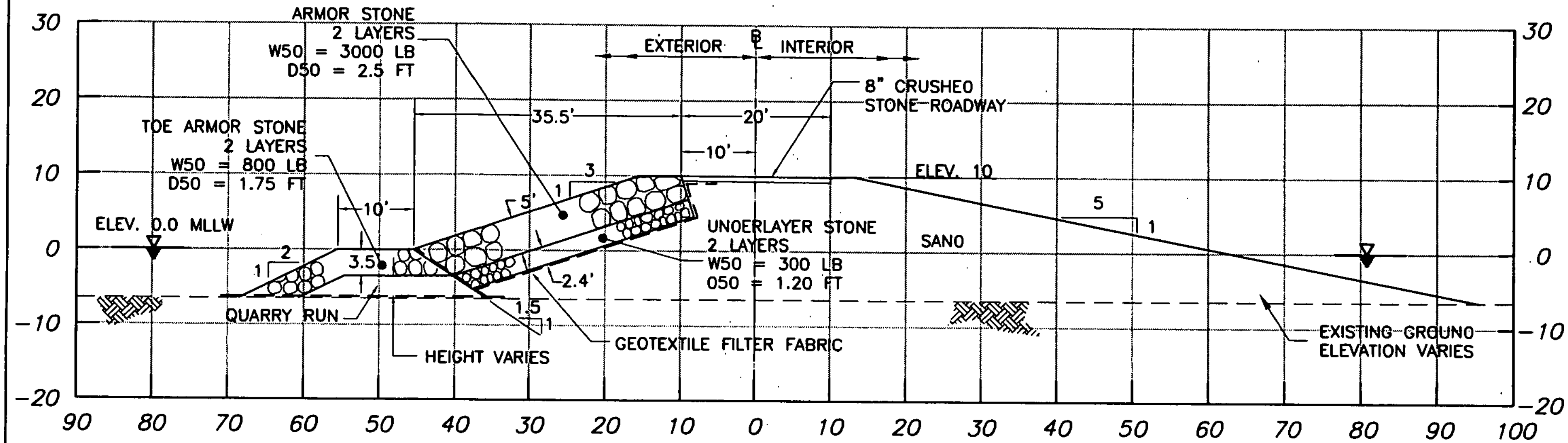
SCALE: 1" = 20'



TYPICAL DIKE SECTION 3D

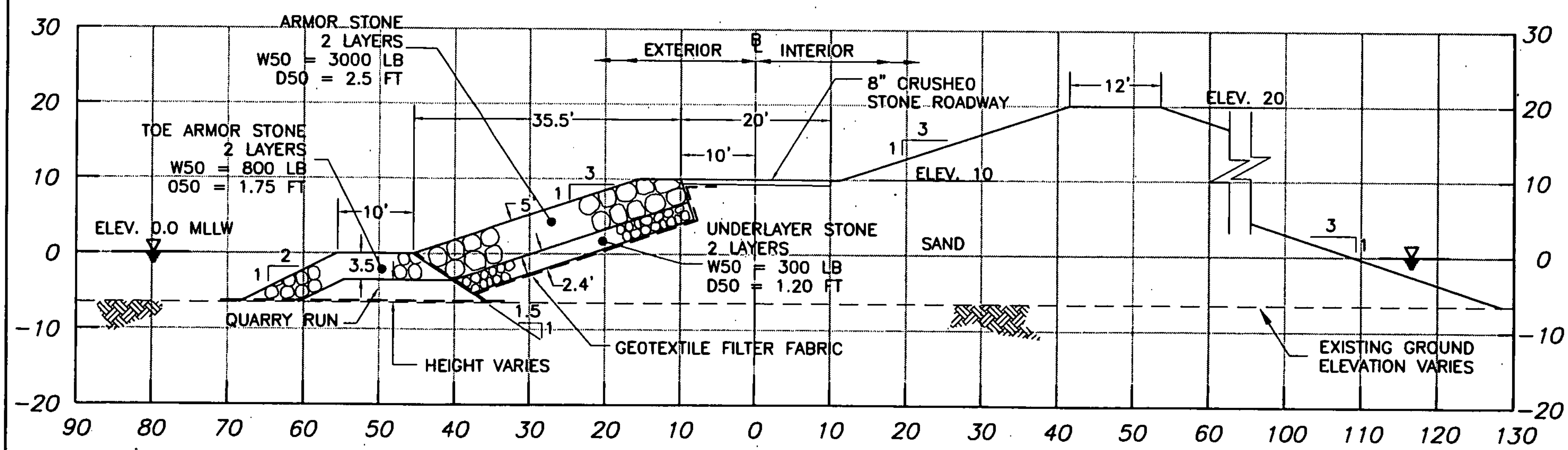
SCALE: 1" = 20'

FIGURE No. 12 – BARREN ISLAND TYPICAL DIKE SECTIONS



TYPICAL DIKE SECTION 4A

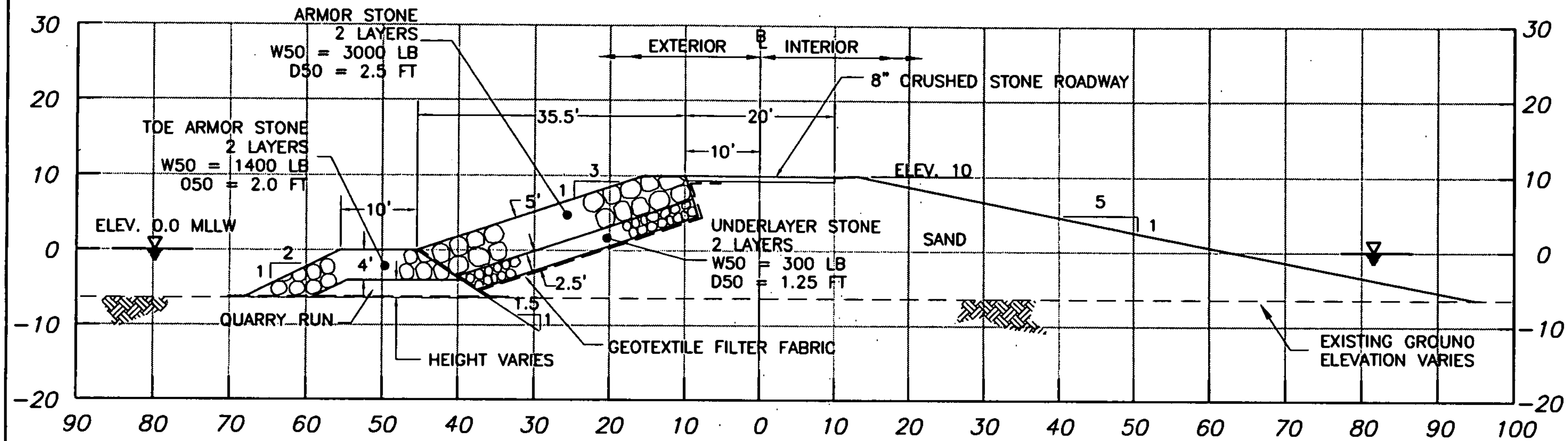
SCALE: 1" = 20'



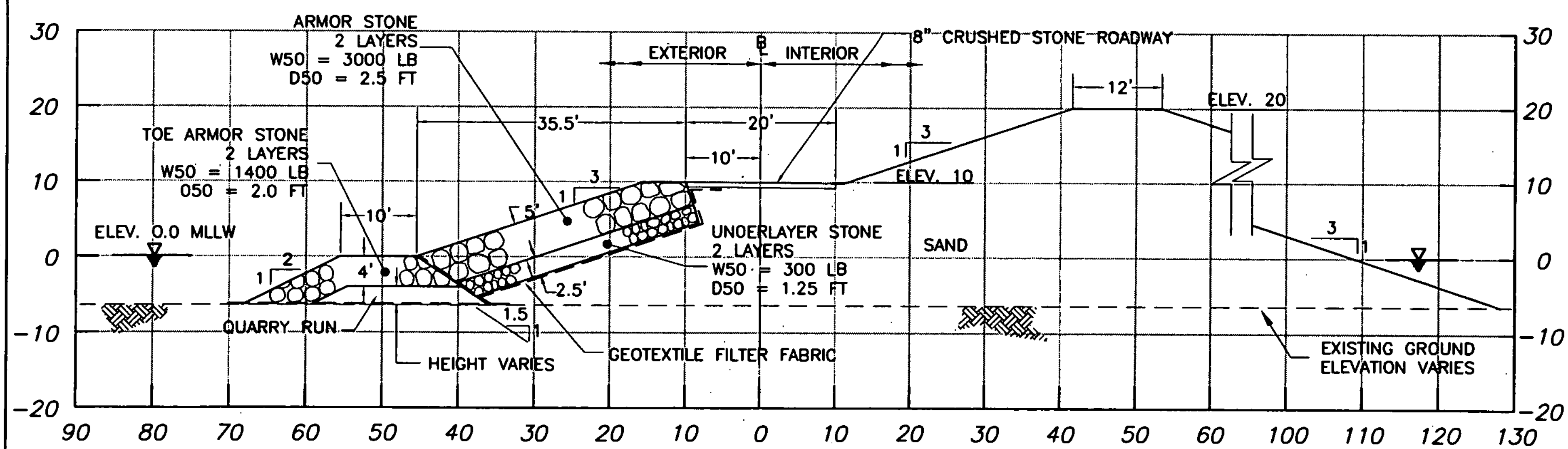
TYPICAL DIKE SECTION 4B

SCALE: 1" = 20'

FIGURE No. 13 – BARREN ISLAND TYPICAL DIKE SECTIONS

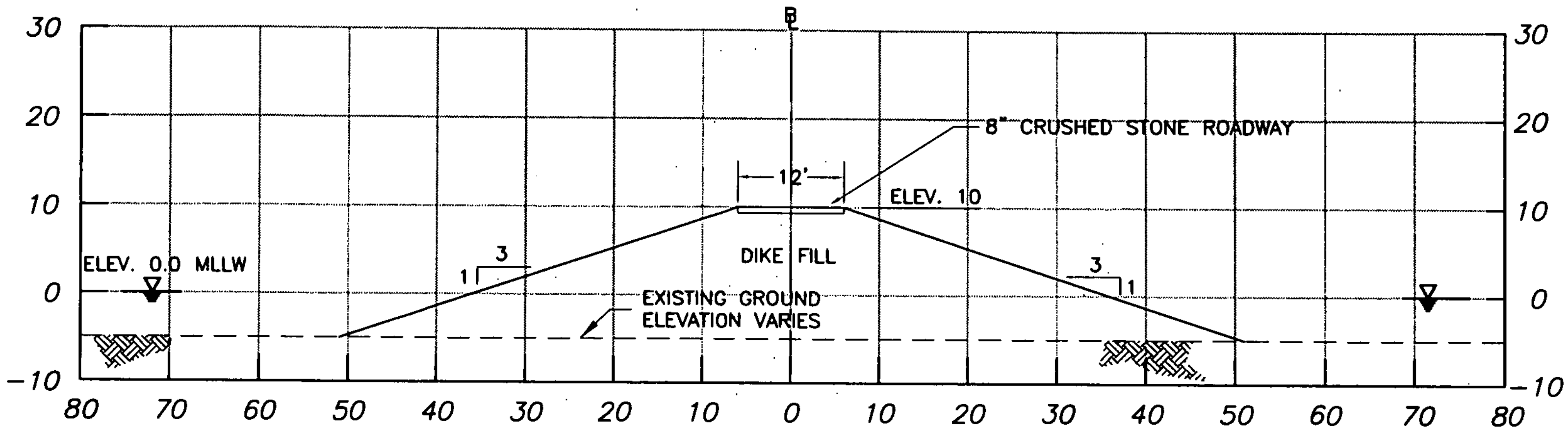


TYPICAL DIKE SECTION 4C
SCALE: 1" = 20'

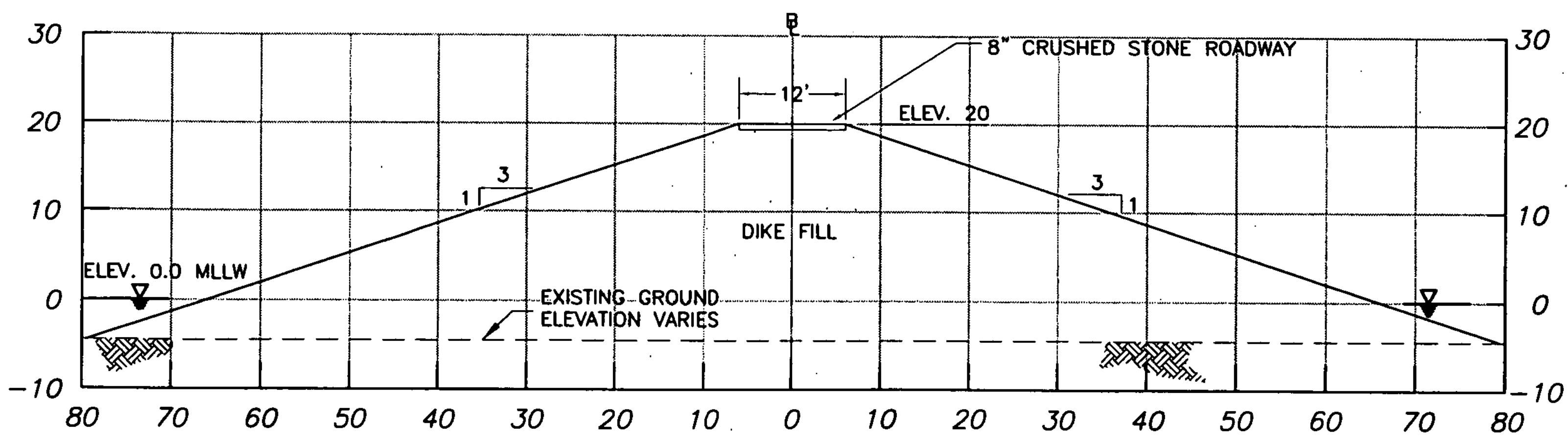


TYPICAL DIKE SECTION 4D
SCALE: 1" = 20'

FIGURE No. 14 – BARREN ISLAND TYPICAL DIKE SECTIONS



TYPICAL LONGITUDINAL DIKE SECTION NO. 5A
SCALE: 1" = 20'



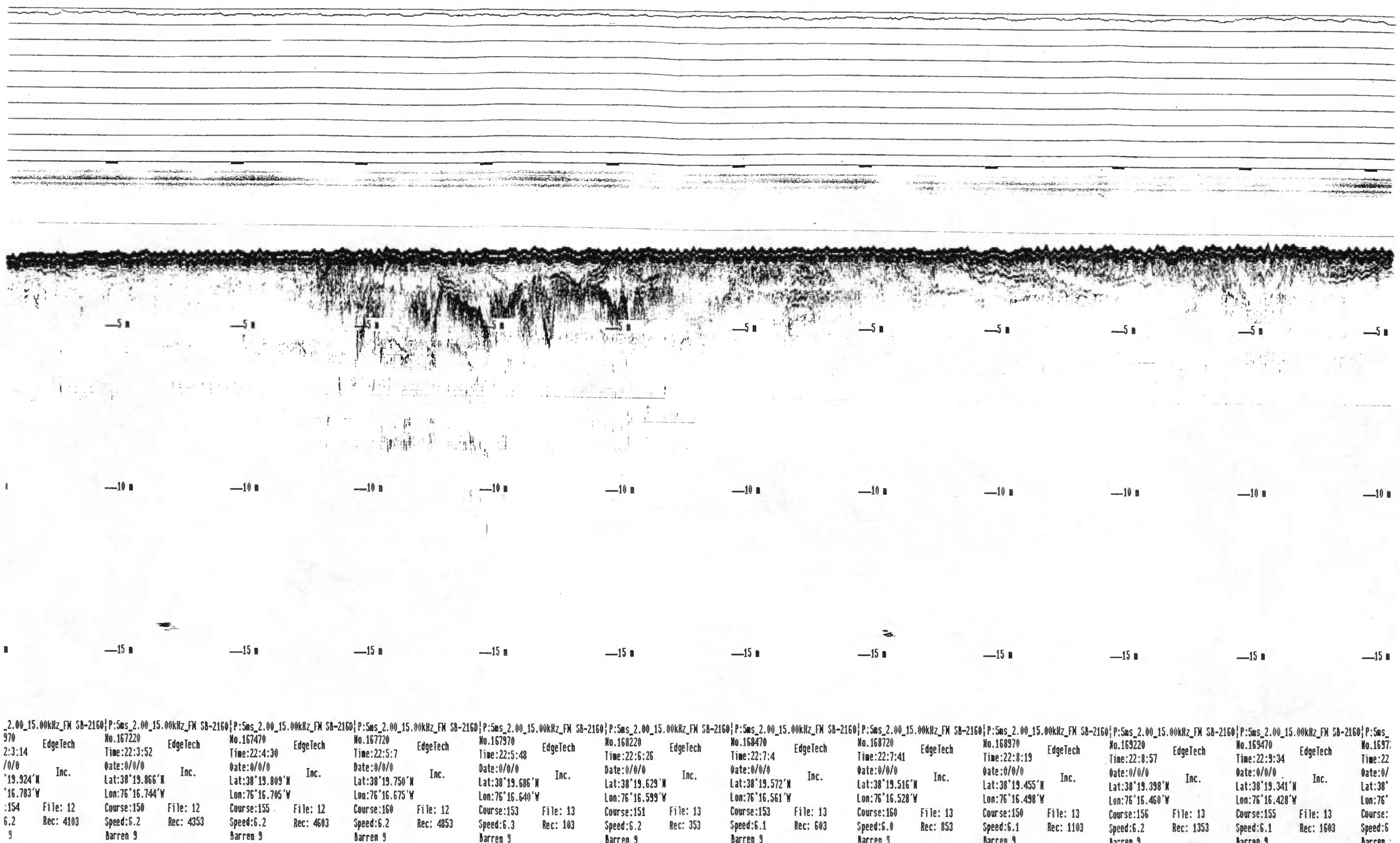
TYPICAL LONGITUDINAL DIKE SECTION NO. 5B
SCALE: 1" = 20'

Barren Island Habitat Development

Table 3 - Preliminary Construction Costs

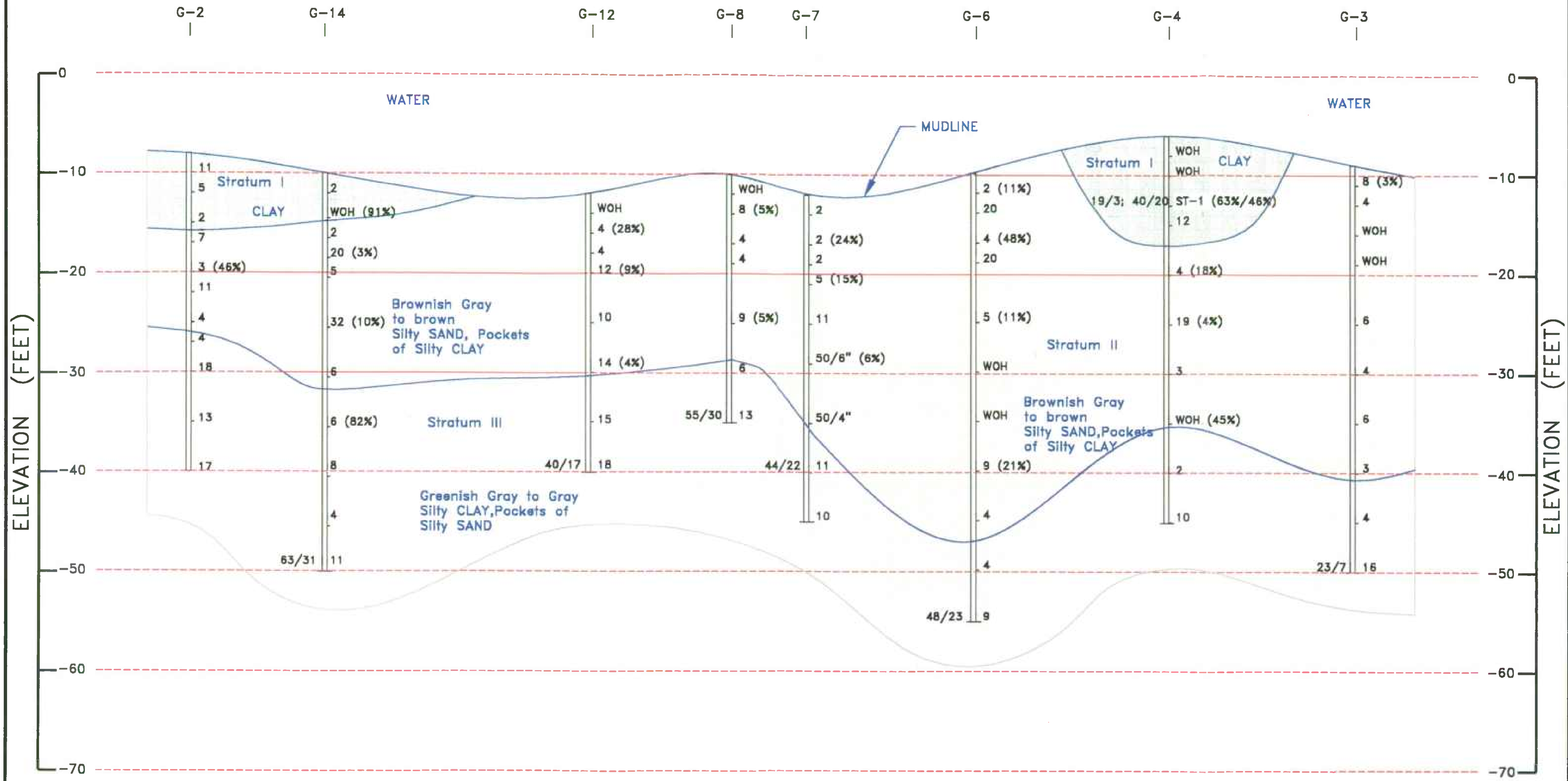
	Unit	Unit Rate	Alignment No. 1 (10 ft) Qty	Alignment No. 1 (10 ft) Cost $	Alignment No. 1 (20 ft) Qty	Alignment No. 1 (20 ft) Cost $	Alignment No. 2 (10 ft) Qty	Alignment No. 2 (10 ft) Cost $	Alignment No. 2 (20 ft) Qty	Alignment No. 2 (20 ft) Cost $
Mobilization/Demobilization	L.S.	N/A	Job	$3,000,000	Job	$3,000,000	Job	$3,500,000	Job	$3,500,000
Road Stone	S.Y.	$11.00	55,594	$611,538	55,594	$611,538	81,731	$899,048	81,731	$899,048
Geotextile	S.Y.	$3.50	444,155	$1,554,541	444,155	$1,554,541	648,745	$2,270,806	648,745	$2,270,606
Personnel Pier	L.S.	$500,000	Job	$500,000	Job	$500,000	Job	$500,000	Job	$500,000
Unsuitable Foundation Excavation	C.Y.	$8.75	300,000	$2,625,000	300,000	$2,625,000	500,000	$4,375,000	500,000	$4,375,000
Stone Work										
Quarry Run	Ton	$33.00	29,656	$978,649	29,656	$978,649	112,379	$3,708,509	112,379	$3,708,509
Toe Armor	Ton	$44.00	73,660	$3,241,043	73,680	$3,241,043	152,169	$6,695,443	152,169	$6,695,443
Underlayer	Ton	$39.00	86,928	$3,390,176	86,928	$3,390,176	130,563	$5,091,940	130,563	$5,091,940
Slope Dike Armor Stone	Ton	$39.00	192,273	$7,498,646	192,273	$7,498,646	280,814	$10,951,747	280,814	$10,951,747
East Slope Dike Armor Stone	Ton	$39.00	38,284	$1,493,084	38,284	$1,493,084	55,930	$2,181,254	55,930	$2,181,254
Spillways	Each	$200,000	6	$1,200,000	6	$1,200,000	8	$1,600,000	8	$1,600,000
Nursery Planting	L.S.	$200,000	Job	$200,000	Job	$200,000	Job	$270,000	Job	$270,000
SUBTOTAL				$26,292,678		$26,292,678		$42,043,545		$42,043,545

Borrow Alternative 1			**Alignment No. 1 (10 ft)**		**Alignment No. 1 (20 ft)**		**Alignment No. 2 (10 ft)**		**Alignment No. 2 (20 ft)**	
Dike Fill Hydraulic Excavation - Mechanical Placement from Onsite	C.Y.	$8.50	1,532,825	$13,029,011	2,572,758	$21,868,441	2,642,252	$22,459,145	4,284,502	$36,418,267
A1 TOTAL CONSTRUCTION COST				**$39,321,688**		**$48,161,118**		**$64,502,690**		**$78,461,812**
per CY of Site Capacity				$1.63		$1.32		$1.23		$1.01
Borrow Alternative 2										
Clam Shell Dredge from Craighill Channel	C.Y.	$2.00	1,532,825	$3,065,650	2,572,758	$5,145,515	2,642,252	$5,284,505	4,284,502	$8,569,004
53 nautical miles one way barge transport	C.Y.	$3.00	1,532,825	$4,598,474	2,572,758	$7,718,273	2,642,252	$7,926,757	4,284,502	$12,853,508
Dike Fill Hydraulically from barge	C.Y.	$7.50	1,532,825	$11,496,186	2,572,758	$19,295,683	2,642,252	$19,816,893	4,284,502	$32,133,765
Subtotal				$19,160,310		$32,159,472		$33,028,154		$53,556,275
A2 TOTAL CONSTRUCTION COST				**$45,452,987**		**$58,452,149**		**$75,071,699**		**$95,599,820**
per CY of Site Capacity				$1.88		$1.60		$1.43		$1.23



Note: The survey was conducted by MGS on August 7, 2001.

