US Army Corps
of Engineers
Philadelphia District

New Jersey Department of
Environmental Protection

BARNEGAT INLET

TO

LITTLE EGG INLET

Final Feasibility Report
and
Integrated Final Environmental
Impact Statement

SEPTEMBER 1999

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BARNEGAT INLET TO LITTLE EGG INLET, NEW JERSEY

FINAL FEASIBILITY REPORT, AND INTEGRATED ENVIRONMENTAL IMPACT STATEMENT

September 1999

EXECUTIVE SUMMARY

This report presents the result of a feasibility phase study to determine the magnitude and effect of shoreline erosion problems and an implementable solution to the problems, at Long Beach Island, New Jersey. The Lead Agency is the U.S. Army Corps of Engineers, Philadelphia District. This study has determined the extent of Federal participation in a shore protection project and provides up-to-date information for state and local management of the study area. This Final Feasibility Study and Integrated Environmental Impact Statement (FEIS) was prepared based on the recommendation of the reconnaissance study completed in March 1995 that identified possible solutions to the erosion problems facing the study area. The reconnaissance study also determined that such a solution was in the Federal interest and identified the non-Federal sponsor.

The feasibility study was cost shared between the Federal Government and the State of New Jersey through the New Jersey Department of Environmental Protection (NJDEP), and was conducted under the provisions of the Feasibility Cost Sharing Agreement executed January 2, 1996.

This study evaluates existing conditions and shoreline erosion problems between Barnegat Inlet and Little Egg Inlet, along the Atlantic coast of New Jersey. Shoreline erosion has left the structures and infrastructure vulnerable to storm damages. The selected plan for hurricane and storm damage protection is berm and dune restorations utilizing sand obtained from offshore borrow sources. This plan would require 4.95 million cubic yards of sand for initial berm placement, and 2.45 million cubic yards for dune placement. Approximately 1.9 million cubic yards would be needed for periodic nourishment every 7 years for the 50-year period of analysis. The berm and dune restoration extends from groin 4 (Seaview Drive, Loveladies) to the terminal groin (groin 98) in Holgate, Long Beach Township, approximately 17 miles. The Barnegat Light area (northern end of the study area) is not included in the initial construction due to low background erosion and ample shore protection. Barnegat Light area is being considered as a sand source for nourishment quantities. The US Fish and Wildlife Service (USFWS, 1996) states that they do not consider beach nourishment in line with the non-intervention plan in place for the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge. Therefore, the Holgate Unit (southern end of study area) was also not included in the project. Because both ends of the project terminate at a groin, no tapers are needed. The template for the plan is a dune at an elevation of 22-ft NAVD, with a 30-ft dune crest width; 1V: 5H slopes from dune crest down to a berm at elevation +8 ft NAVD, a berm width of 125 ft from centerline of dune. Often the public's perception of Berm width is considered from the toe of dune to mean high water (MHW) or the useable portion of the beach. The average usable beach from the seaward toe of dune to MHW water is 105 feet. The beachfill continues from MHW with the profile at 1V: 10H slopes from the berm to mean low water (MLW). The fill is expected to maintain the existing profile shape from MLW to depth of closure (occurring at approximately -29 ft NAVD). Average dune widths for LBI are already at 29 feet. Existing dune elevations are at 19 ft on average while berm width averages are at 111 feet, as defined from the dune centerline.

A Section 404 (b)(1) evaluation has been prepared and is included in this Final Feasibility Report and Integrated Environmental Impact Statement. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to areas of concern under Section 404 of the Federal Clean Water Act.

The feasibility report's final costs are based on January 1999 price levels and benefits optimized at a Federal interest rate of 6.875%. The economic analysis for the selected plan indicates that the proposed plan would provide annual benefits of $10,615,000 that, when compared to the annual cost of the proposed plan of $ 5,771,000 yields a benefit to cost ratio of 1.84 to 1 with $4,844,000 in net excess benefits.