E2CR, INC.	SIDE SCAN SONAR PROFILE BARREN ISLAND	FIGURE: 6	DRAWN BY: NS	CHECKED BY:
		DATE: FEB.,2002	JOB NO.: 01556	SCALE:

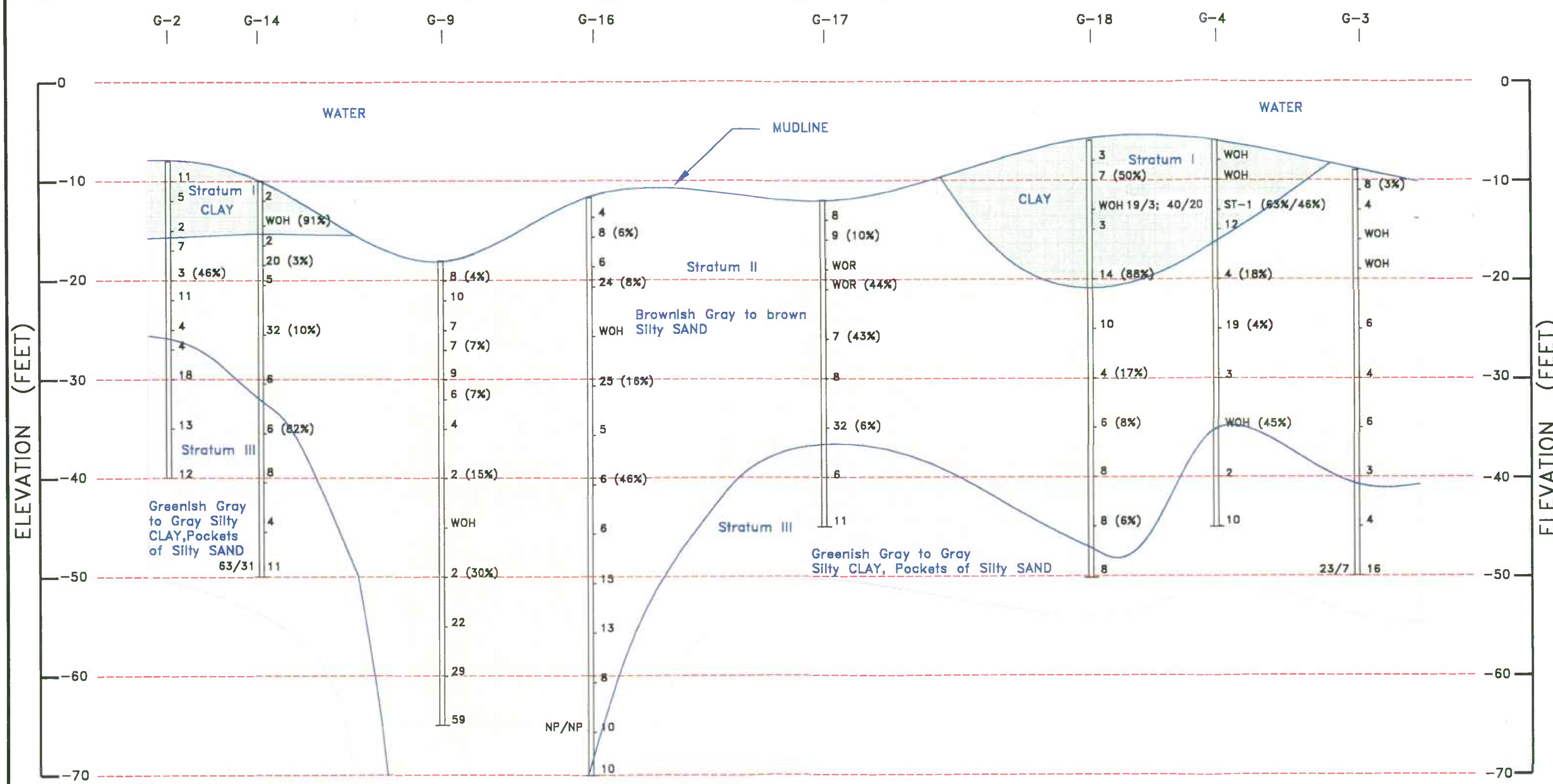


LEGEND

G-1 – Boring Number
WOR – Weight of Rod
WOH – Weight of Hammer
10 – Standard Penetration Resistance, Blows/foot
– Water surface elevation
(22%) – Percentage Fines
66/38 – Liquid Limit/Plasticity Index
ST – Shelby Tube

BARREN ISLAND
DIKE ALIGNMENT OPTION – 1

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 7	DRAWN BY: AD	CHECKED BY: GVK
		DATE: FEB., 2002	JOB NO.: 01556-04	SCALE:



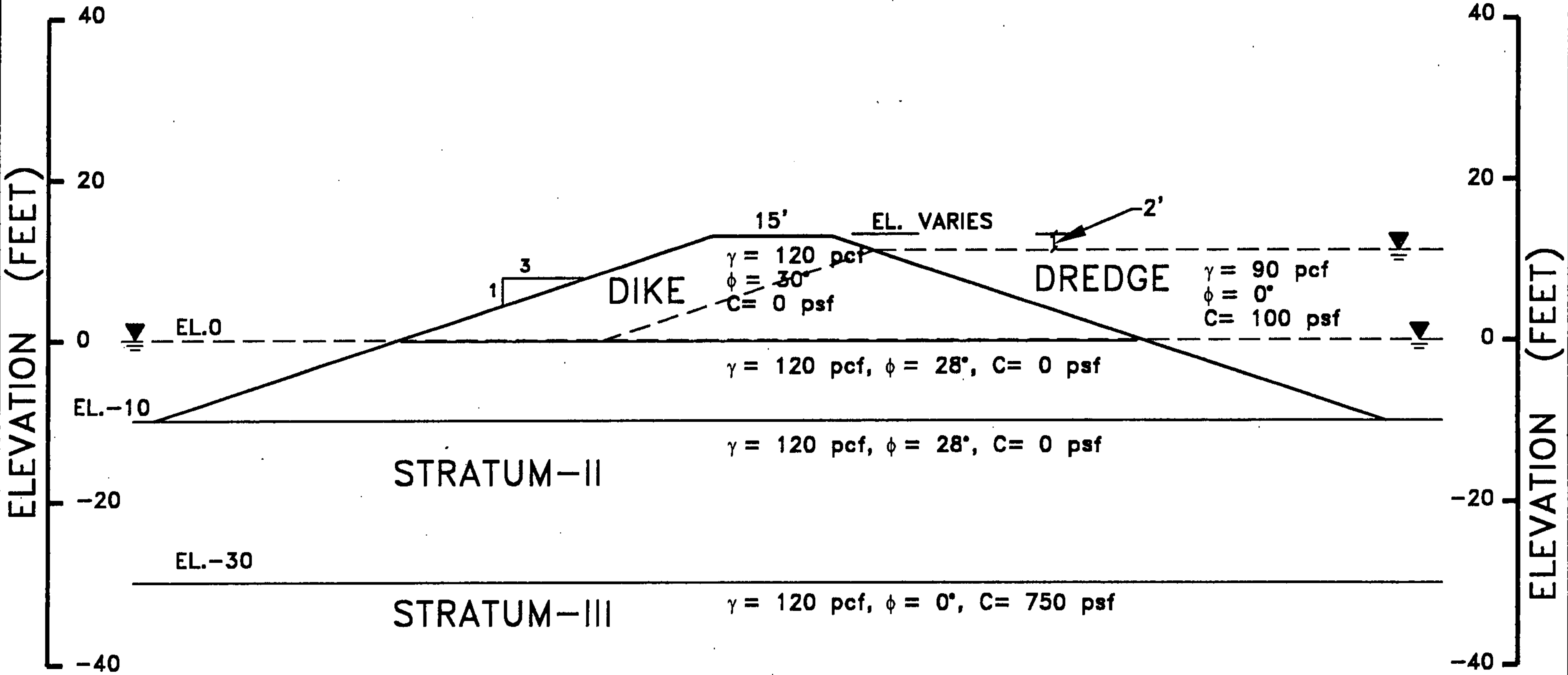
LEGEND

G-1 – Boring Number
WOR – Weight of Rod
WOH – Weight of Hammer
10 – Standard Penetration Resistance, Blows/foot
– Water surface elevation
(22%) – Percentage Fines
66/38 – Liquid Limit/Plasticity Index
ST – Shelby Tube

BARREN ISLAND

DIKE ALIGNMENT OPTION – 2

E2CR, INC.	GENERALIZED SUBSURFACE PROFILE	FIGURE: 8	DRAWN BY: AD	CHECKED BY: GVK
		DATE: FEB., 2002	JOB NO.: 01556-04	SCALE:



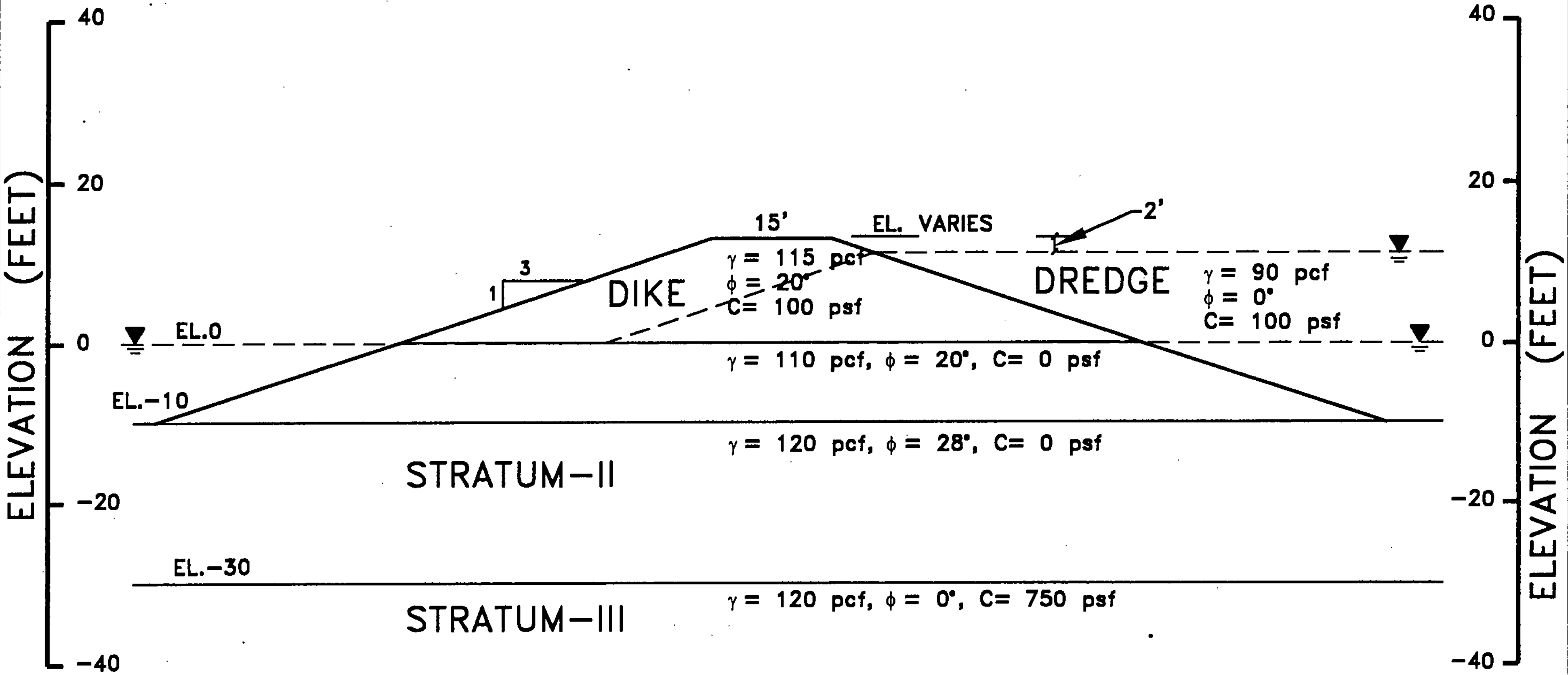
CASE-A (Non plastic fines in the Embankment)

CASE-A1: Dike to EL. +10
CASE-A2: Dike to EL. +15
CASE-A3: Dike to EL. +20

HORIZONTAL: 20 0 20 FEET

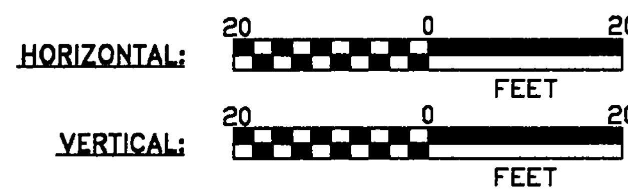
VERTICAL: 20 0 20 FEET

E2CR, INC.	BARREN ISLAND SLOPE STABILITY ANALYSIS	FIGURE: 11	DRAWN BY: NS	CHECKED BY: SB
		DATE: FEB.,2002	JOB NO.: 01556	SCALE:



CASE−B (Plastic fines in the embankment)

CASE−B1: Dike to EL. +10
CASE−B2: Dike to EL. +15
CASE−B3: Dike to EL. +20



E2CR, INC.	BARREN ISLAND SLOPE STABILITY ANALYSIS	FIGURE: 12	DRAWN BY: NS	CHECKED BY:SB
		DATE: FEB.,2002	JOB NO.: 01556	SCALE:

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island

E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-1	S-5	23.5-25.0	20.4			0	48	52			ML	I
	S-6	28.5-30.0	8.8					5			SP	II
	S-7	33.5-35.0	28.5						2000	1000	CL	III
	S-8	38.5-40.0	33.5	45	22				2000	1000	CL	III
G-2	S-3	13.0-15.0	28.1								CL-SC	I
	S-5	18.0-20.0	42.7					46			SM	II
	S-9	28.5-30.0	19.4								CL	III
	S-10	33.5-35.0	36.0								CL	III
G-3	S-1	9.0-11.0	19.2					3			SP	I
	S-6	28.5-30.0	20.7								CL	II
	S-7	33.5-35.0	28.7								SC	II
	S-8	38.5-40.0	34.0								SC	II
	S-9	43.5-45.0	28.6								SC-SM	III
	S-10	48.5-50.0	18.6	23	7				2500	1250	CL	III
G-4	ST-1	11.0-12.0	19.5	19	3		37	63			ML	I
		12.0-13.0	18.2	40	20		54	46			SC	I

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island

E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-4	S-3	13.0-15.0	24.8						1800	750	CL	I
	S-4	18.0-20.0	27.0					18			SM	II
	S-5	23.5-25.0	24.4				96	4			SP	II
	S-6	28.5-30.0	22.7								SM	II
	S-7	33.5-35.0	53.9				55	45	1000	750	SC	II
	S-8	38.5-40.0	43.8								CL	III
G-5	S-1	10.0-12.0	33.6					14			SM	II
	S-5	23.5-25.0	28.6			0	52	48			SM-SC	II
	S-8	38.5-40.0	22.9					10			SP-SM	II
	S-9	43.5-45.0	53.6	52	14				1500	750	MH	III
G-6	S-1	10.0-12.0	25.7					11			SP-SM	II
	S-3	15.0-17.0	26.7				52	48			SM	II
	S-5	23.5-25.0	15.3					11			SP-SM	II
	S-8	38.5-40.0	22.8				79	21			SM	II
	S-10	48.5-50.0	76.8						1000	450	CL	III
	S-11	53.5-55.0	63.8	48	23				800	450	CL	III

ENGINEERING · CONSULTATION ·
E2CR inc.
CONSTRUCTION · REMEDIATION ·

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island
E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-7	S-2	15.0-17.0	26.8				76	24			SM	II
	S-4	19.0-21.0	21.6					15			SM	II
	S-6	28.5-30.0	13.2			37	57	6			SP-SM	II
	S-7	33.5-35.0	7.7								SP-SM	II
	S-8	38.5-40.0	28.9	44	22				3000	1500	CL	III
	S-9	43.5-45.0	28.6								CL	III
G-8	S-2	12.0-14.0	23.9				95	5			SP	II
	S-5	23.5-25.0	15.8			1	94	5			SP-SM	II
	S-6	28.5-30.0	50.4								CH	III
	S-7	33.5-35.0	62.6	55	30				800	500	CH	III
G-9	S-1	18.0-20.0	29.0					4			SP	II
	S-4	25.0-27.0	27.8					7			SP-SM	II
	S-6	30.0-32.0	29.2				93	7			SP-SM	II
	S-8	38.5-40.0	26.2					15			SM	II
	S-10	48.5-50.0	25.7				70	30			SM	II

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island

E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-10	ST-1	15.0-16.0	25.4	23	5		23	77			CL-ML	I
		16.0-17.0	18.4				89	11			SP-SM	I
	S-3	17.0-19.0	33.5								SM	II
	S-4	23.5-25.0	18.9			1	84	15			SM	II
	S-5	28.5-30.0	25.3						2000	1250	CL	III
	S-6	33.5-35.0	26.8						2000	1250	CL	III
G-11	S-2	14.0-16.5	19.2					8			SP-SM	II
	S-4	19.0-21.0	22.6			1	81	18			SM	II
	ST-1	20.5-29.5	15.3								SM	II
	S-6	29.5-30.0	9.2								SP-SM	II
	S-7	33.5-35.0	27.1						1800	1000	CL	III
	S-8	38.5-40.0	27.9	37	15				2000	1250	CL	III
G-12	S-2	14.5-16.5	30.1					28			SM	II
	S-4	18.5-20.5	24.1				91	9			SP-SM	II
	S-6	28.5-30.0	12.7					4			SP	II

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island

E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-12	S-7	33.5-35.0	30.1						1600	1375	CL	III
	S-8	38.5-40.0	25.6	40	17				2000	1375	CL	III
G-13	S-6	23.5-25.0	40.0								CL	I
	S-7	28.5-30.0	21.8				87	13			SM	II
	S-9	38.5-40.0	27.8					18			SC	II
	S-10	43.5-45.0	30.4					27			SC	II
	S-11	48.5-50.0	35.8	28	7						CL-ML	III
G-14	S-2	12.0-14.0	67.2					91			CL	I
	S-4	16.0-18.0	21.6					3			SP	II
	S-6	23.5-25.0	22.6				90	10			SP-SM	II
	S-8	33.5-35.0	28.4					82			CL	III
	S-10	43.5-45.0	32.8								MH	III
	S-11	48.5-50.0	70.6	63	31						MH	III
G-15	S-3	11.0-13.0	30.3					62			ML	I
	S-5	18.5-20.0	25.7			1	74	25			SM	II
	S-7	28.5-30.0	33.3								CL	III

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island
E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-15	S-8	33.5-35.0	18.2								SM	III
	S-9	38.5-40.0	23.7								CL	III
G-16	S-2	14.0-16.0	28.0				94	6			SP-SM	II
	S-4	19.0-21.0	23.1					8			SP-SM	II
	S-6	28.5-30.0	23.6				84	16			SM	II
	S-8	38.5-40.0	27.8					46			SM	II
	S-12	58.5-60.0	67.2								SM	II
	S-13	63.5-65.0	37.1	NP	NP						SM	II
	S-14	68.5-70.0	26.7								CL	III
G-17	S-2	14.0-16.0						10			SM-SC	II
	S-4	19.0-21.0					56	44			SM-SC	II
	S-5	23.5-25.0						43			SM	II
	S-7	33.5-35.0						6			SP-SM	II
	S-8	38.5-40.0	28.1								CL	III
	S-9	43.5-45.0	31.5								CL	III

ENGINEERING · CONSULTATION · E2CR inc. CONSTRUCTION · REMEDIATION ·

TABLE-1: SUMMARY OF LABORATORY TEST RESULTS

Barren Island

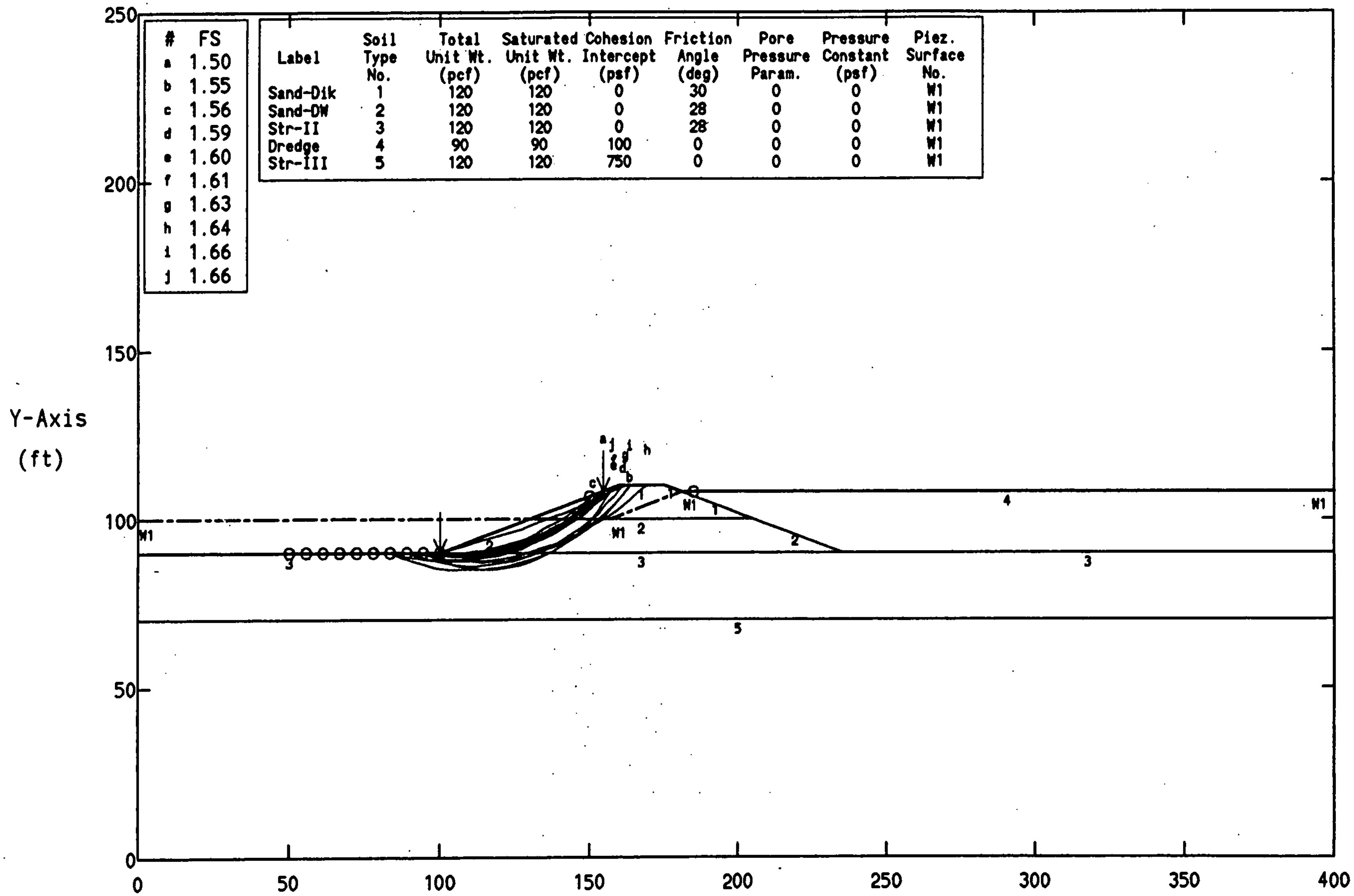
E2CR Project No. 01556-04

Note : * Depth from the existing water surface at El. 0.00

BORING NO	SAMPLE NO	DEPTH* (FEET)	NATURAL MOISTURE CONTENT(%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	GRAIN SIZE DISTRIBUTION			STRENGTH		USCS CLASSIFICATION	STRATUM
						GRAVEL (%)	SAND (%)	FINES (%)	PENETRO QP(PSF)	TORVANE TV(PSF)		
G-18	S-2	8.0-10.0						50			SC-SM	I
	S-5	18.4-20.0						88			ML	I
	S-7	28.5-30.0					83	17			SM	II
	S-8	33.5-35.0						8			SP-SM	II
	S-10	43.5-45.0						6			SP-SM	II
	S-11	48.5-50.0	28.7								CL	III

Barren Island Dike to +10: Case A1: Dike

Ten Most Critical. C:BIA1D.PLT By: GVK 11-29-01 6:41pm



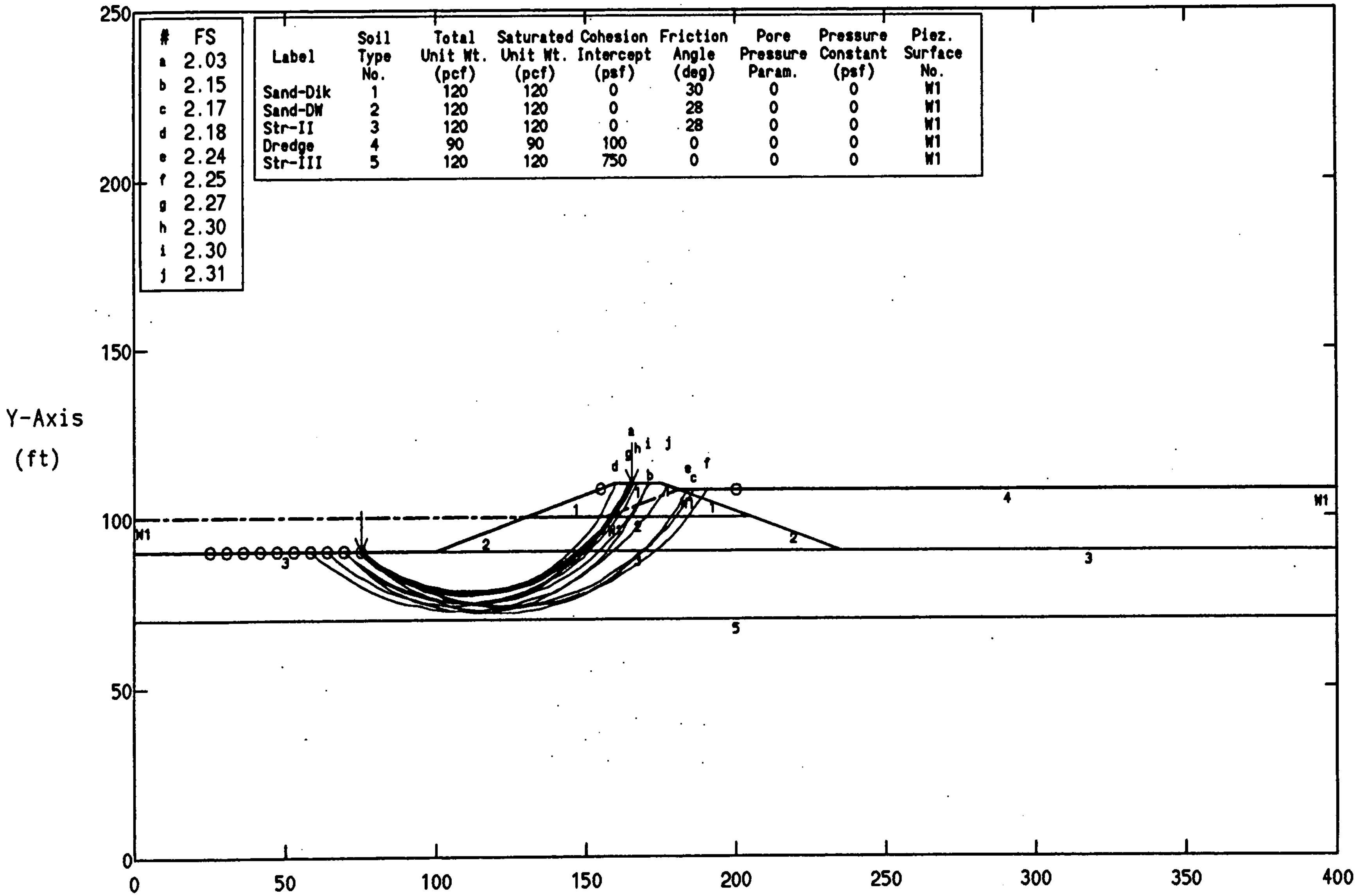
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	120	120	0	30	0	0	W1
Sand-DW	2	120	120	0	28	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.50 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +10: Case A1: Foundation

Ten Most Critical. C:BIA1F.PLT By: GVK 11-29-01 7:06pm



#	FS
a	2.03
b	2.15
c	2.17
d	2.18
e	2.24
f	2.25
g	2.27
h	2.30
i	2.30
j	2.31

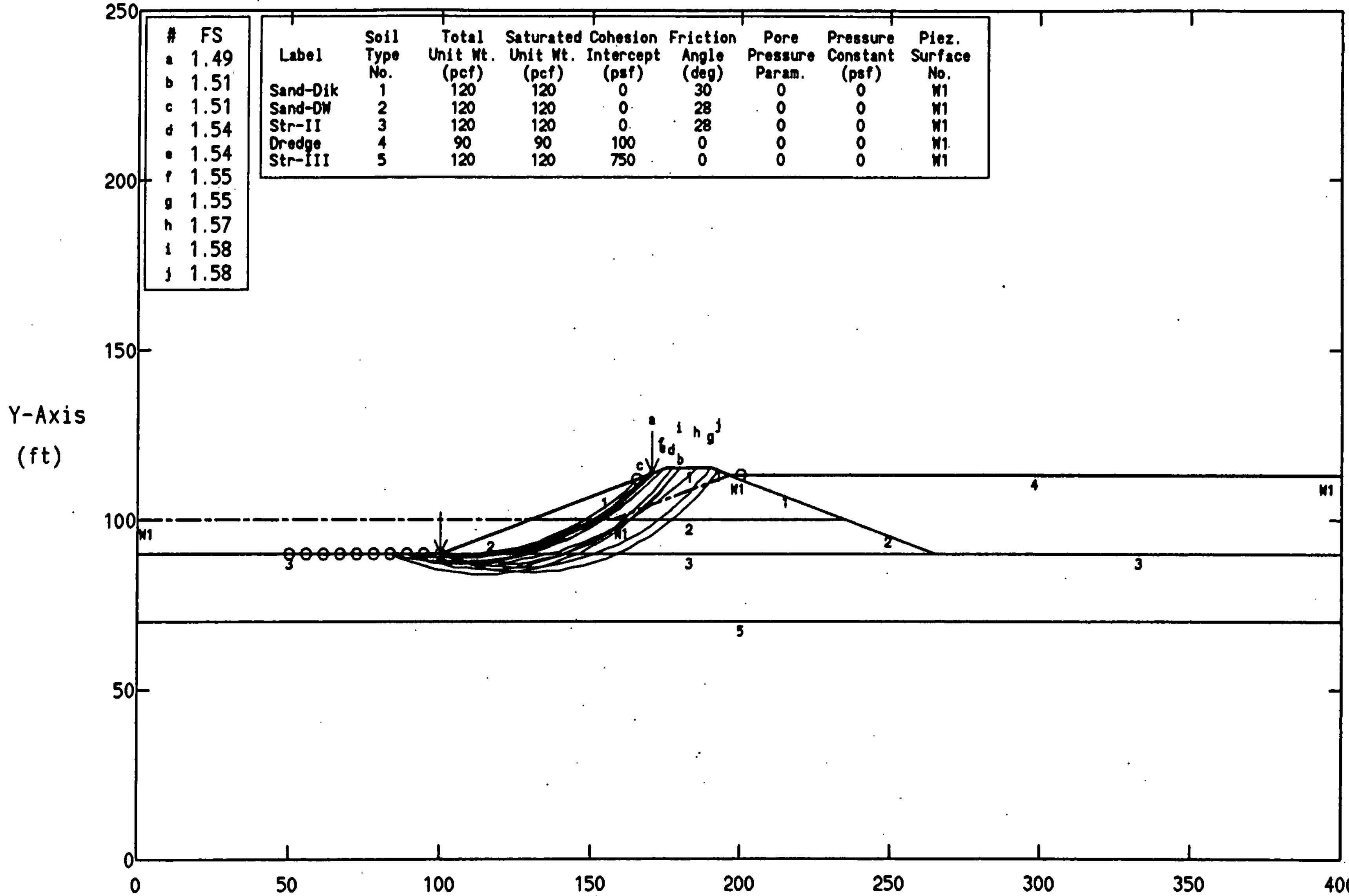
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	120	120	0	30	0	0	W1
Sand-DW	2	120	120	0	28	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=2.03 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +15: Case A2: Dike

Ten Most Critical. C:BIA2D.PLT By: GVK 11-29-01 10:56am



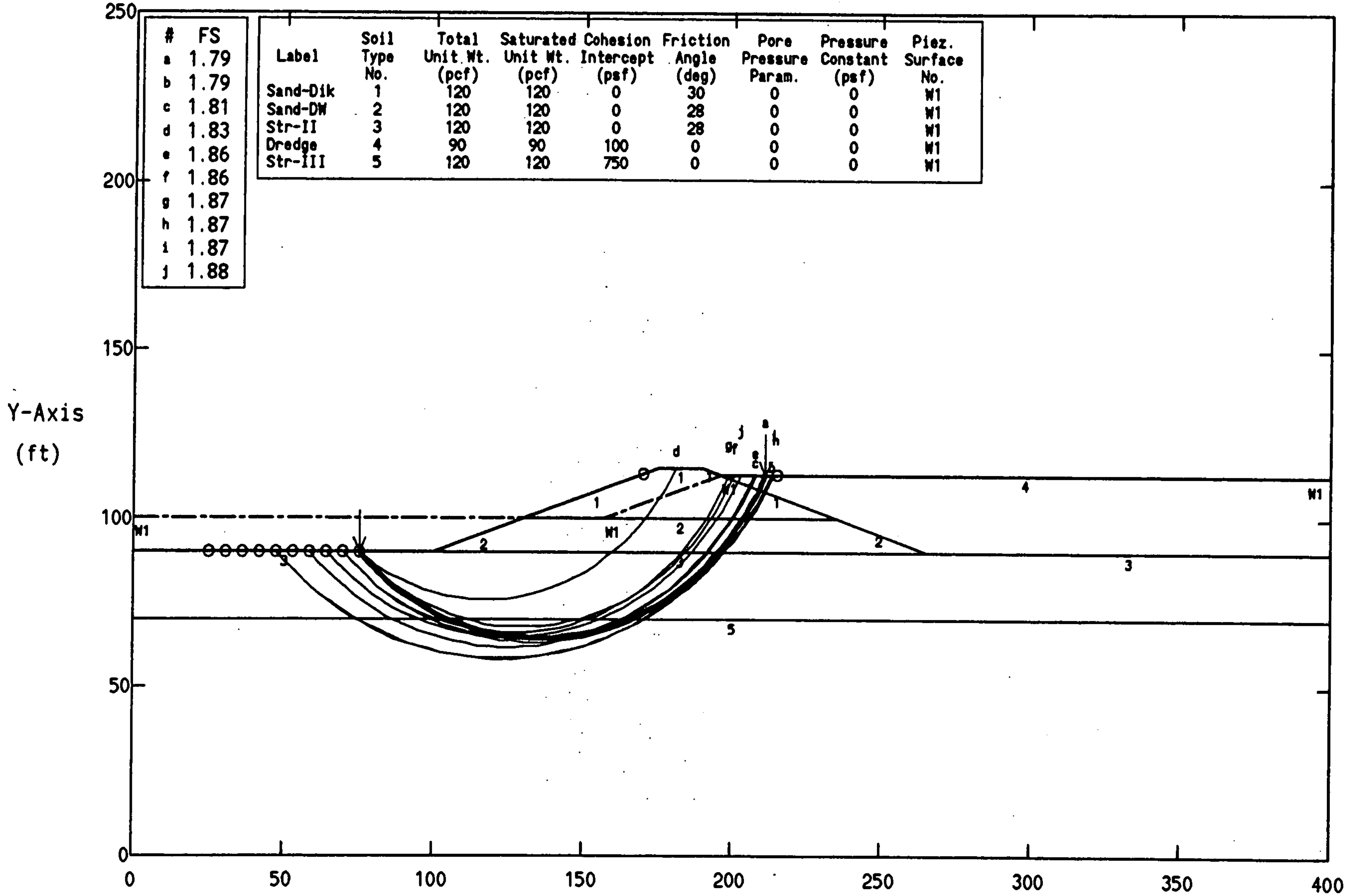
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	120	120	0	30	0	0	W1
Sand-DW	2	120	120	0	28	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.49 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +15: Case A2: Foundation

Ten Most Critical. C:BIA2F.PLT By: GVK 11-29-01 10:57am



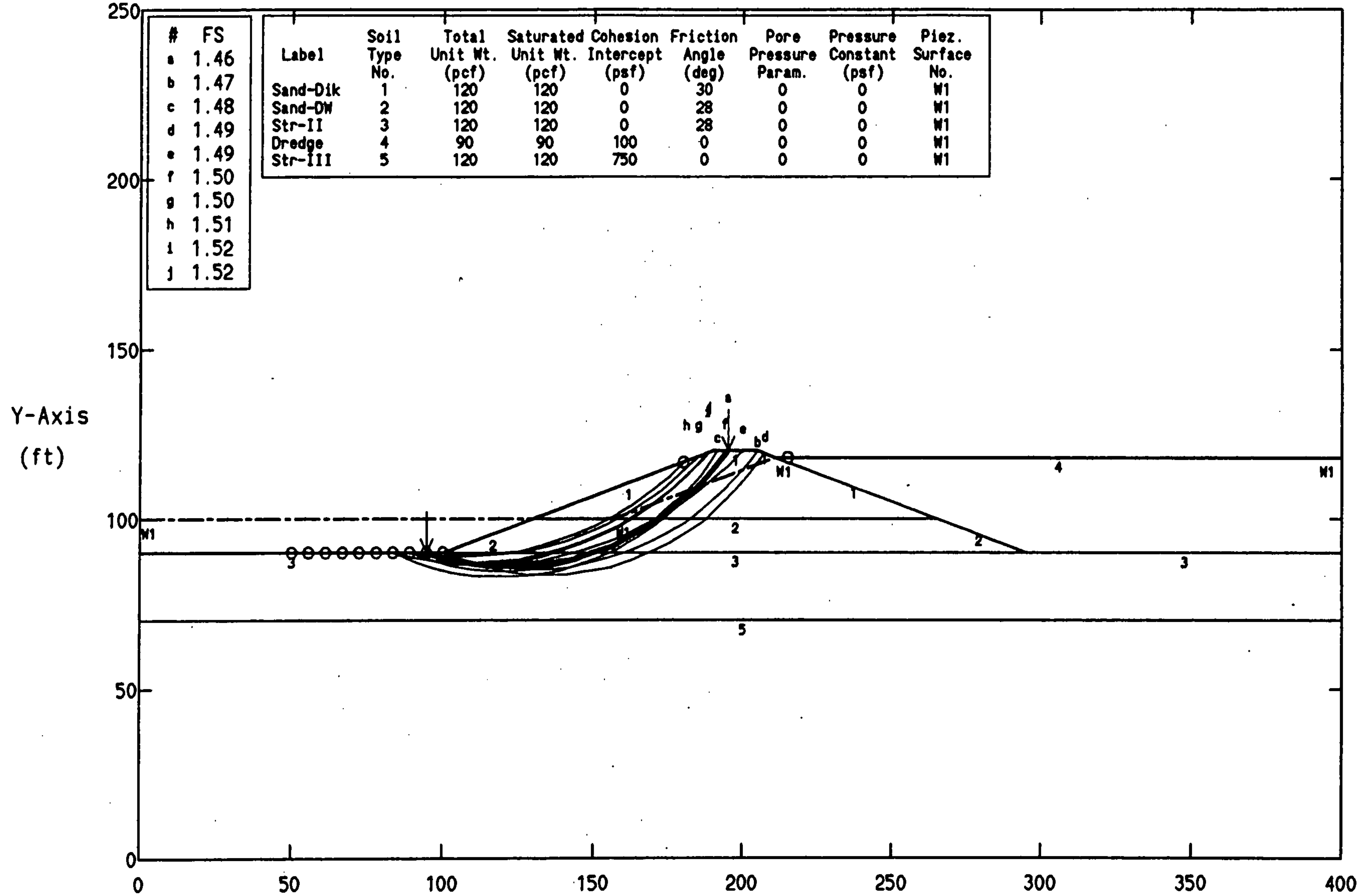
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	120	120	0	30	0	0	W1
Sand-DW	2	120	120	0	28	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.79 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +20: Case A3: Dike

Ten Most Critical. C:BIA3D.PLT By: GVK 11-29-01 11:01am



#	FS
a	1.46
b	1.47
c	1.48
d	1.49
e	1.49
f	1.50
g	1.50
h	1.51
i	1.52
j	1.52

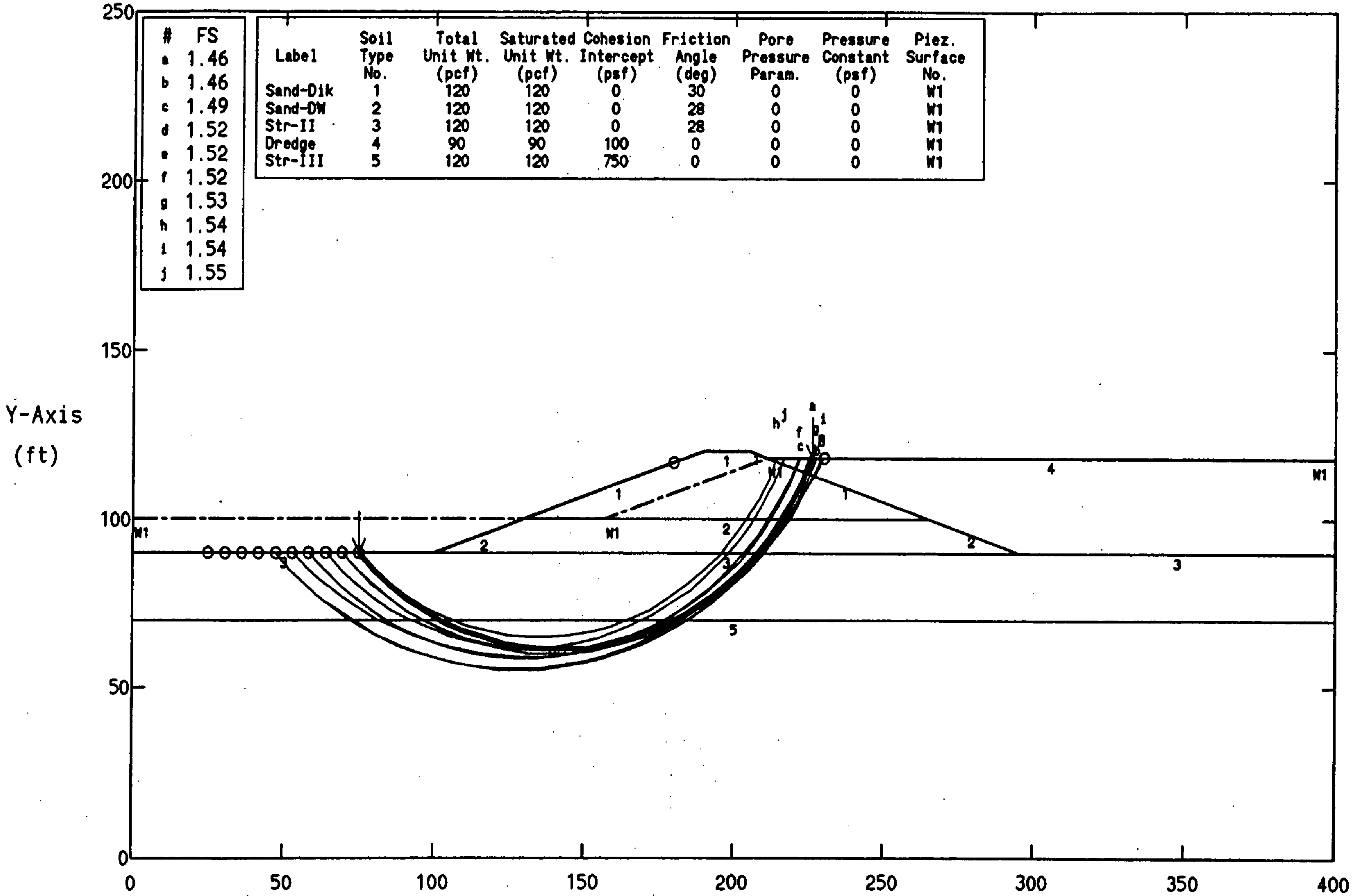
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	120	120	0	30	0	0	W1
Sand-DW	2	120	120	0	28	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.46 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +20: Case A3: Foundation