Congress has approved a new cost sharing policy for the periodic nourishment of shore protection projects. Under the new cost sharing policy, periodic nourishment associated with plans to respond to natural erosion and storm damage reduction will generally be cost-shared 50 % Federal and 50 % non-Federal. The Water Resources Development Act of 1999 (WRDA 99) however, allows that the previous cost sharing policy of 65% Federal and 35% non-Federal apply to Feasibility Studies completed before December 31, 1999, which applies to the Barnegat Inlet to Little Egg Inlet study. The non-Federal sponsor supports the implementation of the project and supports cost sharing of project features consistent with existing law and implementation of periodic nourishment elements consistent with cost sharing enacted by Congress in law. (See pertinent correspondence for a copy of the letter from the state of New Jersey.)

The total initial project cost of construction is currently estimated to be $50,084,000 (at January 1999 cost levels). The Federal share of this first cost is $ 32,555,000 and the non-Federal share is $ 17,529,000. Periodic nourishment is estimated at an average cost of $ 13,700,000 over the seven proposed cycles. Major renourishment following a major storm or series of storms is factored into year 28 at an additional cost of $9,230,000 or a total cost of 22,811,000 including normal nourishment cycle costs. The periodic nourishment is cost shared 65% Federal and 35% non-Federal for the life of the project. The ultimate project cost that includes initial construction and fifty years of periodic nourishment and project monitoring is currently estimated to be $ 156,632,000.

The following recommendation is made given consideration to all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests. Several alternative plans for the purposes of Hurricane and Storm Damage Reduction were evaluated. A project has been identified that is technically sound, economically cost effective over the life of the project, is socially and environmentally acceptable, and has broad local support. Therefore, the recommendation is that Federal participation continues in the planning, design, and construction of a hurricane and storm damage reduction project for Long Beach Island, New Jersey.

IF YOU HAVE ANY ADDITIONAL QUESTIONS REGARDING THIS FINAL FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL IMPACT STATEMENT PLEASE CONTACT

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MAJOR CONCLUSIONS AND FINDINGS

A protective dune/berm with periodic nourishment represents the least environmentally damaging structural method of reducing potential storm damages at a reasonable cost. It is socially acceptable, proven to work in high-energy environments, and is the only engineered shore protection alternative that directly addresses the problem of a sand budget deficit (National Research Council, 1995). The somewhat transient nature of beach nourishment is actually advantageous. Beach fill is dynamic, and adjusts to changing conditions until equilibrium can again be achieved. Despite begin structurally flexible, the created beach can effectively dissipate high storm energies, although at its own expense. Costly rigid structures like seawalls and breakwaters utilize large amounts of material foreign to the existing environment to absorb the force of waves. Beach nourishment uses material typical of adjacent area, sand to buffer the shoreline structures against storm damage. Consequently, beach nourishment is more aesthetically pleasing as it represents the smallest departure from existing conditions in a visual and physical sense, unlike groins. When the protective beach is totally dispersed by wave action, the original beach remains.

AREAS OF CONCERN

A project of this nature would have temporary adverse impacts on water quality and on aquatic organisms. Dredging would increase suspended solids and turbidity at the point of dredging and at the berm and dune restoration site. The area to be dredged and the area where the material would be deposited would be subject to extreme disturbance. Many existing benthic organisms will be covered at the berm restoration site. Dredging would result in the temporary complete loss of the benthic community in the borrow area. These disruptions are expected to be of short-duration and of minor significance if rapid recolonization by the benthic community occurs. Dredging would consequently temporarily displace a food source for some finfish. Scott and Kelley (1988 B) showed that benthic organisms rapidly recover (i.e. within two years) after multiple dredging areas in borrow areas along the New Jersey Coastline.

Seven offshore borrow areas were identified for this study (A, B, C, D, E, F and Barnegat Light Inlet). Areas C, F and Barnegat Light Inlet were eliminated due to inadequate material grain size, limited quantities and proximity to submerged cables. The four offshore borrow sites considered for further evaluation were A, B, D and E (Figure 2-2). A recent survey conducted at the borrow sites has shown that the benthic organisms in the sites are similar to those in the surrounding areas.

The New Jersey Department of Environmental Protection has identified two of the borrow areas as Prime Fishing Areas, as defined by the Rules on Coastal Zone Management N.J.A.C. 7:7E as amended July 18, 1994. The New Jersey CZM rules also state that development within surf clam areas is conditionally acceptable only if the development is of national security interest and no prudent and feasible alternative sites exist. The USFWS recommends avoidance of the use of Borrow Areas B and E, and reevaluating alternative borrow areas. The Service also suggest limiting hydraulic dredging during the period of lowest biological activity and rotational dredging of borrow areas. As a consequence of coordination with natural resource agencies, borrow areas B and E were eliminated.