Ten Most Critical. C:BIA3F.PLT By: GVK 11-29-01 11:03am

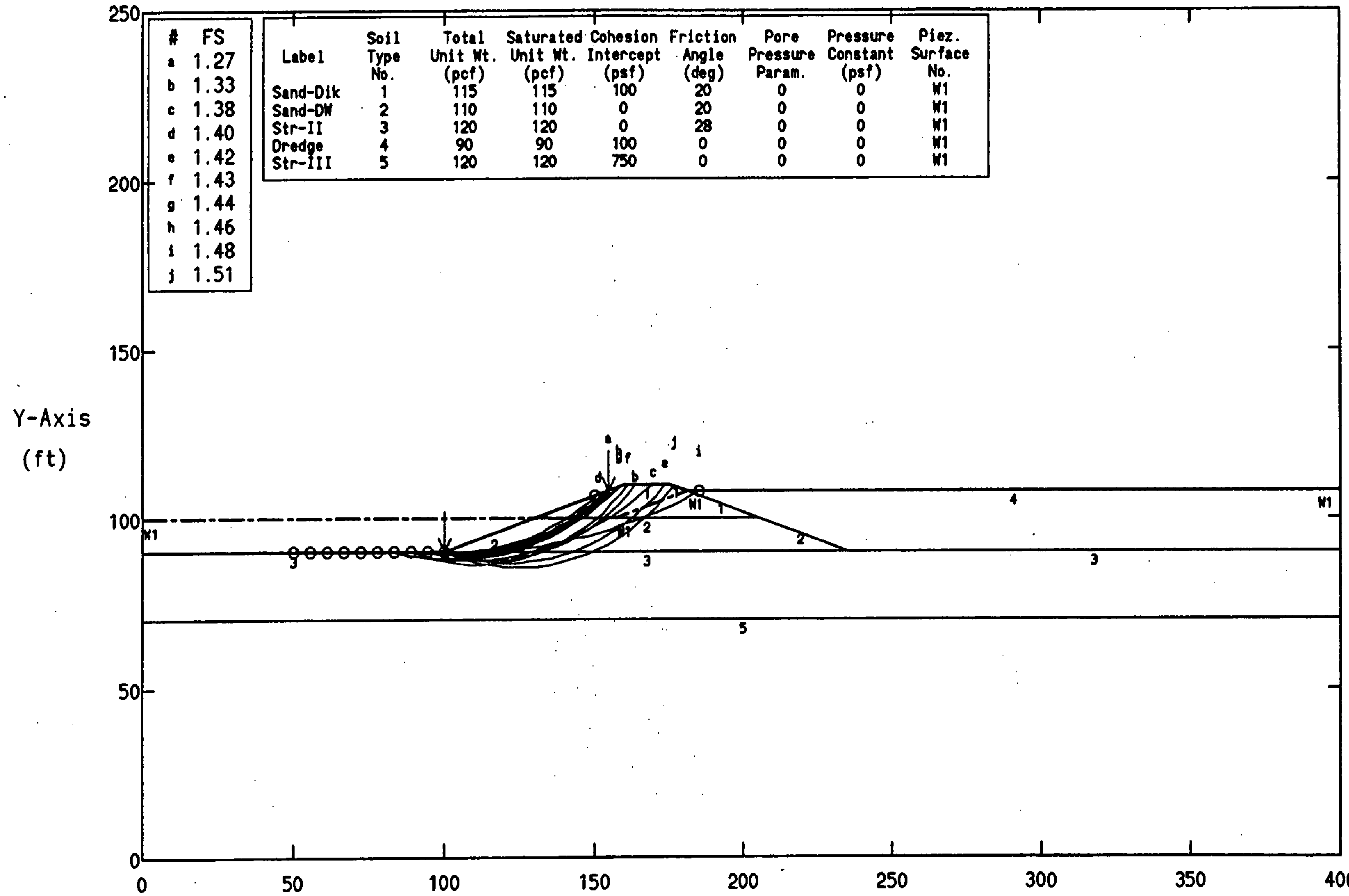


PCSTABL5 FSmin=1.46 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +10: Case B1: Dike

Ten Most Critical. C:BIB1D.PLT By: GVK 11-29-01 11:16am



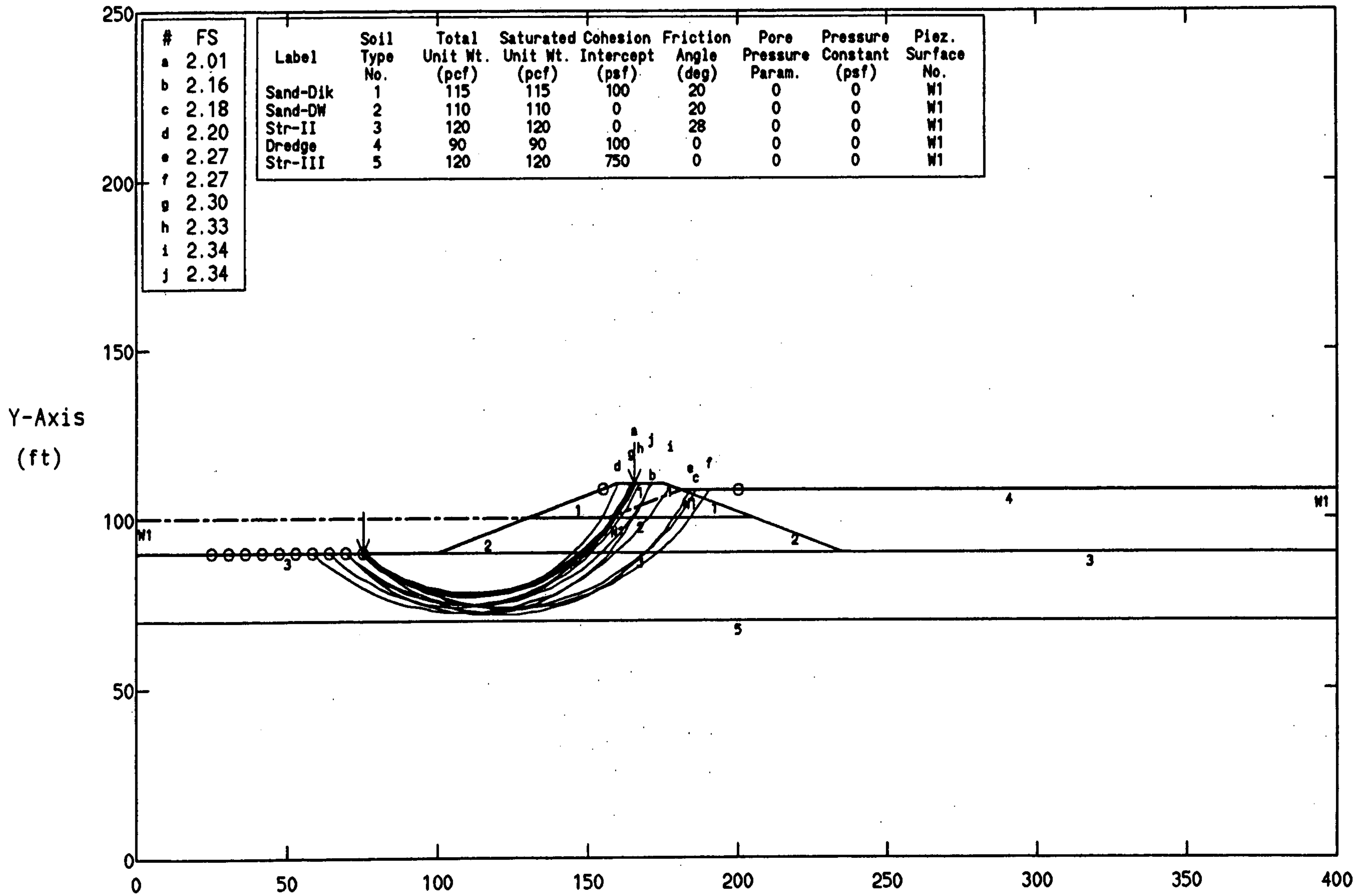
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.27 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +10: Case B1: Foundation

Ten Most Critical. C:BIB1F.PLT By: GVK 11-29-01 11:17am



#	FS
a	2.01
b	2.16
c	2.18
d	2.20
e	2.27
f	2.27
g	2.30
h	2.33
i	2.34
j	2.34

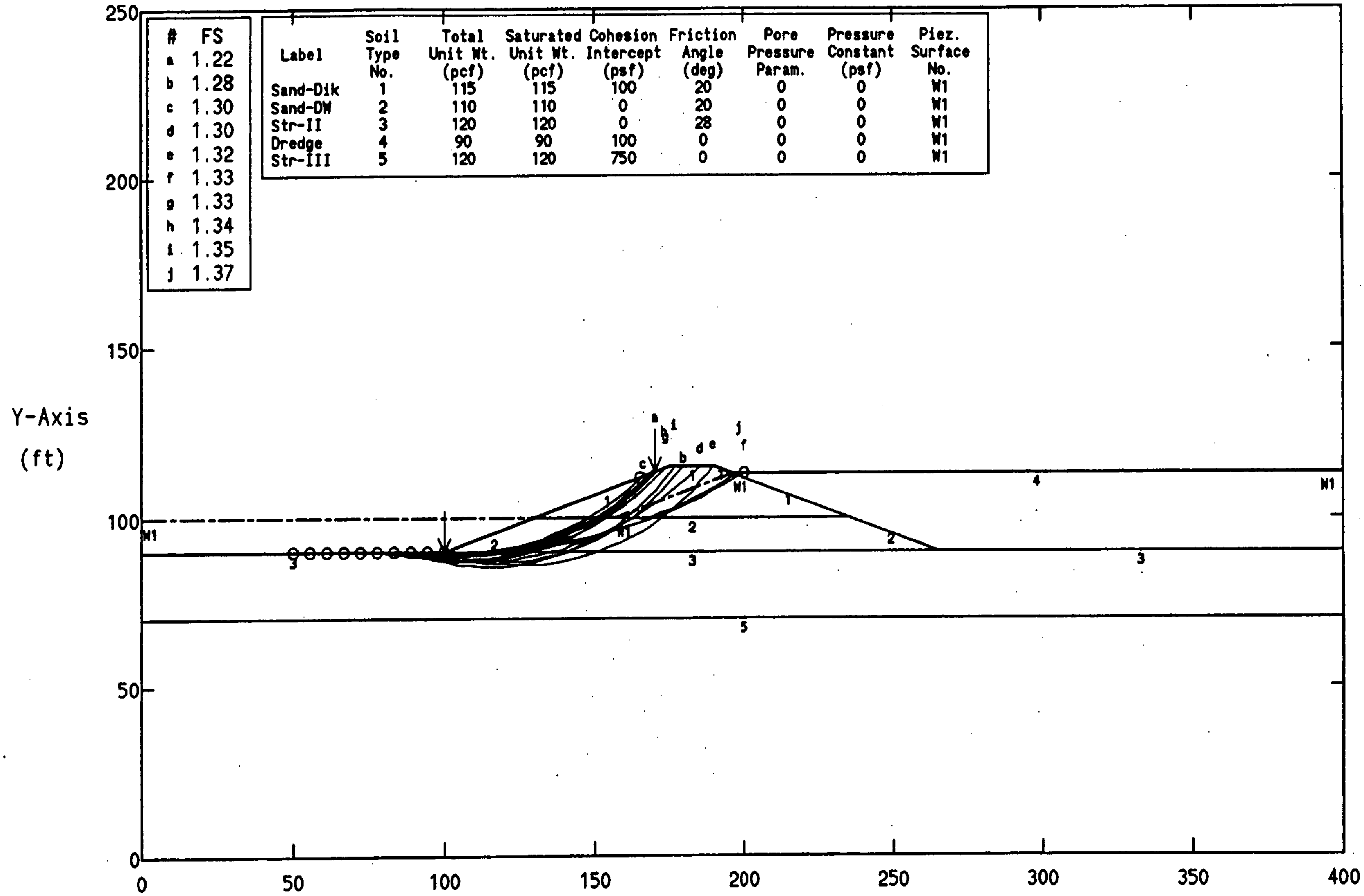
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=2.01 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +15: Case B2: Dike

Ten Most Critical. C:BIB2D.PLT By: GVK 11-29-01 11:20am



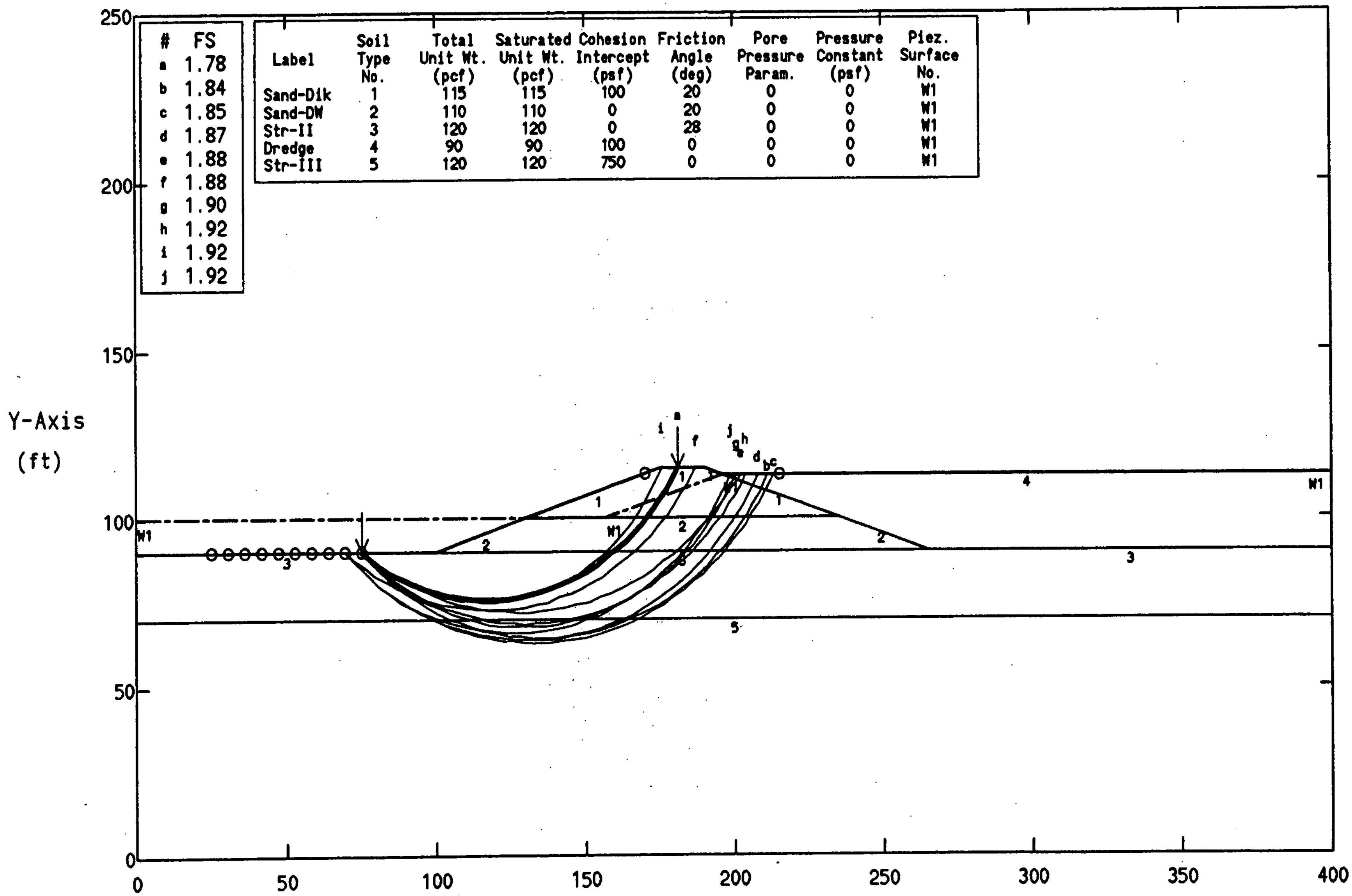
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.22 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +15: Case B2: Foundation

Ten Most Critical. C:BIB2F.PLT By: GVK 11-29-01 11:21am



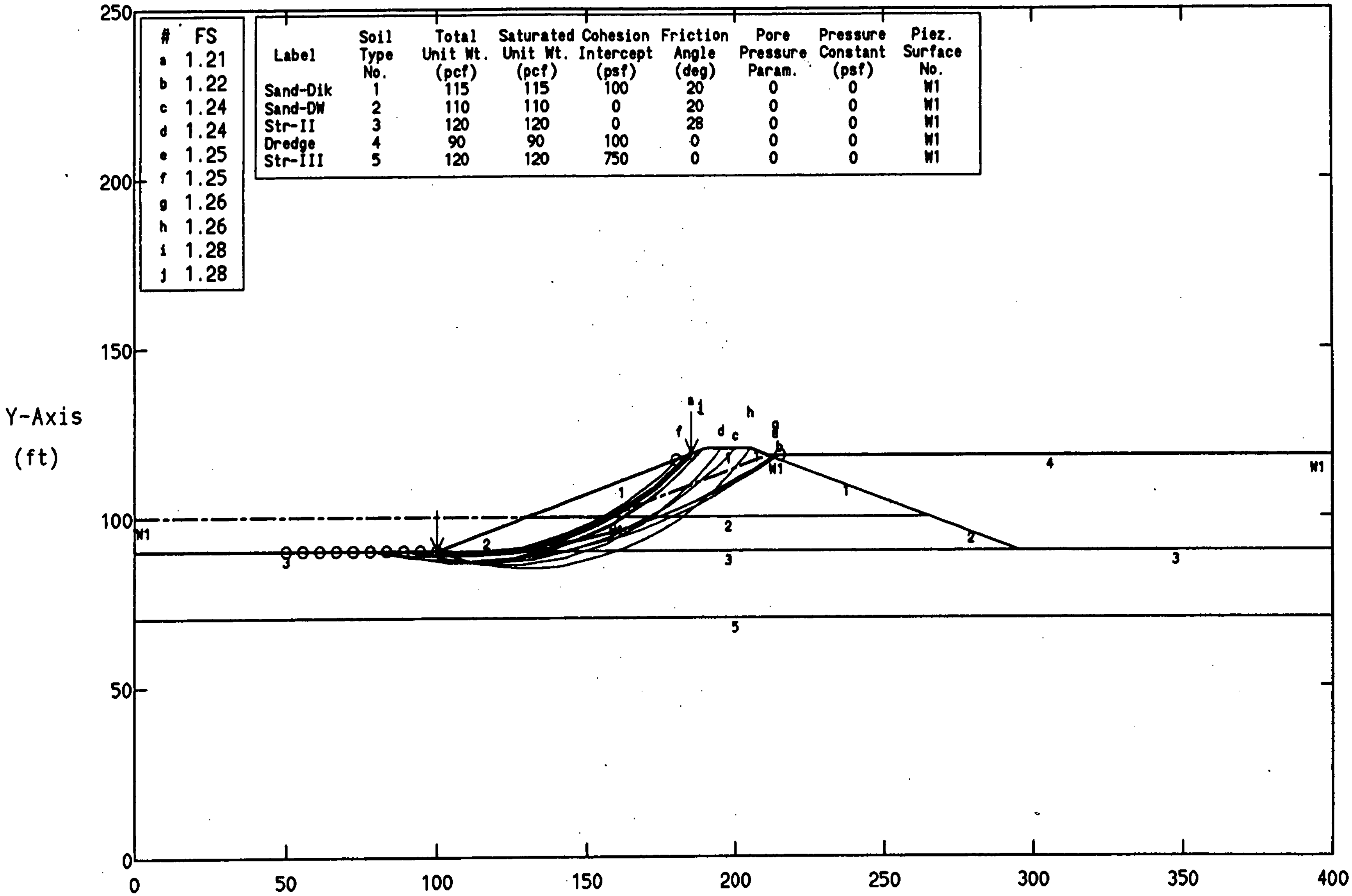
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.78 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +20: Case B3: Dike

Ten Most Critical. C:BIB3D.PLT By: GVK 11-29-01 6:56pm



#	FS
a	1.21
b	1.22
c	1.24
d	1.24
e	1.25
f	1.25
g	1.26
h	1.26
i	1.28
j	1.28

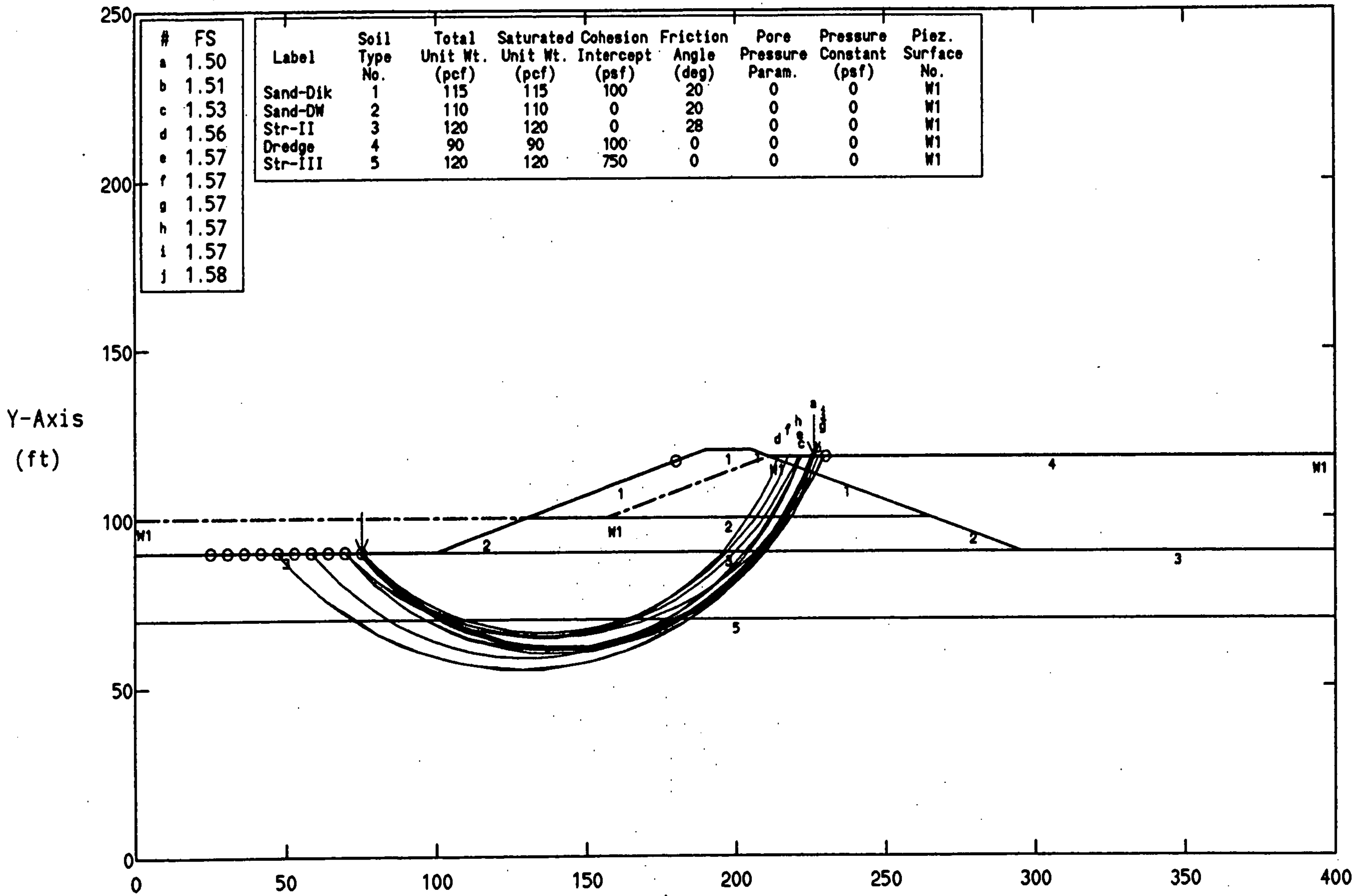
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.21 X-Axis (ft)

Factors Of Safety Calculated By The Modified Bishop Method

Barren Island Dike to +20: Case B3: Foundation

Ten Most Critical. C:BIB3F.PLT By: GVK 11-29-01 3:34pm



Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
Sand-Dik	1	115	115	100	20	0	0	W1
Sand-DW	2	110	110	0	20	0	0	W1
Str-II	3	120	120	0	28	0	0	W1
Dredge	4	90	90	100	0	0	0	W1
Str-III	5	120	120	750	0	0	0	W1

PCSTABL5 FSmin=1.50 X-Axis (ft)

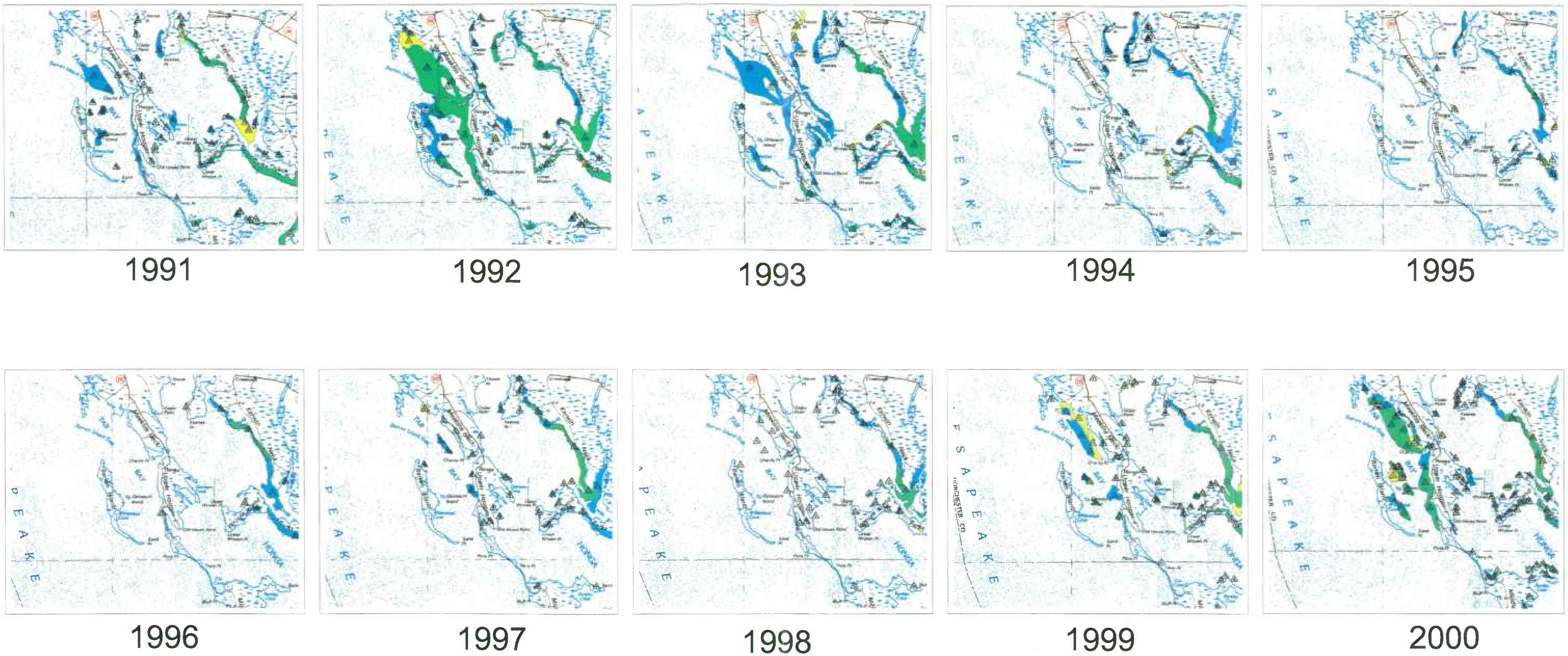
Factors Of Safety Calculated By The Modified Bishop Method

Table 10. Sediment Boring Data Collected near Barren Island
October 2001
E2CR Project No. 01556-04

Boring Number	Coordinates		Water Depth in Feet	Total Depth in feet	Generalized Subsurface
	Northing	Easting			
G-1	38° 20.481	76° 16.060	10	40	Interbedded layers of Silty Sand and Silty Clay from 10' to 18.5'. Silty Sand from 18.5' to 31'. Silty clay from 31' to 40'.
G-2	38° 19.886	76° 15.715	8	40	Interbedded layers of Silty Sand and Silty Clay from 8' to 40'. The thickness of Silty sand layers are less than 5'.
G-3	38° 19.051	76° 15.445	9	50	Silty Sand from 9' to 11.5'. Silty Clay from 11.5' to 33' with thin sand seams. Interbedded layers Clayey Sand and Silty Clay from 33' to 50'.
G-4	38° 18.494	76° 14.946	6	45	Silty Clay from 6' to 17'. Clayey Sand from 17' to 22'. Silty Sand from 22' to 32'. Silty Clay from 32' to 45.
G-5	38° 18.263	76° 15.631	10	45	Silty Sand from 10' to 15'. Silt & Sand from 15' to 27'. Interbedded layers of Clayey Sand, Silty Clay & Silty Sand from 27' to 45'.
G-6	38° 18.461	76° 15.754	9.8	55	Silty Sand from 10' to 14'. Sand & Silt from 14' to 17'. Silty sand from 17' to 29'. Clayey Sand & Silty Clay from 29' to 37'. Silty sand from 37' to 47'. Silty Clay from 47' to 55'.
G-7	38° 18.752	76° 16.370	12	45	Silty Sand from 12' to 36'. Silty Clay from 36' to 45'.
G-8	38° 18.961	76° 16.509	10	35	Silty Sand from 10' to 27'. Silty Clay from 27' to 35'.
G-9	38° 19.700	76° 17.229	18	65	Silty Sand from 18' to 65'.
G-10	38° 20.646	76° 16.585	11	35	Silty Clay from 10' to 16'. Clayey Sand from 16' to 27'. Silty Clay from 27' to 35'.
G-11	38° 20.178	76° 16.734	12.2	40	Silty Sand from 12' to 18'. Clayey Sand & Silt from 18' to 32'. Silty Clay from 32' to 40'.
G-12	38° 19.430	76° 16.493	12.6	40	Silty Sand from 12.6' to 31'. Silty Clay from 31' to 40'.
G-13	38° 19.224	76° 15.937	11	50	Silty Clay from 11' to 27'. Clayey to silty Sand from 27' to 47'. Silty Clay from 47' to 50'.
G-14	38° 19.968	76° 16.275	10	50	Silty Sand & Clayey Sand & silty Clay from 10' to 18'. Clayey and Silty Sand from 18' to 42'. Silty Clay from 42' to 50'.
G-15	38° 18.801	76° 14.843	3.5	40	Silty Clay from 3.5' to 11.5'. Silty Sand from 11.5' to 27'. Interbedded layers of Silty Sand and Silty Clay from 27' to 40'.
G-16	38° 18.994	76° 16.829	12	70	Silty Sand from 12' to 54'. PEAT from 54' to 62'. Silty Sand from 62' to 70'.
G-17	NA	NA	NA	45	Silty sand & Clayey sand mixture from 14' to 23.5'. Silty sand from 23.5' to 33.5'. Poorly graded sands, gravelly sands & silty sands from 33.5' to 38.5'. Silty Clay from 38.5' to 45'.
G-18	NA	NA	NA	50	Clayey sand & silty sand mixture from 8' to 10'. Inorganic silts and very fine sands from 18.4' to 20'. Silty sands and sand-silt mixtures from 28.5' to 33.5'. Poorly graded sands, gravelly sand and silty sand mixture from 33.5' to 45'. Silty Clay from 45' to 50'.

NOTE: The above subsurface conditions are based field visual description. The suitability of the Sand depends on the percent fines and can be concluded only after laboratory testing. NA = Not available.

VIRGINIA INSTITUTE OF MARINE SCIENCE - SUBMERGED AQUATIC VEGETATION DATA FOR 1991 THROUGH 2000



SAV Bed Species

- Rm
- Zm
- SAV Points

SAV Bed Density

- 0 - 10%
- 10 - 40%
- 40 - 70%
- 70 - 100%

N

All SAV data from VIMS SAV Monitoring Project Report Maps and VIMS GIS data downloaded from www.vims.edu on 17 December 2001.

Note that SAV Monitoring Report Maps for the Barren Island USGS Quadrangle for the years 1994, 1995, and 1996 are not available. SAV Monitoring Reports are available for 1994 through 2000 only. All SAV data for these earlier years is derived from the downloaded GIS data.

WESTON MANAGERS DESIGNERS/CONSULTANTS

Maryland Environmental Service

Figure 11.
SAV Beds 1991 to 2000

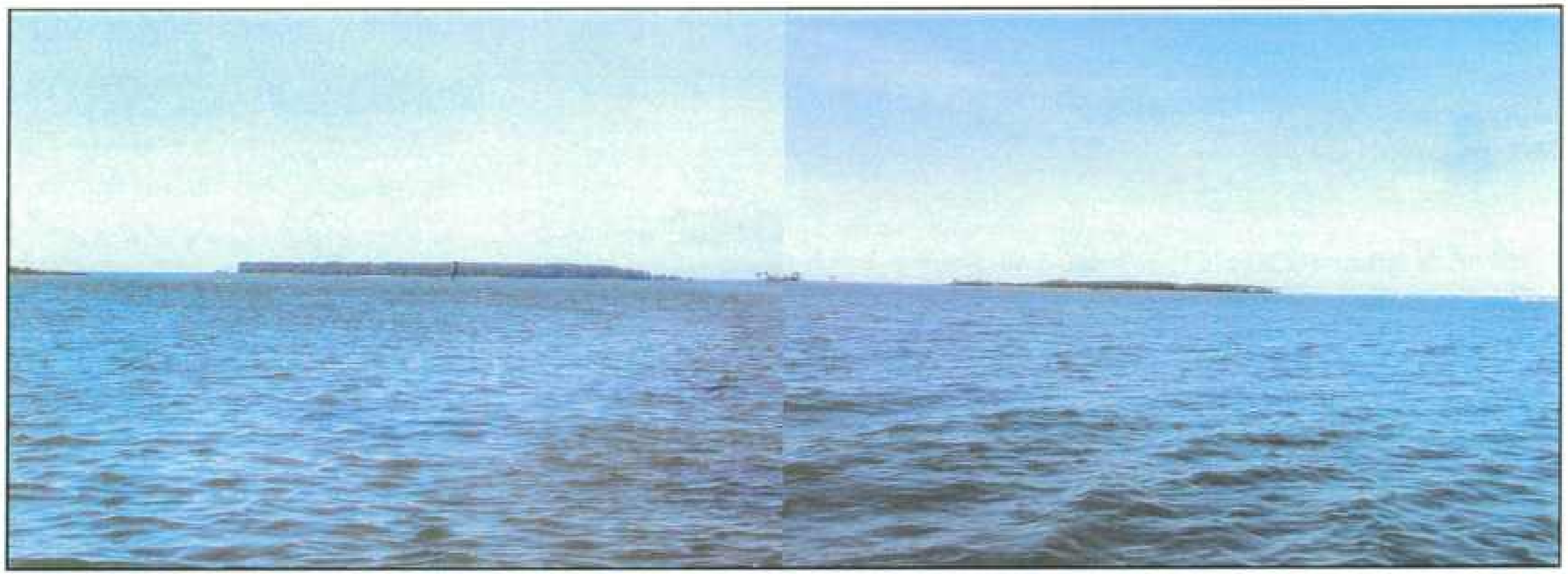


Photo 1. View, facing west, of Barren Island from Tar Bay. The small remnant portion of the Island is to the far left. The Island proper consists of the south part (predominantly wooded upland and high marsh), a low marsh in the middle, and the north end (wooded upland, high marsh, and low marsh).

Photo 2. View from Bay main stem, facing south, of the north end of Barren Island and remnants of the hunting lodge and old bulkhead. Note loblolly pine trees dying from salt intrusion.

Photo 3. View from Bay main stem, facing northeast, of remnants of old wooden bulkhead.

Photo 4. View from west shoreline on Barren Island, facing north, of beach areas and failed geotube site on north end of the island.

Photo 5. View from west shore, facing south, of restored low marsh areas on north end of island.

Photo 6. View from western shore low marsh, facing east, of high marsh and upland areas on north end of island.

Photo 7. View from west shore, facing north, of sandy beach (potential Northeastern Tiger Beetle habitat) and remnants of hunting lodge on north end of island.

Photo 8. View from restored low marsh, facing southeast, of standing water pools in restored areas on north end of island.

Photo 9. View from former airfield, facing northeast, of high marsh near interior of north end of island.

Photo 10. View from north end island interior, facing south, of former airstrip. Note upland habitat in this portion of island.

Photo 11. View from east shore, facing east, of low marsh and high marsh along eastern edge of the north end of the island.

Photo 12. View from Bay main stem, facing east, of low marsh between north and south ends of the island. This area is particularly susceptible to erosion.

Photo 13. View from southwestern tip of island, facing north, of eroding western shoreline.

Photo 14. View from Bay side southwestern tip of island, facing east, of south end loblolly pine forested area, Great Blue Heron Rookery, and marsh on southern tip of island.

Photo 15. View from SAV beds south of island, facing northeast, of southern tip and eastern shore of island. This area contained Bald Eagle's nest.

Photo 16. View from Tar Bay, facing west, of loblolly pine area containing the Bald Eagle's nest on eastern shore of south end of island. Note dark patches of SAV in shallow water (foreground).

Photo 17. View from southern tip of island, facing south, of small breakaway island supporting Brown Pelican nesting areas.

Photo 18. View of the Bald Eagle's nest in a tall loblolly pine on the southeast end of the island.

Photo 19. View of the under story within the loblolly pine forest on south end of island. Note browse line from White-tailed deer foraging.

Photo 20. View from forested area in south end of island, facing north, of high marsh habitat.

Photo 21. View of Great Blue Heron nests in rookery area of loblolly pine forest on south end of island.

Photo 22. View from Tar Bay, facing east, of marsh area on south end of island. Note Bald Eagle sitting on tall pine tree (arrow).

Photo 23. View from SAV beds off south tip of island, facing south, of Brown Pelicans flying from small breakaway island (arrow).

CERCLIS Query Results

Source: USEPA, 2001b

Consolidated facility information (from multiple EPA systems) was searched to select facilities
COUNTY NAME: **Dorchester**
STATE ABBREVIATION: **MD**
EPA REGION CODE: **03**
Results are based on data extracted on DEC-17-2001

CERCLIS EPA ID	SITE NAME	ADDRESS	COUNTY	FEDERAL FACILITY	NPL STATUS	RECORD OF DECISION (ROD) INFO	EPA REGIONAL LINK	OWNERSHIP	SITE INCIDENT
MDD980694038	CAMBRIDGE TOWN GAS	403 CHERRY ST CAMBRIDGE, MD 21613	DORCHESTER	N	Not on the NPL	No	No	Other	
MDD981040207	EASTERN MD WOOD TREATING CO	CLARKS CANNING HOUSE RD FEDERALSBURG, MD 21632	DORCHESTER	N	Not on the NPL	No	No	Private	Non-Oil Spill
MD7170090016	USN BLOODSWORTH ARCHIPELAGO	N POTOMAC R RUNS CHESPKE BAY N/A, MD 21613	DORCHESTER	Y	Not on the NPL	No	No	Federally Owned	

Total Number of Facilities Displayed: 3

Summary of Essential Fish Habitat (EFH) and General Habitat Parameters for Federally Managed Species

Species	Life Stage	Geographic Area	Temp (• C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
American plaice	Eggs	GOME, GB and astuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass. Bay to Capa Cod Bay, MA	<12	(32)	30 - 90	All year in GOME Dec - June on GB Peaks April & May both	Surfaca waters	
	Larvaa	GOME, GB, Southem NE and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass Bay to Cape Cod Bay, MA	<14	(32)	30-130	Between January and August, with paaks In April and May	Surfaca Waters	
	Juveniles	GOME and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass Bay to Capa Cod Bay, MA	<17	(32)	45-150		Bottom habitats with fine-grained sediments or substrate of sand or gravel	(Strong concentrations inside and around 100m isobath in Westem GOME; Major Prey: echinoderms, arthropods, annelids)
	Adults	GOME, GB and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass Bay to Capa Cod Bay, MA	<17	(34-20)	45-175		Bottom habitats with fine-grained sediments or a substrate of sand or gravel	
	Spawning Adults	GOME, GB and estuaries from Passamaquoddy Bay to Saco Bay, ME and from Mass Bay to Cape Cod Bay, MA	<14	(32)	<90	March through June	Bottom habitats of all substrate types	
Atlantic cod	Eggs	GOME, GB, aastern portion of continental shelf off southem NE and following estuaries: Englishman/ Machias Bay to Blua Hill Bay; Sheepscot R., Casco Bay, Saco Bay, Great Bay, Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	<12	32 - 33 (10 - 35)	<110	Begins In fall, peaks In winter and spring	Surface Waters	
	Larvaa	GOME, GB, aastern portion of continental shelf off southem NE and following estuaries: Passamaquoddy Bay to Penobscot Bay; Sheepscot R., Casco Bay, Saco Bay, Great Bay, Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	<10	32 - 33	30-70	Spring	Pelagic waters	
	Juveniles	GOME, GB, eastern portion of continental shelf off southem NE and following estuaries: Passamaquoddy Bay to Saco Bay; Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	<20	30 - 35	25 - 75		Bottom habitats with a substrate of cobble or gravel	HAPC - An area approximata of 300sq. nautical miles along the northem edge of GB and the Hague line containing gravel cobble substrate.
	Adults	GOME, GB, southem NE, middle Atlantic south to Delawara Bay and following estuaries: Passamaquoddy Bay to Saco Bay; Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	<10	(29 - 34)	10-150		Bottom habitats with a substrate of rocks, pebbles, or gravel	(Major prey: fish crustaceans, decapods, amphipods)

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (°C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Spawning Adults	GOME, GB, southern NE, middle Atlantic south to Delaware Bay and following estuaries: Englishman/ Machias Bay to Blue Hill Bay; Sheepscot R., Mass Bay, Boston Harbor, Cape Cod Bay, MA	<10	(10 - 35)	10-150	spawn during fall, winter, and early spring	Bottom habitats with a substrate of smooth sand, rocks, pebbles, or gravel	
Atlantic hallbut	Eggs	GOME, GB	4 - 7	<35	<700	Between late fall and early spring, peak Nov and Dec.	Pelagic waters to the sea floor	
	Lervae	GOME, GB		30 - 35			Surface waters	
	Juveniles	GOME, GB	>2		20 - 60		Bottom habitats with a substrate of sand, gravel, or clay	
	Adults	GOME, GB	<13.6	30.4-35.3	100-700		Bottom habitats with a substrate of sand, gravel, or clay	(Major prey: crustaceans, fish, cod, squid)
	Spewning Adults	GOME, GB	<7	<35	<700	Between late fall and early spring, peaks in Nov. and Dec.	Bottom habitats with a substrate of soft mud, clay, sand, or gravel; rough or rocky bottom locations along slopes of the outer banks	
Atlantic herring	Eggs	GOME, GB and following estuaries: Englishman/ Machias Bay, Casco Bay,& Cape Cod Bay .	<15	32 - 33	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble, shell fragments & aquatic macrophytes. .	Eggs adhere to bottom forming extensive beds. Eggs most often found in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots (Egg beds can range from 4500 to 10,000 Km^2 on GB. Eggs susceptible to suffocation from high densities and siltation)
	Larvae	GOME, GB, Southern NE and following estuaries: Passamaquoddy Bay to Cape Cod Bay; Narragansett Bey, & Hudson R./ Reritan Bay	<16	32	50 - 90	Between August and April, peaks from Sept. - Nov.	Pelagic waters	
	Juveniles	GOME, GB, Southern NE and Middle Atlantic south to Cape Hatteras and following estuaries: Passamaquoddy Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bay	<10	26 - 32	15-135		Pelagic waters and bottom habitats	
	Adults	GOME, GB, southern NE and middle Atlantic south to Cepe Hatteras and following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay to Delaware Bey; & Chesapeake Bay	<10	>28	20-130		Pelagic waters and bottom habitats	(major prey: zooplankton)
	Spawning Adults	GOME, GB, southern NE and middle Atlantic south to Delaware Bay and Englishman/ Machias Bay Estuary	<15	32 - 33	20 - 80	July through November	Bottom habitats with a substrate of gravel, sand, cobble and shell fragments, also on aquatic macrophytes	Herring eggs are spawned in areas of well-mixed water, with tidal currents between 1.5 and 3.0 knots