To minimize impacts to the Federally-listed piping plover, the USFWS recommends seasonal restrictions of dredging, further consultation prior to initial nourishment and all subsequent renourishment activities, monitoring, and compliance with the Services Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act", dated April 15, 1994.

To minimize impacts to the Federally-listed threatened seabeach amaranth, the U.S. Fish and Wildlife Service suggest conducting surveys prior to construction activities. If seabeach amaranth is identified in the project area, a protective zone should be established around the plants (Arroyo, 1999).

Concerns regarding the potential impacts of dredging on Federally listed threatened and endangered species (sea turtles and whales) were raised with respect to this project. Based on coordination with the National Marine Fisheries Service (NMFS), the Philadelphia District would continue the measures used in the past to reduce the likelihood of negatively impacting marine species. These measures include the use of NMFS approved turtle monitors, and drag-arm deflectors on hopper dredges, and timing the dredging when these species are known to be absent from the borrow areas. These and any other measures would be fully coordinated with NMFS prior to dredging. State listed species of birds, such as the black skimmer, roseate tern and least tern occur along beaches in the project area. The District will coordinate with the NJ Endangered and Nongame Species Program prior to construction to develop and implement a comprehensive and beach nesting bird management plan.

The non-Federal sponsor for this Feasibility study is the New Jersey Department of Environmental Protection (NJDEP). Currently, NJDEP's concern within the scope of this interim feasibility study is with shore protection problems along Long Beach Island. The State is interested in a long-term Federal shore protection project due to funding constraints, which prohibit the State and local governments from carrying out a long-term shore protection program on their own.

ENVIRONMENTAL STATUTES AND REQUIREMENTS

Preparation of this Final Feasibility Report and Integrated Environmental Impact Statement (FEIS) has included coordination with appropriate Federal and State resource agencies. During the public review of this FEIS, a Water Quality Certificate, in accordance with Section 401 of the Clean Water Act, and a concurrence of Federal consistency with the New Jersey Coastal Zone Management program, in accordance with Section 307(c) of the Coastal Zone Management Act, was requested and conditionally granted from the New Jersey Department of Environmental Protection (NJDEP). A Section 404 (b)(1) evaluation is included in this Final Feasibility Report and Integrated Environmental Impact Statement. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to areas of concern under Section 404 of the Federal Clean Water Act. In accordance with the Fish and Wildlife Coordination Act (FWCA), a planning aid report was obtained from the US Fish and Wildlife Service in 1996, and is provided in Appendix B. A draft Section 2(b) FWCA report was prepared and provided in March 1999. A final Section 2(b) report is included in the final report.

For this stage of the planning process, compliance was met for all environmental quality statutes and environmental review requirements. The following table provides a list of Federal environmental quality statutes applicable to this statement, and their compliance status relative to the current stage of the project review.

Compliance with Environmental Quality Protection Statutes and Other Environmental Review Requirements at the Present Phase of the Project

Federal Statutes	Compliance w/Proposed Plan
Archeological - Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	Full
Safe Drinking Water Act Section 1414E	Full

Compliance with Environmental Quality Protection Statutes and Other Environmental Review Requirements at the Present Phase of the Project

Federal Statutes	Compliance w/Proposed Plan
Coastal Zone Management Act of 1972, as amended	Conditional
Endangered Species Act of 1973, as amended	Full with coordination
Estuary Protection Act	Full
Federal Water Project Recreation Act, as amended	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act, as amended	N/A
Magnuson-Stevenson Act - Essential Fish Habitat	Full with coordination
Marine Mammal Protection Act	Full
Marine Protection, Research and Sanctuaries Act	Full
National Historic Preservation Act of 1966	Ongoing
National Environmental Policy Act, as amended	Full

Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic River Act	N/A
Coastal Barrier Resources Act	Full

Compliance with Environmental Quality Protection Statutes and Other Environmental Review Requirements at the Present Phase of the Project

Executive Orders, Memorandum, etc.	**Compliance w/Proposed Plan**
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO 12114, Environmental Effects of Major Federal actions	Full

Full compliance - Requirements of the statute, EO, or other environmental requirements are meet for the current stage of review.