This table was complied by NMFS Northeast Regional Office, Habltat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nl additional ecological Information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habilal Area of Particular Concern; YOY - Young-of-Year Please nole: This Table does nol contain EFH info on Highly Migralory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
Atlantic salmon	Eggs	Rivers from CT to Maine: Connecticut, Pewcatuck, Merrimack, Cocheco, Seco, Androscoggin, Presumpscot, Kannebec, Sheepscot, Ducktrap, Union, Penobscot, Narraguagus, Machias, East Machias, Pleasant, St. Croix, Denny's, Passagassawaukeag Aroostook, Lamprey, Boyden, Orland Rivers, and the Turk, Hobart & Patten Streams; and tha following estuaries for juveniles and adults: Passamaquoddy Bay lo Muscongus Bay; Casco Bay to Wells Harbor; Mass Bay, Long Island Sound, Gardiners Bay to Great South Bay. All aquatic habitats in the watersheds of lhe above listed rivers, including all tributaries to the extent that they are currently or were historically accessible for salmon migration.	<10	Fresh water	30-31 cm	Between October and April	Bottom habitats with a gravel or cobbla riffle (redd) above or below a pool in rivers	need clean well-oxygenated freshwater
	Larvae		<10	Fresh water		Between March and June for alevins/fry	Bottom habitats with a gravel or cobble riffle (redd) above or below a pool in rivers	
	Juveniles		<25	Fresh water to Oceanic	10- 61 cm		Bottom habitats of shallow gravel/cobble riffles interspersed with deeper riffles and pools in rivers and estuaries Water velocities between 30 - 92cm/sec	As they grow, parr transform into smolts. Atlantic salmon smolls require access downstream to tha ocean. Upon entering lhe ocean, post-smolts become pelagic and range from Long Island Sound north to lhe Labrador Sea.
	Adulls		<22.8	Fresh water to Oceanic			Oceanic adult Atlantic salmon are primarily pelagic and range from waters of lhe continental shelf off southem NE north throughout the GOME Dissolved oxygen above 5ppm for migratory pathway.	HAPC - Eleven rivers in Maine includes: St. Croix, Denny's, Easl Mechlas, Machias, Pleasant, Turk stream, Narraguagus, Penobscot, Ducktrep, Shaepscot, and Kennebec River.
	Spawning Adults		<10	Fresh water	30- 61 cm	October and November	Bottom habitats with a gravel or cobble riffle (redd) above or below a pool in rivers	Water velocity around 61cm per second
Atlantic sea acallop	Eggs	GOME, GB, southem NE and middla Atlantic south to Virglnia-North Carolina border and following astuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Mass Bay, and Cape Cod Bay	<17			May through October Peaks in May and June in middle Atlantic area, and in Sept. and Oct. on GB and GOME	Bottom habitats	Eggs remain on sea floor until they develop into tha first frea-swimming larval stage.
	Larvae	GOME, GB, southem NE and middla Atlantic south lo Virginla-North Carolina border and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Mass Bay, and Cape Cod Bay	<18	16.9 - 30			Pelagic waters and bottom habitats with a substrate of gravelly sand, shell fragmenls, pebbles, or on various red algae, hydroids, amphipod tubes and bryozoans	
	Juveniles	GOME, GB, southem NE and middla Atlantic south to Virginia-North Carolina bordar and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Great Bay, Mass Bay, and Cape Cod Bay	<15		18-110		Bottom habilats with a substrate of cobble, shells, and silt	(prey: filter feeders on phytoplankton; preferred substrates are associaled with low concentrations of inorganics for optimal feeding)
	Adults	GOME, GB, southem NE and middla Atlantic south to Virginia-North Carolina border and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Great Bay, Mass Bay, and Capa Cod Bay	<21	>16.5	18-110		Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand	

This lable was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presenled is part of lhe Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please nole: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Spawning Adults	GOME, GB, southern NE and middle Atlantic south to Virginia-North Carolina border and following estuaries: Passamaquoddy Bay to Sheepscot R.; Casco Bay, Mass Bay, and Cape Cod Bay	<16	>16.5	18-110	May through October, peaks in May and June in middle Atlantic area, and in Sept. and Oct. on GB and in GOME	Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand	
Haddock	Eggs	GB southwest to Nantucket Shoals and coastal areas of GOME and the following estuaries: Great Bay, Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay	<10	34 - 36	50 - 90	March to May, peak in April	Surface waters	
	Larvaa	GB southwest to the middle Atlantic south to Delaware Bay and tha following astuaries: Great Bay, Mass Bay, Boston Harbor, Cape Cod Bay, Buzzards Bay, and Narragansett Bay	<14	34 - 36	30 - 90	January to July, peak in April and May	Surface waters	
	Juveniles	GB, GOME, middle Atlantic south to Delaware Bay	<11	31.5 - 34	35-100		Bottom habitats with a substrata of pebble gravel	
	Adults	GB and eastern side of Nantucket Shoals, throughout GOME, *additional area of Nantucket Shoals, and Great South Channel	<7	31.5 - 35	40-150		Bottom habitats with a substrate of broken ground, pebbles, smooth hard sand, and smooth areas between rocky patches	*additional area more accurately reflects historic patterns of distribution and abundance
	Spawning Adults	GB, Nantucket Shoals, Great South Channel, throughout GOME	<6	31.5 - 34	40-150	January to June	Bottom habitats with a substrate of pebble gravel or gravelly sand	
Monkfish (Goose-fish)	Eggs	GOME, GB, southern NE, middle Atlantic south to Capa Hatteras, North Carolina	<18		15- 1000	March to September	Surface waters	(eggs contained in long mucus veils that float near or at the surfaca)
	Larvae	GOME, GB, southern NE, middle Atlantic south to Capa Hatteras, North Carolina	15		25-1000	March to September	Pelagic waters	
	Juveniles	Outer continental shelf in the middle Atlantic, mid-shelf off southern NE, all areas of GOME	<13	29.9-36.7	25-200		Bottom habitats with substrates of a sand-shell mix, algaa covered rocks, hard sand, pebbly gravel, or mud	
	Adults	Outer continental shelf in the middla Atlantic, mid-shelf off southern NE, outer perimeter of GB, all areas of GDME	<15	29.9-36.7	25-200		Bottom habitats with substrates of a sand-shell mix, algae covered rocks, hard sand, pebbly gravel, or mud	(Major prey: fish, shrimp, squid, crustaceans, mollusks)
	Spawning Adults	Outer continental shelf in tha middle Atlantic, mid-shelf off southern NE, outer perimeter of GB, all areas of GOME	<13	29.9-36.7	25-200	February to August	Bottom habitats with substrates of a sand-shell mix, algae covered rocks, hard sand, pebbly gravel, or mud	
Ocean pout	Eggs	GOME, GB, southern NE, middle Atlantic south to Delawara Bay and tha following estuaries: Passamaquoddy Bay to Saco Bay; Mass Bay and Cape Cod Bay	<10	32-34	<50	Late fall and winter	Bottom habitats, generally hard bottom sheltered nests, holes, or crevices where they are guarded by parents	(eggs ara laid in gelatinous masses and take 2-3 months to develop

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Oivision. All information presenled is part of the Regional Fishery Management Council's EFH designations except for lhat contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (• C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Larvae	GOME, GB, southern NE, middle Atlantic south to Delewere Bey end the following estuaries: Passamequoddy Bay to Saco Bay; Mass Bay and Cape Cod Bay	<10	>25	<50	Lete fall to spring	Bottom habitats in close proximity to hard bottom nesting areas	
	Juveniles	GOME, GB, southern NE, middle Atlantic south to Delawere Bey end the following estuaries: Passamaquoddy Bay to Saco Bay; Mess Bay, Boston Harbor and Cape Cod Bay	<14	>25	<80		Bottom habitets, often smooth bottom near rocks or algae	
	Adults	GOME, GB, southern NE, middle Atlantic south to Delaware Bey and the following estuaries: Passamaquoddy Bay to Saco Bay; Mass Bay, Boston Harbor end Cape Cod Bay	<15	32 - 34	<110		Bottom habitats. (Dig depressions in soft sediments which are then used by other species)	(mejor prey: mollusks, crusteceans, echinoderms, sand dollars)
	Spawning Adults	GOME, GB, southern NE, middle Atlantic south to Delaware Bey and the following estuaries: Passamaquoddy Bay to Seco Bay; Mess Bay, and Cape Cod Bay	<10	32 - 34	<50	Late summer to early winter, peaks in Sept. and October	Bottom habitats with a hard bottom substrate, including artificial reefs and shipwrecks	(internal fertilization)
Offshore hake	Eggs	Outer continental shelf of GB and southern NE south to Cape Hatteras, North Carolina	<20		<1250	Observed all year and primarily collected et depths from 110 - 270m	Pelagic waters	
	Lervae	Outer continental shelf of GB and southern NE south to Chesepeake Bay	<19		<1250	Observed all yeer end primarily collected at depths from 70 - 130m	Pelagic waters	
	Juveniles	Outer continental shelf of GB and southern NE south to Cape Hatteras, NC	<12		170- 350		Bottom habitats	
	Adults	Outer continental shelf of GB end southern NE south to Cape Hatteras, NC	<12		150 - 380		Bottom habitats	(major prey: fish - cannibalistic, shrimp, other crustaceans)
	Spawning Adults	Outer continental shelf of GB and southern NE south to the Middle Atlantic Bight	<12		330 - 550	Spawn all throughout the year	Bottom habitats	
Pollock	Eggs	GOME, GB and the following estuaries: Great Bay to Boston Herbor	<17	32 - 32.8	30-270	October to June, peaks in November to February	Pelagic waters	
	Larvae	GOME, GB and the following estuaries: Passamaquoddy Bay, Sheepscot R., Great Bay to Cape Cod Bay	<17		10-250	September to July, peaks from Dec. to February	Pelagic waters	(migrate inshore es they grow)
	Juveniles	GOME, GB and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay to Waquoit Bay; Long Island Sound, Great South Bay	<18	29 - 32	0 - 250		Bottom habitats with aquatic vegetation or a substrate of sand, mud or rocks	(Intertidal zone may be important nursery area. Juveniles present in shallow intertidal zone at all tide stages throughout summer. Subtidal marsh creeks such as Little Egg Harbor, NJ are also seasonally important as nursery)

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as important additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Adults	GOME, GB, southern NE, and middle Atlantic south to New Jersey and the following estuaries: Passamaquoddy Bay, Damariscotta R., Mass Bay, Capa Cod Bay, Long Island Sound	<14	31 - 34	15-365		Hard bottom habitats including artificial reefs	(major prey: crustaceans, fish, mollusks)
	Spawning Adults	GOME, southern NE, and middle Atlantic south to New Jersey includes Mass Bay	<8	32 - 32.8	15-365	September to April, peaks December to February	Bottom habitats with a substrate of hard, stony, or rocky bottom includes artificial reefs	
Red hake	Eggs	GOME, GB, continental shelf off southern NE, and middle Atlantic south to Capa Hatteras	<10	< 25		May to November, peaks in June and July	Surface waters of inner continental shelf	
	Larvaa	GOME, GB, continental shelf off southern NE, and middle Atlantic south to Cape Hatteras and following estuaries: Sheepscot R., Mass Bay to Cape Cod Bay; Buzzards Bay, Narragansett Bay & Hudson R./ Raritan Bay	<19	>0.5	<200	May to December, peaks in Sept. and October	Surface waters	(newly settled larvae need shelter, including live sea scallps, also use floating or mid-water objects for shelter)
	Juveniles	GOME, GB, continental shelf off southern NE, and middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay, Mass Bay to Cape Cod Bay; Buzzards Bay to Conn. R.; Hudson R./ Raritan Bay, & Chesapeake Bay	<16	31 - 33	<100		Bottom habitats with substrate of shell fragments, including areas with an abundance of live scallops	
	Adults	GOME, GB, continental shelf off southern NE, and middla Atlantic south to Cape Hattaras and the following estuaries: Passamaquoddy Bay to Saco Bay; Great Bay, Mass Bay to Capa Cod Bay; Buzzards Bay to Conn. R.; Hudson R./ Raritan, Delawara Bay, & Chesapeake Bay	<12	33 - 34	10-130		Bottom habitats in depressions with a substrate of sand and mud	(major prey: fish and crustaceans)
	Spawning Adults	GOME, southern edge of GB, continental shelf off southern NE, and middle Atlantic south to Cape Hatteras and following estuaries: Sheepscott R., Mass Bay, Cape Cod Bay, Buzzards Bay, & Narragansett Bay	<10	>25	<100	May to November, peaks in June and July	Bottom habitats in depressions with a substrate of sand and mud	
Redfish	Eggs	No EFH identification or description for this life history stage						Redfish are ovoviviparous (live bearers)
	Larvae	GOME, southern GB	<15		50-270	March to October, peak in August	Pelagic waters	
	Juvaniles	GOME, southern edga of GB	<13	31 - 34	25-400		Bottom habitats with a substrata of silt, mud, or hard bottom	
	Adults	GOME, southern edge of GB	<13	31 - 34	50-350.		Bottom habitats with a substrate of silt, mud, or hard bottom	
	Spawning Adults	GOME, southern adge of GB	<13	31 - 34	5 -350	April to August	Bottom habitats with a substrate of silt, mud, or hard bottom	copulation occurs between Oct-Jan. Fertilization is delayed until Feb-Apr

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
White hake	Eggs	GOME, GB, southern NE and tha following estuaries: Great Bay to Cape Cod Bay				August to September	Surface waters	
	Larvae	GOME, southern edge of GB, southern NE to middle Atlantic and the following estuaries: Mass Bay, to Cape Cod Bay				May - mid-Atlantic area Aug. & Sept. - GOME, GB area	Pelagic waters	
	Juveniles	GOME, southern edge of GB, southern NE to middle Atlantic and the following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Capa Cod Bay	<19		5 - 225	May-Sep - pelagic	Pelagic stage - pelagic waters; Dermersal stage - Bottom habitat with seagrass beds or substrate of mud or fine-grained sand	
	Adults	GOME, southern edge of GB, southern NE to middla Atlantic and tha following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Capa Cod Bay	<14		5 - 325		Bottom habitats with substrate of mud or fine-grained sand	(major prey: small fish, shrimp and other crustaceans)
	Spawning Adults	GOME, southern edga of GB, southern NE to middle Atlantic	<14		5 - 325	April to May - southern part of range; August - Sept.- northern part of range	Bottom habitats with substrate of mud or fine-grained sand in deep water.	
Whiting (Silver hake)	Eggs	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and the following estuarias: Merrimack R. to Capa Cod Bay	<20		50-150	All year, peaks June to October	Surface waters	
	Larvae	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and tha following estuaries: Mass Bay to Cape Cod Bay	<20		50-130	All year, peaks July to September	Surface waters	
	Juveniles	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and the following estuarias: Passamaquoddy Bay to Casco Bay, Mass Bay to Cape Cod Bay	<21	>20	20-270		Bottom habitats of all substrate types	
	Adults	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Casco Bay, Mass Bay to Cape Cod Bay	<22		30-325		Bottom habitats of all substrate types	
	Spawning Adults	GOME, GB, continental shelf off southern NE, middla Atlantic south to Cape Hatteras and the following estuaries: Mass Bay and Capa Cod Bay	<13		30-325		Bottom habitats of all substrate types	
Window-pane flounder	Eggs	GOME, GB, southern NE, middle Atlantic south to Cape Hatteras and the following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Delaware Inland Bays	<20		<70	February to November, peaks May and October in middle Atlantic July - August on GB	Surface waters	

This table was complled by NMFS Northeast Regional Office, Habital Conservation Division. All information presented is part ol the Regional Fishery Managemenl Council's EFH designations excepl for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year . Please note: This Table does not contain EFH info on Highly Migralory Species (sharks, lunas, billfish).

Species	Life Stage	Geographic Area	Temp (• C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Larvae	GOME, GB, southern NE, middle Atlantic south to Cape Hatteras and tha following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Delaware Inland Bays	<20		<70	February to November, peaks May and October in middle Atlantic July - August on GB	Pelagic waters	
	Juveniles	GOME, GB, southern NE, middla Atlantic south to Capa Hatteras and tha following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Chesapeake Bay	<25	5.5 - 36	1 - 100		Bottom habitats with substrate of mud or fine grained sand	
	Adults	GOME, GB, southern NE, middle Atlantic south to Virginia - NC border and the following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Chesapeake Bay	<26.8	5.5 - 36	1 - 75		Bottom habitats with substrate of mud or fine grained sand	(major prey: polychaetes, small crustaceans, mysids, small fish)
	Spawning Adults	GOME, GB, southern NE, middle Atlantic south to Virginia -NC border and the following estuaries: Passamaquoddy Bay to Great Bay; Mass Bay to Delaware Inland Bays	<21	5.5 - 36	1 - 75	February - December, peak in May in middle Atlantic	Bottom habitats with substrate of mud or fine grained sand	
Winter flounder	Eggs	GB, Inshore areas of GOME, southern NE, middle Atlantic south to Delaware Bey and the following estuarias: Passamaquoddy Bay to Delaware Inland Bays	<10	10 - 30	<5	February to June, peak in April on GB	Bottom habitats with a substrate of sand, muddy sand, mud, and gravel	* On GB, eggs are generally found in water temp < 8• C, and < 90m deep.
	Larvae	GB, inshore areas of GOME, southern NE, middla Atlantic south to Delawara Bay and the following estuaries: Passamaquoddy Bay to Delaware Inland Bays	<15	4 - 30	<6	March to July, peaks in April and May on GB	Pelagic and bottom waters	* On GB, larvae are generally found in water tamp < 8• C, and < 90m deep.
	Juveniles (age 1+)	GB, inshore areas of GOME, southern NE, middle Atlantic south to Delaware Bay end the following estuaries: Passamaquoddy Bay to Chincoteague Bay	<25	10 - 30	1 - 50		Bottom habitats with a substrate of mud or fine grained sand	* Young-of-year exist where water temp <28, depths 0.1 - 10m, salinities 5 - 33 (major prey: amphipods, copepods, polychaetes, bivalve siphons)
	Adults	GB, inshore areas of GOME, southern NE, middle Atlantic south to Delaware Bay and the following estuaries: Passamaquoddy Bay to Chincoteague Bay	<25	15 - 33	1.- 100		Bottom habitats including estuaries with substrate of mud, sand, gravel	(major prey: amphipods, polychaetes, bivalve siphons, crustaceans)
	Spawning Adults	GB, inshore areas of GOME, southern NE, middle Atlantic south to Dalawara Bay and the following estuaries: Passamaquoddy Bay to Delawara Inland Bays	<15	5.5 - 36	<6*	February to June	Bottom habitats including estuaries with substrate of mud, sand, gravel	*except on GB where they spawn as deep as 80m
Witch flounder	Eggs	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras	<13	High	Deep	March to October	Surface waters	
	Larvae	GOME, GB, continental shelf off southern NE, middle Atlantic south to Cape Hatteras	<13	High	Deep	March to November, peaks In May - July	Surface waters to 250m	

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Teble does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Juveniles	GOME, outer continental shelf from GB south to Cape Hatteras	<13	34 - 36	50-450 to 1500m		Bottom habitats with fine-grained substrate	(the upper slope is nursery erea; major prey: crusteceans, polychaetes, mollusks)
	Adults	GOME, outer continental shelf from GB south to Chesapeake Bay	<13	32 - 36	25-300		Bottom habitats with fine-grained substrate	(major prey: potycheetes, echinoderms, crustaceans, mollusks, squid)
	Spawning Adults	GOME, outer continental shelf from GB south to Chesapeake Bay	<15	32 - 36	25-360	March to November, peaks in Mey-August	Bottom habitats with fine-grained substrete	
Yellowtail flounder	Eggs	GB, Mass Bay, Cepe Cod Bay, southem NE continental shelf south to Delaware Bay end the following estueries: Passamequoddy Bey to Saco Bay; Greet Bay to Cape Cod Bay	<15	32.4 - 33.5	30 - 90	Mid-March to July, peaks in April to June in southem NE	Surface weters	
	Larvae	GB, Mass Bay, Cape Cod Bay, southem NE continental shelf, middle Atlantic south to Chesapeake Bay end the following estuaries: Passamaquoddy Bay to Cape Cod Bay	<17	32.4 - 33.5	10 - 90	March to April in New York bight; May to July in south NE and southeastem GB	Surface waters	(largety an oceanic nursery)
	Juveniles	GB, GOME, southem NE continental shelf south to Delawere Bay and the following estueries: Sheepscot R., Cesco Bay, Mass Bay to Cepe Cod Bay	<15	32.4 - 33.5	20 - 50		Bottom habitats with substrate of send or sand and mud	
	Adults	GB, GOME, southem NE continental shelf south to Delaware Bay end the following estueries: Sheepscot R., Cesco Bay, Mass Bay to Cepe Cod Bay	<15	32.4 -33.5	20 - 50		Bottom habitats with substrate of sand or sand and mud	(major prey: annelids, arthropods, mollusks)
	Spawning Adults	GB, GOME, southem NE continental shelf south to Deleware Bey end the following estueries: Mass Bay to Cape Cod Bay	<17	32.4 - 33.5	10-125		Bottom habitats with substrate of sand or sand and mud	
Atlantic mackerel	Eggs	Continental Shelf from Maine through Cape Hatteras, NC elso includes estuaries from Great Bay to Cape Cod Bay; Buzzards Bay to Long Island Sound; Gardiners Bay and Great South Bay	5-23	(18 - >30)	0 - 15		Pelagic waters	(peak spawning in salinities >30ppt)
	Lervae	Continental Shelf from GOME through Cape Hatteras, NC also includes estuaries from Great Bay to Cape Cod Bay; Narragansett Bay to Long Island Sound; Gardiners Bay and Great South Bay	6-22	(>30)	10-130		Pelagic waters	
	Juveniles	Continental Shelf from GOME through Cape Hatteras, NC also includes estuaries from Passamaquoddy Bay; Penobscot Bay to Saco Bay; Great Bay; Mass Bay to Cape Cod Bay; Narragensett Bay, Long Island Bay; Gardiners Bay to Hudson R./ Raritan Bay	4 - 22	(>25)	0 - 320		Pelagic waters	

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - Georga's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Adults	Continental Shelf from GOME through Cape Hatteras, NC also includes estuaries from Passamaquoddy Bay to Saco Bay; Mass Bay to Long Island Bay; Gardiners Bay to Hudson R./ Raritan Bay	4 - 16	(>25)	0 - 380		Pelagic waters	(opportunistic feeding: can filter feed or select individual prey. Major prey: crustaceans, pelagic mullosks, polychaetes, squid, fish)
Black sea bass	Eggs	Continental Shelf and estuaries from southern NE to North Carolina, also includes Buzzards Bay			0 - 200	May to October	Water column of coastal Mid-Atlantic Bight and Buzzards Bay	
	Larvae	Pelagic waters over Continental Shelf from GOME to Cape Hatteras, NC, also includes Buzzards Bay	(11-26)	(30 - 35)	(<100)	(May - Nov, peak Jun - Jul)	Habitats for transforming (to juveniles) larvae are near coastal areas and into marine parts of estuaries between Virginia and NY. When larvae become demersal, found on structured inshore habitat such as sponge beds.	
	Juveniles	Demersal waters over Continental Shelf from GOME to Cape Hatteras, NC, also includes estuaries from Buzzards Bay to Long Island Sound; Gardiners Bay, Barnegat Bay to Chesapeake Bay; Tangier/ Pocomoke Sound and James River	>6	>18	(1 - 38)	Found in coastal areas (Apr - Dec, peak Jun - Nov) between VA and MA, but winter offshore from NJ and south; Estuaries in summer and spring	Rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas, offshore clam beds and shell patches may be used during wintering	(YOY use salt marsh edges and channels; high habitat fidelity)
	Adults	Demersal waters over Continental Shelf from GOME to Cape Hatteras, NC, also includes estuaries: Buzzards Bay, Narragansett Bay, Gardiners Bay, Great South Bay, Barnegat Bay to Chesapeake Bay; Tangier/ Pocomoke Sound and James River	>6	(>20)	(20- 50)	Wintering adults (Nov. to April) offshore, south of NY to NC Inshore, estuaries from May to October	Structured habitats (natural & man-made) sand and shell substrates preferred	(spawn in coastal bays but not estuaries; change sex to males with growth; prey: benthic and near bottom inverts, small fish, squid)
Bluefish	Eggs	North of Cape Hatteras, found over Continental Shelf from Montauk Point, NY south to Cape Hatteras, South of Cape Hatteras, found over Continental Shelf through Key West, Florida	>18	>31ppt	Mid-shelf depths	April to August	Pelagic waters	*No EFH designation inshore
	Larvae	North of Cape Hatteras, found over Continental Shelf from Montauk Point, NY south to Cape Hatteras, South of Cape Hatteras, found over Continental Shelf through Key West, Florida, the slope sea and Gulf Stream between latitudes 29N and 40N; includes the following estuaries: Narragansett Bay	>18	>30ppt	>15	April to September	Pelagic waters	No EFH designation inshore for larvae

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nl additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Juveniles	North of Cape Hatteras, found over Continental Shelf from Nantucket Island, MA south to Cape Hatteras,South of Cape Hatteras, found over Continental Shelf through Key West, Florida, tha slope sea and Gulf Stream between latitudes 29N and 40N also includes estuaries between Penobscot Bay to Great Bay; Mass Bay to James R.; Albemaria Sound to St. Johns River, FL	(19-24)	(23 - 36) freshwater zone in Albemarie Sound		North Atlantic estuaries from June to October Mid-Atlantic estuaries from May to October South Atlantic estuaries from March to December	Pelagic waters	(use estuaries as nursery areas; can intrude into areas with salinities as low as 3 ppt)
	Adults	North of Capa Hatteras, found over Continental Shelf from Cape Cod Bay, MA south to Cape Hatteras,South of Cape Hatteras, found over Continental Shelf through Key West, Florida also includes estuaries betwaen Penobscot Bay to Great Bay; Mass Bay to James R.; Albemarie Sound to Pamilco/ Pungo R., Bougua Sound, Cape Faar R., St. Helena Sound, Broad R., St. Johns R., & Indian R.	(14-18)	>25ppt		North Atlantic estuaries from June to October Mid-Atlantic estuaries from April to October South Atlantic estuaries from May to January	Pelagic waters	Highly migratory (major prey: fish)
Butterfish	Eggs	Over Continental shelf from GOME through Capa Hatteras, NC,also in estuaries from Mass Bay to Long Island Sound; Gardiners Bay, Great South Bay, and Chesapeaka Bay	11 - 17	(25 - 33)	0-1829	(spring and summer)	Pelagic waters	
	Larvae	Over Continental shelf from GOME through Cape Hatteras, NC,also in estuaries from Boston Harbor, Waquoit Bay to Long Island Sound; Gardiners Bay to Hudson R./ Raritan Bay; Delaware Bay and Chesapeake Bay	9 - 19	(6.4 - 37)	10-1829	(summer and fall)	Pelagic waters	
	Juveniles	Over Continental shelf from GOME through Cape Hatteras, NC also in estuaries from Mass Bay, Cape Cod Bay to Delawara Inland Bays; Chesapeake Bay, York R. and James R.	3 - 28	(3 - 37)	10-365 (most <120)	(winter - shelf spring to fall - estuaries)	Pelagic waters (larger individuals found over sandy and muddy substratas)	(pelagic schooling - smaller individuals associated with floating objects including jellyfish)
	Adults	Over Continental shelf from GOME through Cape Hatteras, NC,also in estuaries from Mass Bay, Cape Cod Bay to Hudson R./ Raritan Bay; Delaware Bay and Inland Bays; York R. and James R.	3 - 28	(4 - 26)	10-365 (most <120)	(winter - shelf summer to fall - estuaries)	Pelagic waters (schools form over sandy, sandy-silt and muddy substrates)	(common in inshore areas and surf zone; prey: planktonic, thaliacians, squid, copepods)
Illex squid	Juveniles	Over Continental shelf from GOME through Capa Hatteras, NC	2 -23		0 - 182	(carried northward by Gulf Stream)	Pelagic waters	
	Adults	Over Continental shelf from GOME through Capa Hatteras, NC	4 - 19		0 -182	(late fall - offshore, spawn Dec- Mar)	Pelagic waters	(prey: fish, crustaceans, squid; die after spwaning)
Loligo	Eggs***	Over Continental shelf from GOME through Cape Hatteras, NC	(>8)	(30 - 32)	(<50)	(May - spawned, hatch in Jul)	(Demersal egg masses are commonly found on sandy/mud bottom, usually attached to rocks/boulders, pilings or algae such as fucus, ulva, laminaria, porphyra)	*** EFH is not currently designated for this life stage (Eggs are demersal, enclosed in gelatinous capsule containing up to 200 eggs. Laid in masses of hundreds of capsules from different females)

This table was compiled by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH into on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
	Juveniles	Over Continental shelf from GOME through Cape Hatteras, NC	4 - 27	(31 - 34)	0 - 213	spring - fall - inshore winter - offshore	Pelagic waters	(inhabit upper 10m at depth of 50 - 100m on continental shelf)
	Adults	Over Continental shelf from GOME through Cape Hatteras, NC	4 - 28		0 - 305	(Mar - Oct - inshore; winter - offshore)	Pelagic waters	(prey: fish, crustaceans)
Ocean quahog	Juveniles	Eastern edge of GB and GOME throughout the Atlantic EEZ	<18	(>25)	8-245		Throughout substrate to a depth of 3ft within federal waters, occurs progressively further offshore between Cape Cod and Cape Hatteras	(medium to fine grained sands, sandy mud, silty sand)
	Adults	Eastern edge of GB and GOME throughout the Atlantic EEZ	<18	(>25)	8 -245	(spawn May-Dec with several peaks)	Throughout substrate to a depth of 3ft within federal waters, occurs progressively further offshore between Cape Cod and Cape Hatteras	(medium to fine grained sands, sandy mud, silty sand; earliest age of maturity 7 yrs, avg 13 yrs; suspension feeders on phytoplankton)
Scup	Eggs	Southern NE to coastal Virginia includes the following estuaries: Waquoit Bay to Long Island Sound; Gardiners Bay, Hudson R./ Raritan Bay	13 - 23	>15	(<30)	May - August	Pelagic waters in estuaries	
	Larvae	Southern NE to coastal Virginia includes the following estuaries: Waquoit Bay to Long Island Sound; Gardiners Bay, Hudson R./ Raritan Bay	13 - 23	>15	(<20)	May - September	Pelagic waters in estuaries	
	Juveniles	The Continental Shelf from GOME to Cape Hatteras, NC includes the following estuaries: Mass Bay, Cape Cod Bay to Long Island Sound; Gardiners Bay to Delawara Inland Bays; & Chesapeake Bay	>7	>15	(0 - 38)	Spring and summer in estuaries and bays	Dermersal waters north of Cape Hatteras and Inshore on various sands, mud, mussel, and eelgrass bed type substratas	
	Adults	The Continental Shelf from GOME to Cape Hatteras, NC includes the following estuaries: Cape Cod Bay to Long Island Sound; Gardiners Bay to Hudson R./ Raritan Bay; Delaware Bay & Inland Bays; & Chesapeake Bay	>7	>15	(2 -185)	Wintering adults (November - April) are usually offshore, south of NY to NC	Dermersal waters north of Cape Hatteras and Inshore estuaries (various substrate types)	(spawn < 30m during Inshore migration - May - Aug; prey: small benthic inverts)
Spiny Dogfish	Juveniles	GOME through Capa Hatteras, NC across the Continental Shelf; Continental Shelf waters South of Cape Hatteras, NC through Florida; also includes estuaries from Passamaquaddy Bay to Saco Bay; Mass Bay & Cape Cod Bay	3 - 28		10-390		Continental Shelf waters and estuaries	
	Adults	GOME through Cape Hatteras, NC across the Continental Shelf;Continental Shelf waters South of Cape Hatteras, NC through Florida; also includes estuaries from Passamaquaddy Bay to Saco Bay; Mass Bay & Cape Cod Bay	3 - 28	(30 - 32)	10-450		Continental Shelf waters and estuaries	(major prey: crabs, eels, small fish)

This table was complied by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as importa nt additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

Species	Life Stage	Geographic Area	Temp (° C)	Salinity (‰)	Depth (m)	Seasonal Occurrence	Habitat Description	Comments
Summer flounder	Eggs	Over Continental Shalf from GOME to Cape Hatteras, NC; South of Cape Hatteras to Florida			30-70 fall; 110 winter; 9-30 spring	October to May	Pelagic waters , heaviest concentrations within 9miles of shore off NJ and NY	
	Larvae	Over Continental Shelf from GOME to Cape Hatteras, NC; South of Cape Hatteras to Florida; also includes estuaries from Waquoit Bay to Narragansett Bay; Hudson River/ Raritan Bay; Bamegat Bay, Chesapeake Bay, Rappahannock R., York R., James R., Albemarie Sound, Pemlico Sound, Neuse R. to Indian R.	(9 - 12)	(23-33) Fresh in Hudson R. Raritan Bay area	10-70	mid-Atlantic Bight from Sept. to Feb.; Southem part from Nov. to May at depths 9-30m	Pelagic waters, larvae most abundant 19 - 83km from shore; Southem areas 12 - 52 miles from shore	(high use of tidal creeks and creek mouths)
	Juveniles	Over Continental Shelf from GOME to Cape Hatteras, NC; South of Cape Hatteras to Florida; also includes estuaries from Waquoit Bay to James R.; Albemarie Sound to Indian R.	>11	10 -30 Fresh in Narrag. Bay, Albem/ Pamlico Sound, & St. Johns R.	(0.5-5) in estuary		Demersal waters, muddy substrate but prefer mostly sand; found in the lower estuaries in flats, channels, salt marsh creeks, and eelgrass beds	HAPC - All native species of macroalgae, seagrasses and freshwater and tidal macrophytes in any size bed as well as loose aggregations, within edult end juvenile EFH. (Major prey: mysld shrimp)
	Adults	Over Continental Shelf from GOME to Cape Hatteras, NC; South of Cepe Hatteras to Florida; elso includes estuaries from Buzzards Bay, Narragansett Bay, Conn. R. to Jamas R.; Albemarie Sound to Broad R.; St. Johns R., & Indian R.		Fresh in Albemaria Sound, Pamlico Sound, & St. Johns R.	(0 - 25)	Inhabit shallow coastal and estuarine waters during warmer months and move offshore on outer Continental Shelf at depths of 150m in colder months	Demersal waters and estuaries	HAPC - All native species of macroalgae, seagrasses and freshwater and tidal macrophytes in any size bed as well as loose aggregations, within adult and juvenile EFH. (Major prey: fish, shrimp, squid, polychaetes)
Surf clams	Juveniles	Eastem edge of GB and the GOME throughout Atlantic EEZ	(2-30)		0 -60 , low density beyond 38		Throughout substrate to a depth of three feet within federal waters. (Burrow in med. To coarse sand and gravel substrates. Also found in silty to fine sand, not in mud)	
	Adults	Eastem edge of GB and the GOME throughout Atlantic EEZ	(2-30)		0 -60 , low density beyond 38	(spawn-summer to fall at 19 - 30 °C)	Throughout substrate to a depth of three feet within federal waters	
Tilefish	Eggs	US Canadian Boundary to VA/NC boundary (shelf break; GB to Cape Hatteras)	8 - 19	(34 - 36)	76-365	(Serial spawning March - November; peaks April - October)	Water column	
	Larvae	US Canadian Boundary to VA/NC boundary Outer continental shelf; (GB to Cape Hetteras)	8 - 19	(33 - 35)	76-365	(Feb - Oct; peaks July - Oct)	Water column	

This table was compiled by NMFS Northeast Regional Office, Habitat Conservation Division. All information presented is part of the Regional Fishery Management Council's EFH designations except for that contained within ( ) which is provided as important additional ecological information. Definitions: GOME - Gulf of Maine; GB - George's Bank; HAPC - Habitat Area of Particular Concern; YOY - Young-of-Year Please note: This Table does not contain EFH info on Highly Migratory Species (sharks, tunas, billfish).

APPENDIX E

RESOURCE MAPS

The attached maps were developed by and were provided to Maryland Environmental Service by the University of Maryland.

1. Barren Island (1:50,000): Bottom Type
2. Barren Island (1:50,000): Winter Mean Crab Abundance (1990-1998)
3. Barren Island (1:50,000): Classified Shellfish Areas
4. Barren Island (1:50,000): Cultural Resources
5. Barren Island (1:50,000): Anadromous and Semi-anadromous Finfish Spawning Extents with Species Count
6. Barren Island (1:50,000): Critical Finfish Habitat
7. Barren Island (1:50,000): Commercial and Recreational Fishing Grounds
8. Barren Island (1:50,000): Oyster Bar Delineations
9. Barren Island (1:50,000): Submerged Aquatic Vegetation with Tier 1 and Tier 2 Habitat
10. Barren Island (1:50,000): Potential Summer Flounder Habitat
11. Barren Island (1:50,000): Water Depth
12. Barren Island (1:50,000): Waterfowl and Shorebird Usage

Figure E-1. Barren Island (1:50,000): Bottom Type

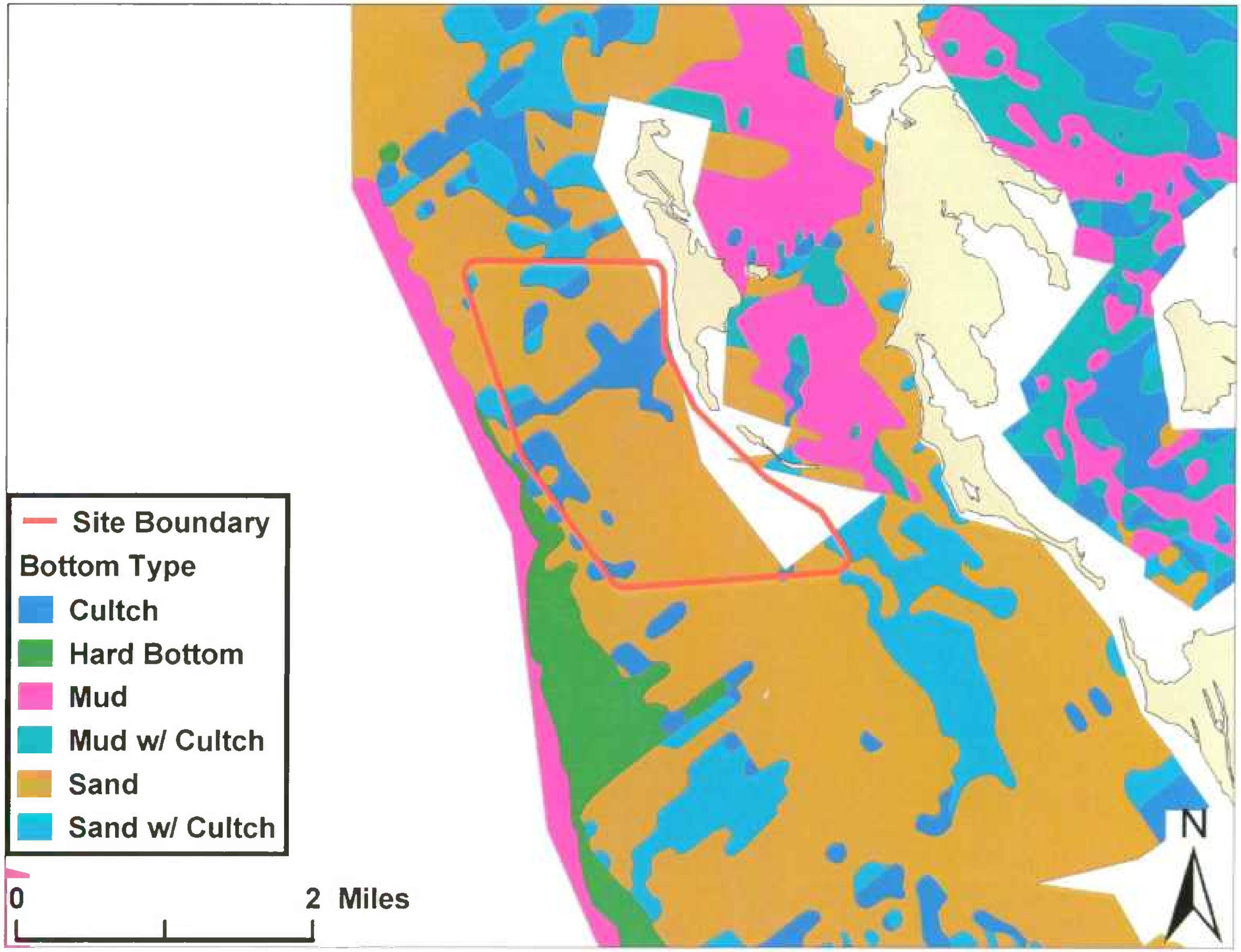


Figure E-2. Barren Island (1:50,000):
Winter Mean Crab Abundance (1990-1998)