Noncompliance - None of the requirements of the statute, EO, or other policy and related regulations have been met.

N/A - Statute, EO, or other policy and related regulations are not applicable.

Ongoing - Coordination is continuing.

DESCRIPTION OF THE SELECTED PLAN
FOR BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND

Project Title: New Jersey Shore Protection Study, Barnegat Inlet to Little Egg Inlet Feasibility Study

Description: The proposed project provides a protective beach with a dune system to reduce the potential for storm damage along the ocean coast of Long Beach Island.

Beach Fill	
Volume of Initial Fill	7,400,000 cubic yards
Volume of Periodic Nourishment Fill	1,900,000 cubic yards
Interval of Periodic Nourishment	7 years
Length of Fill (Berm/Dune)	89,000,000 feet
Beach Berm/Dune	
Berm Width	125 feet
Dune Width	30 feet
Elevations	
Dune Crest	+22 feet NAVD
Beach Berm	+8 feet NAVD
Slopes	
Dune (Landward)	1V:5H to
Dune (Seaward)	1V:5H
Dune Appurtenances	
Grass Planting	347.0 acres
Sand Fencing	540,000 linear feet
Outfall Modification	none necessary
Project Costs	
Ultimate Project Cost	$156,632,000
Initial Cost	$ 50,084,000
Annualized (Discounted 6 7/8 %)	$ 3,573,000
Average Annual Benefits	
Storm Damage Reduction	$ 7,706,000
Reduced Maintenance	$ 986,000
Advanced Nourishment	$ included in initial
Benefits During Construction	$ not included
Recreation	$ 1,923,000
Benefit-Cost	1.84 (1.50 w/out recreation)
Cost Apportionment (First Cost)	
Federal	$32,555,000
Non-Federal	$18,194,000

Note: All elevation referenced to the North American Vertical Datum (NAVD), 1998.

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September 1999

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New Jersey Shore Protection Study

BARNEGAT INLET TO LITTLE EGG INLET
FEASIBILITY STUDY
Volume I

Draft Feasibility Report and Integrated Environmental Impact Statement (EIS)

Table of Contents

***** Indicates information required for National Environmental Policy Act (NEPA) Compliance

VOLUME 2

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List of Tables and Figures

LIST OF FIGURES		
Figure #	Description	Page #

List of Figures continued

List of Tables

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US Army Corps
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Philadelphia District

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FINAL FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL IMPACT STATEMENT

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1. INTRODUCTION .

The New Jersey Shore Protection Study is an ongoing study of the shore protection and water quality problems facing the entire ocean coast and back bays of New Jersey. The study will provide recommendations for future actions and programs to reduce storm damage, minimize the harmful effects of shoreline erosion, improve the information available to coastal planners and engineers, and be used by various resource agencies to help preclude further degradation of coastal waters. This report presents the results of one site specific study, entitled the Barnegat Inlet to Little Egg Inlet Feasibility Study, the fifth site specific study conducted under the New Jersey Shore Protection Study.

This document was prepared in accordance with ER 1105-2-100 (Civil Works planning Guidance Notebook), ER 1110-2-1150 (Engineering & Design for Civil Works Projects), ER 1165-2-130 (Federal Participation in Shore Protection) ER 1165-2-various and other applicable guidance and regulations. The guidelines for planning water and related land resources activities as contained in the Civil Works Planning Guidance Notebook, require that Federal water resources activities be planned for achieving the National Economic Development (NED) objective. The NED objective is to increase the value of the Nations' output of goods and services and improve national economic efficiency, consistent with protecting the Nation's environment pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements.

1.1 STUDY AUTHORITY.

The New Jersey Shore Protection Study was authorized under resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987.

The Senate resolution adopted by the Committee on Environment and Public Works on December 17, 1987 states:

That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentality thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response.

The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

That the Board of Engineers for Rivers and Harbors is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentality's thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, the development of recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response which is engineeringly, economically, and environmentally feasible.

1.2 STUDY PURPOSE AND SCOPE.

The Feasibility Study is the second of the Corps of Engineers' two-phase planning study process. The objective of the Feasibility Study is to investigate and recommend solutions to problems identified during the Reconnaissance Study and those problems further defined through the Feasibility Study. The scope of this study is to investigate erosion and storm damage problems along the study area, evaluate an array of solutions and, if warranted, formulate a plan to provide an increased level of protection and reduce damages from coastal storms for Long Beach Island.