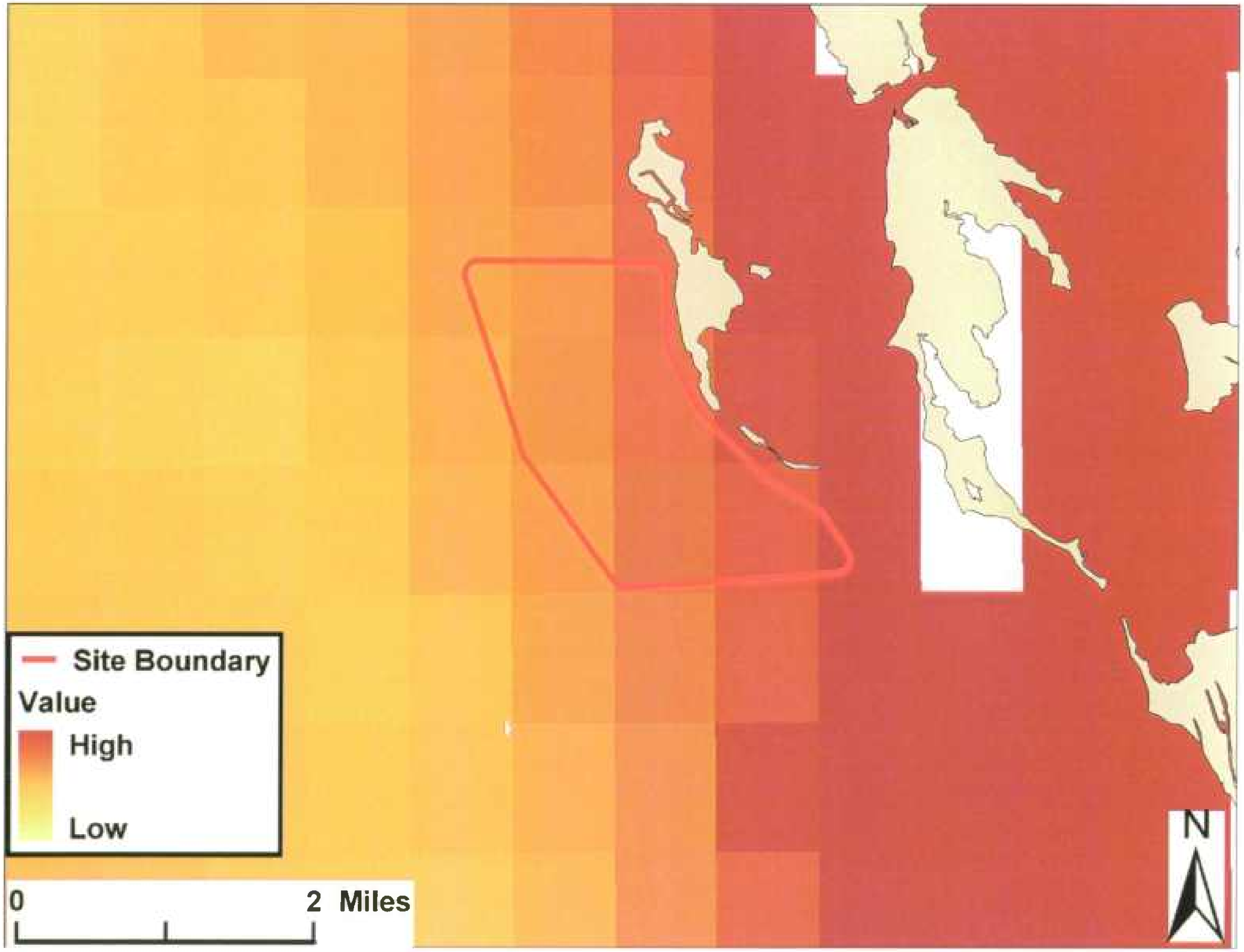


Figure E-3. Barren Island (1:50,000): Classified Shellfish Areas

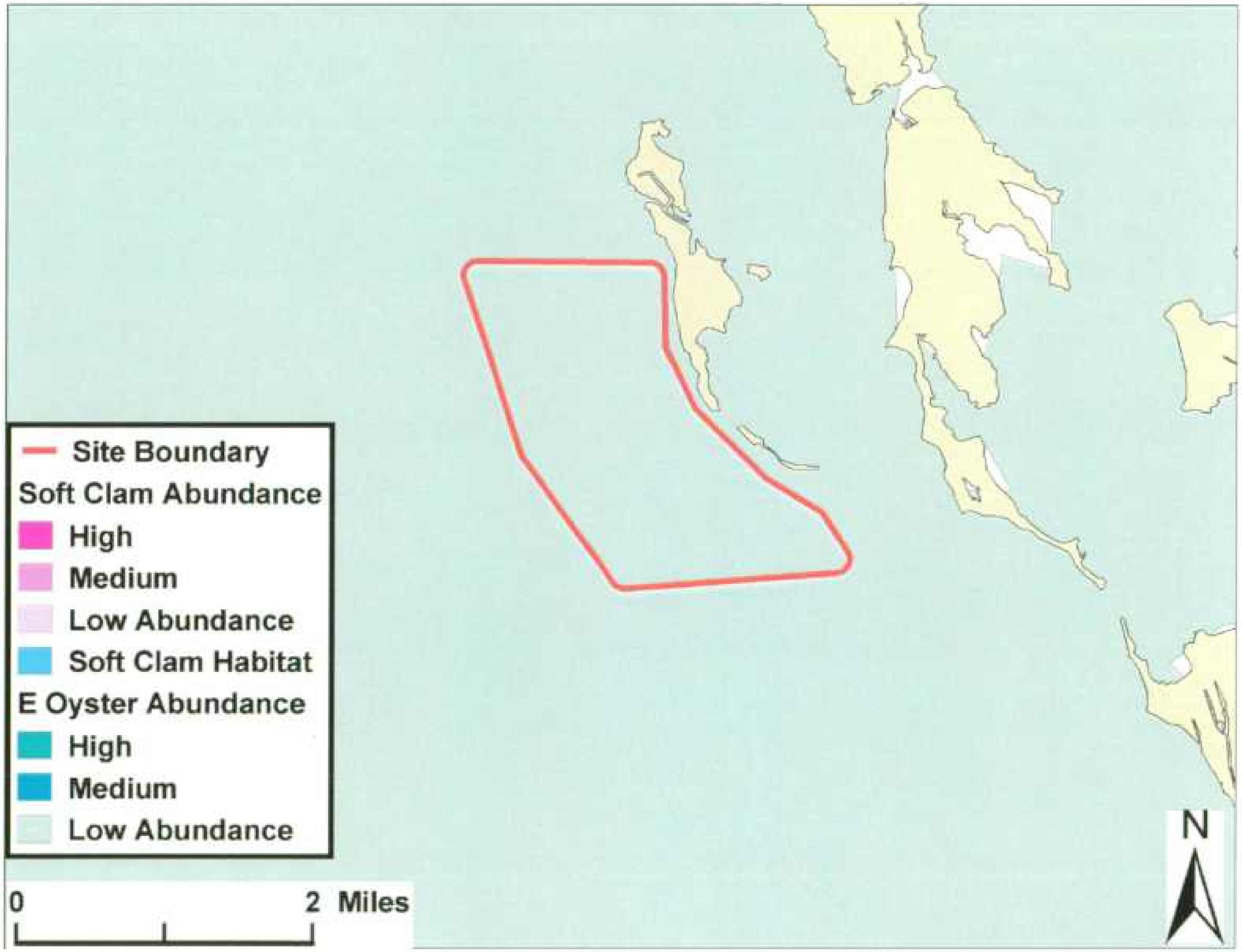


Figure E-4. Barren Island (1:50,000): Cultural Resources

Figure E-5. Barren Island (1:50,000): Anadromous and Semi-anadromous Finfish Spawning Extents with Species Count

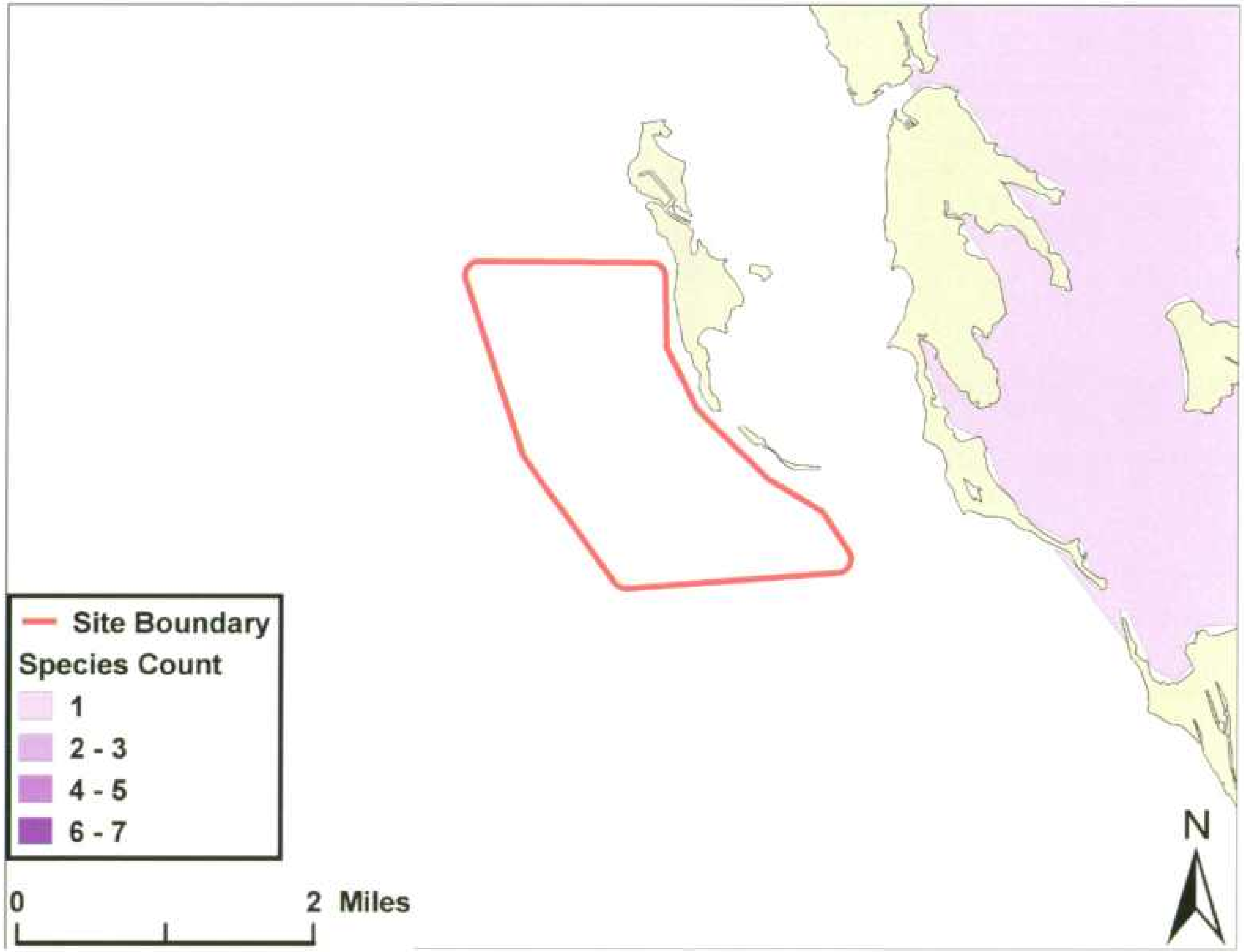


Figure E-6. Barren Island (1:50,000): Critical Finfish Habitat

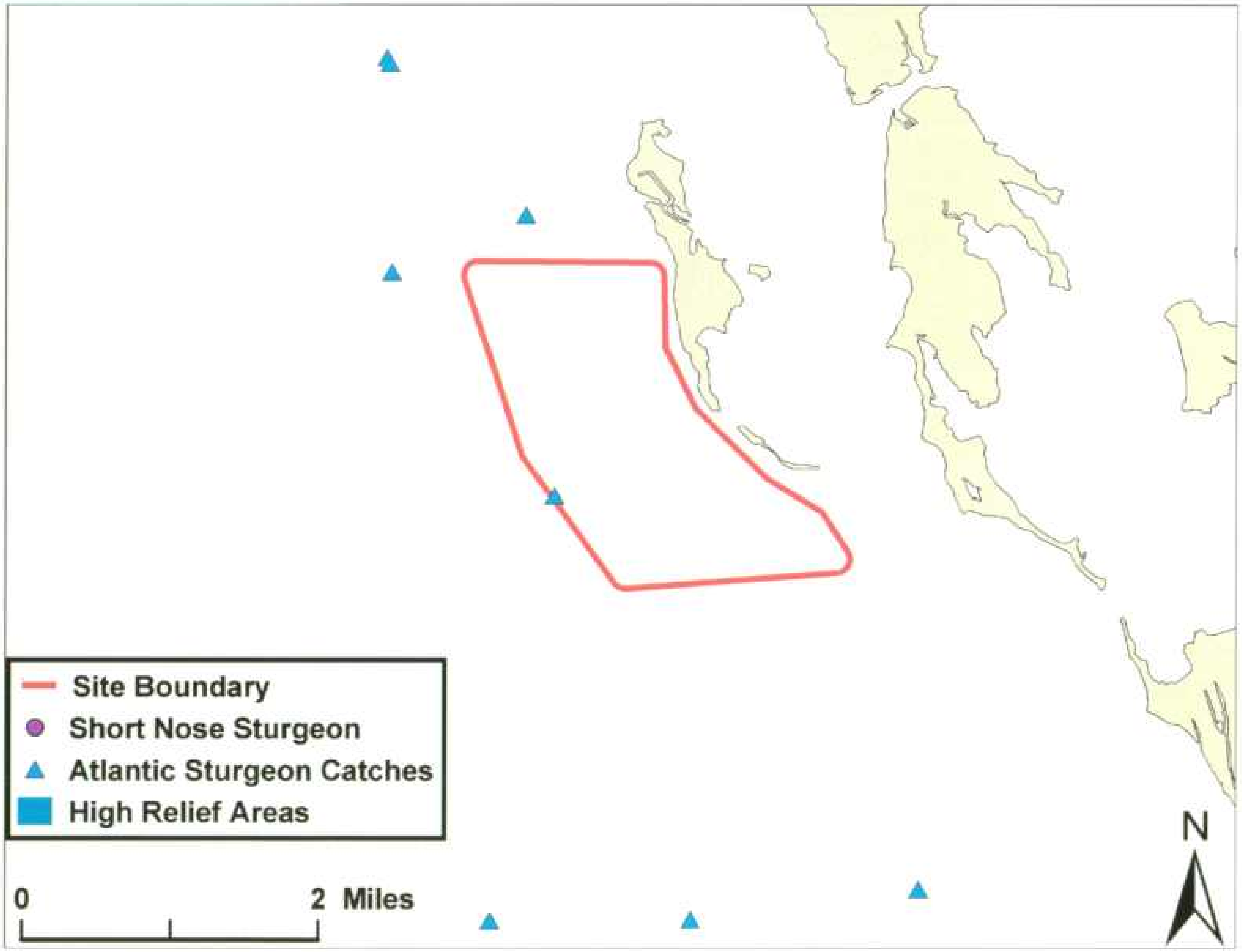


Figure E-7. Barren Island (1:50,000): Commercial and Recreational Fishing Grounds

Figure E-8. Barren Island (1:50,000): Oyster Bar Delineations

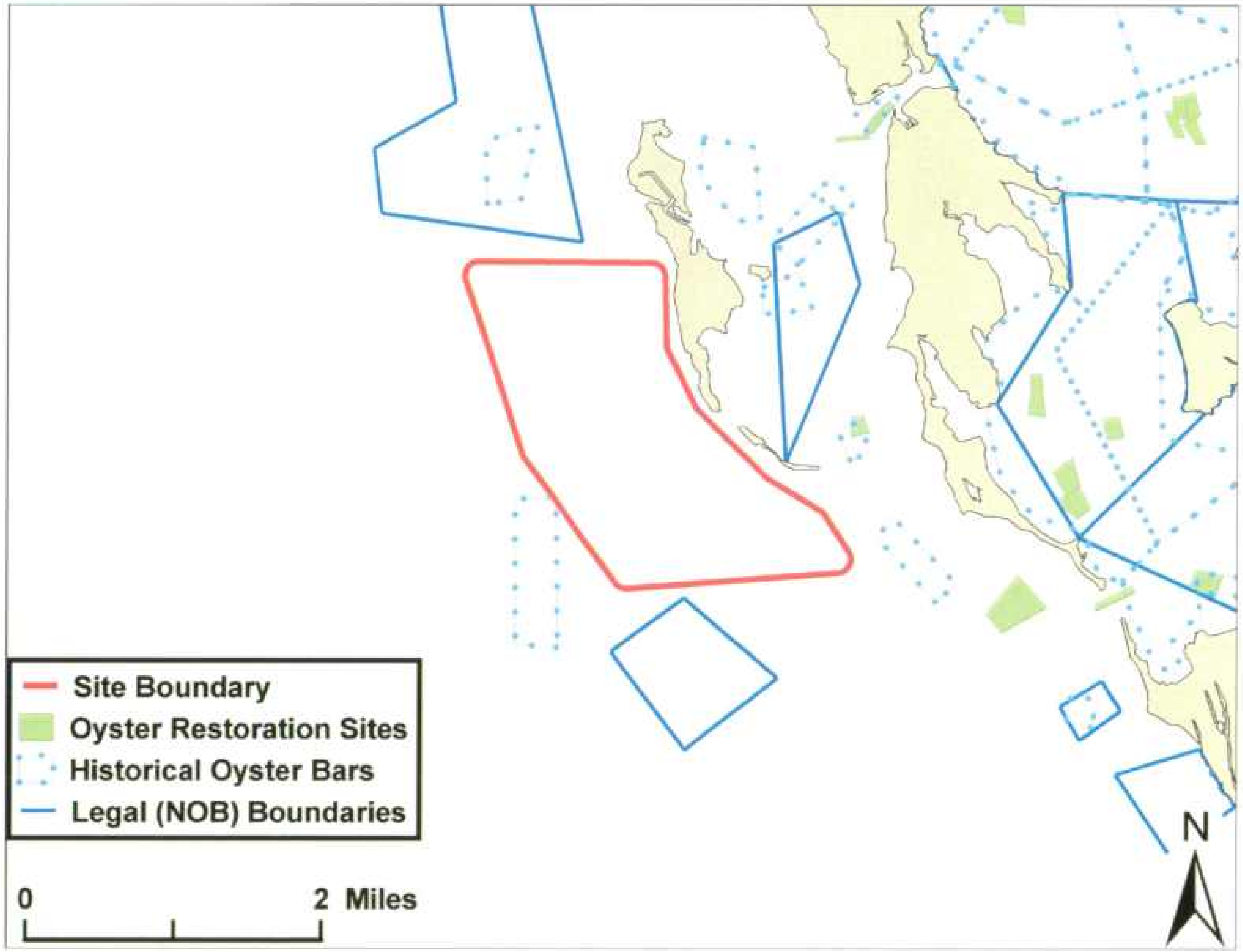


Figure E-9. Barren Island (1:50,000):
Submerged Aquatic Vegetation with Tier 1 and Tier 2 Habitat

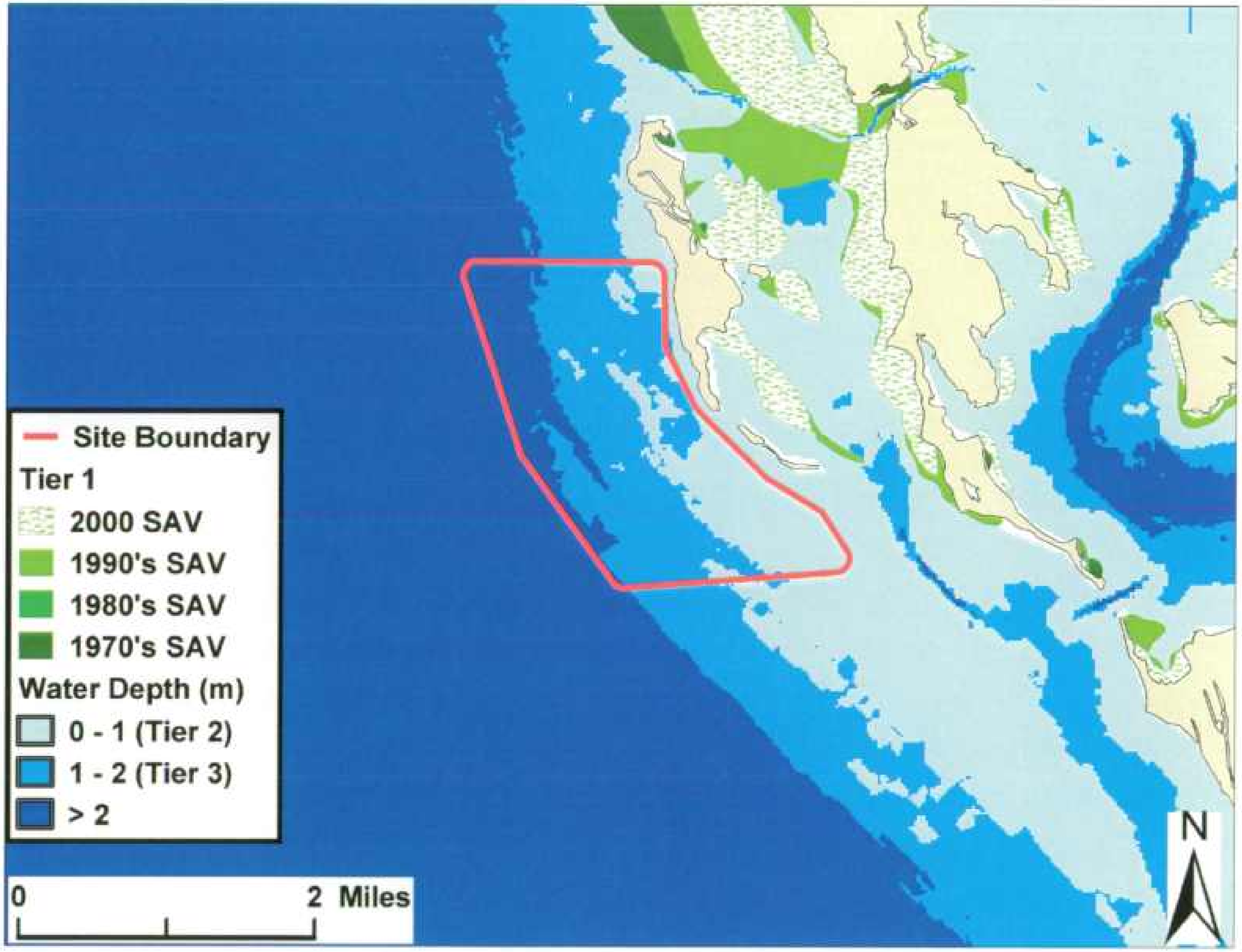


Figure E-10. Barren Island (1:50,000): Potential Summer Flounder Habitat

Figure E-11. Barren Island (1:50,000): Water Depth

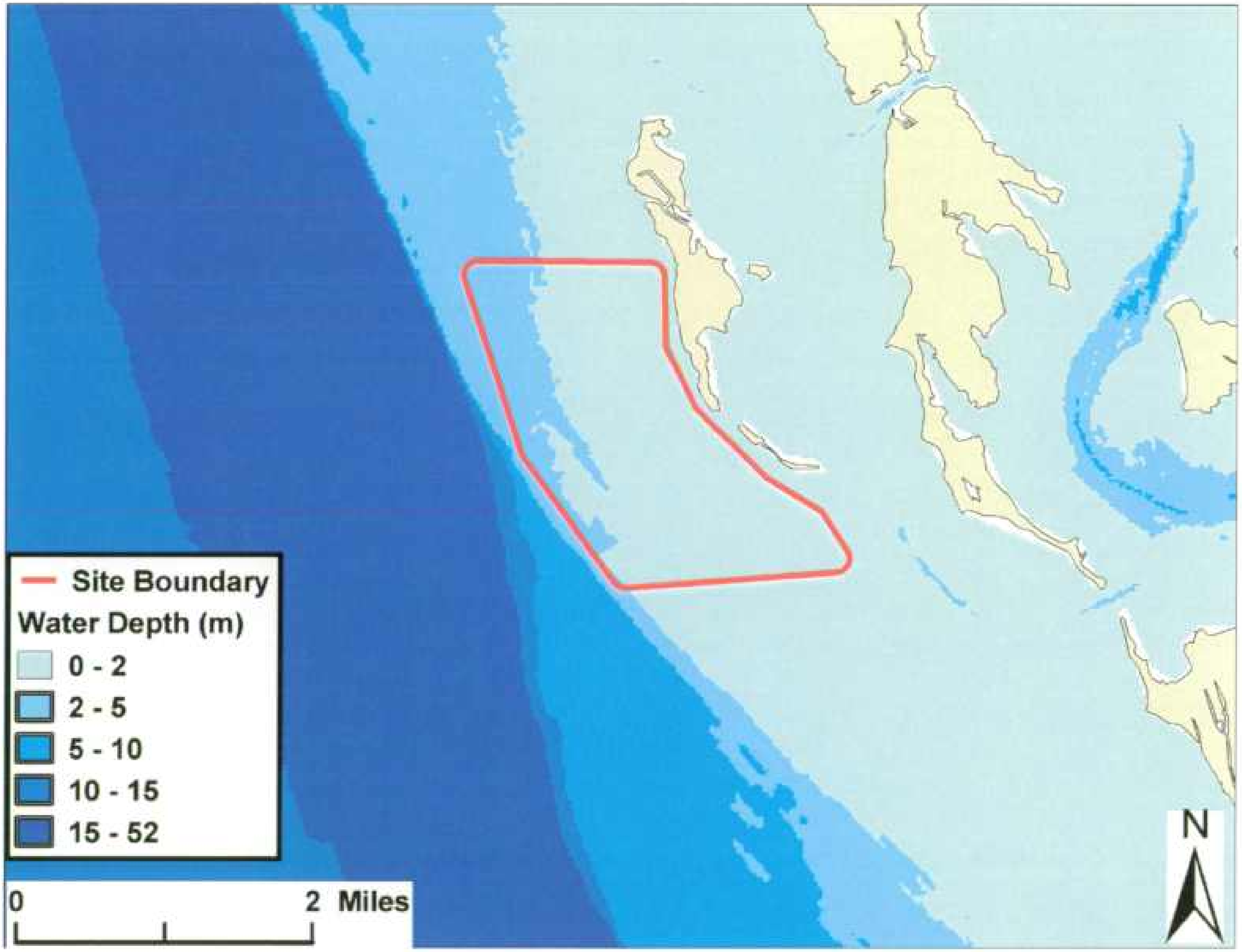


Figure E-12. Barren Island (1:50,000): Waterfowl and Shorebird Usage