This Feasibility Study covers the barrier island known as Long Beach Island (LBI) with municipalities, towns and townships known as Barnegat Light, Borough of Beach Haven, Harvey Cedars, Long Beach Township, Ship Bottom, and Surf City. The scope of this study includes an overview analysis of the entire LBI Atlantic coast to gain an understanding of the coastal processes, to better assess and analyze problems, and to recommend effective lasting solutions.

This report presents the result of the analysis of existing conditions, without project conditions, plan formulation, and design of the NED plan for the feasibility level study conducted pursuant to the previously mentioned resolutions. The scope of work involved field data collection efforts focusing on: vibracore surveys to identify potential borrow areas; hydrographic and topographic surveys; a photogrammetric survey, to create an accurate structure and elevation database; economic and real estate surveys to evaluate structures and identify property owners within the project study area; benthic sampling survey of identified borrow areas; remote magnetometer surveys of the identified offshore borrow sites to investigate the presence of cultural resources; sand samples of the beaches along LBI; and, hydrologic studies involving modeling of erosion, long shore transport and groin functionality.

The Feasibility Report will accomplish the following:

a. Provide a complete presentation of the existing conditions, without-project analysis and plan formulation analysis for LBI;

b. Provide a complete presentation of the study results, findings and indicate compliance with applicable statutes, executive orders and policies;

c. Identify costs, environmental and social impacts, and potential economic indicators of identified potential solutions;

d. Present the recommended optimized NED plan for each problem area, and;

e. Present the Project Cooperation Agreement (PCA) responsibilities of the non-Federal Sponsor.

1.3 DESCRIPTION OF STUDY AREA.

Long Beach Island is a sandy barrier island located in Ocean County, New Jersey, and is centrally located along the state′s open coastline, see Figures 1-1. This barrier island has a total length of about 20.8 statute miles. It is bounded on the north by Barnegat Inlet and on the south by the Little Egg/Beach Haven Inlet complex, and has a general axis of orientation, which is aligned in a north-northeast/south-southwest direction. The island is separated from the mainland to the west by a typical shallow, elongated estuary containing salt marsh fringes and islets. This estuary is a continuous water body comprised of two integral embayments that, in order from north to south, are the southern end of Barnegat Bay and Little Egg Harbor. Barnegat Bay and Little Egg Harbor are the two largest bays along the New Jersey Coast. Both bays are a significant source of fish, shellfish and recreation, as well as habitat for a variety of species of fish and wildlife, both migratory and native.

The feasibility study was prepared based on the recommendations of the reconnaissance study completed in March 1995, which identified possible solutions to the storm damage problems and habitat loss facing the study area. The entire study area was included in economic, environmental and hydraulic analyses to identify large scale and regional problems.

Barnegat Inlet has been a Federally maintained inlet since 1940 with the completion of rock jetties on its north and south sides see Figure 1-2 and 1-2A. Due to shoaling and channel instability, a design deficiency with the original jetty configuration, a new south jetty was built. Completed in 1991, the new jetty is nearly parallel to the north jetty, which was constructed in 1939. The inlet jetties are aligned in a roughly northwest-southeast orientation.

Presently Beach Haven Inlet and Little Egg Inlet to the south of LBI are combined into one inlet system, see Figure 1-3 and 1-3A. The inlet is a natural inlet that migrates and fluctuates with time. Beach Haven Inlet area drains Little Egg Harbor and Little Egg Inlet drains Great Bay and the Mullica River system. Beach Haven Inlet historically migrates south with the growth of the spit at the southern tip Long Beach Island. Eventually the spit becomes too long and is truncated when the ocean breaks through and a new Beach Haven Inlet is formed leaving an island separating the two inlets. This process last occurred in 1920. Historically, the formation of a "new" Beach Haven Inlet has occurred on a 60 to 80 year cycle. Previous truncations of the Barrier Island have occurred before man's intervention when the island was in a more natural state.

Historical records do not show any other inlets existing within the present shoreline of LBI. However storm generated overwash inlets have temporarily existed during storms. The March storm of 1962 created several overwash inlets on Long Beach Island, the largest of which was in Harvey Cedars. The coastal storm of December 1992 produced overwashes in Beach Haven, Brant Beach and Harvey Cedars.

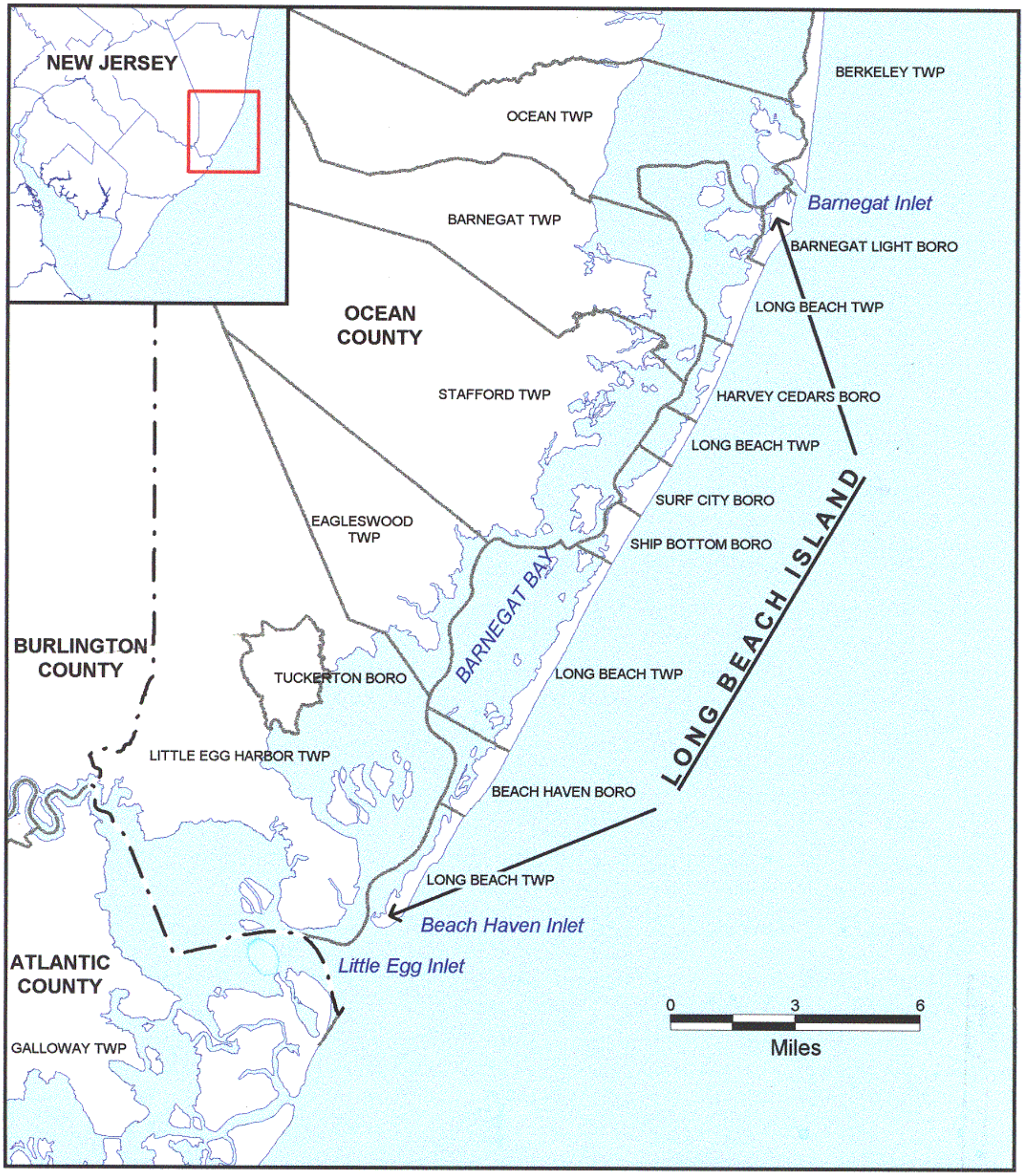

FIGURE 1-1: STUDY AREA LOCATION

FIGURE 1-2 Barnegat Inlet Feb 6, 1995

FIGURE 1-2A Barnegat Inlet, Barnegat Light Township Aug 30, 1995

FIGURE 1-3 Little Egg Inlet Aug 30, 1995

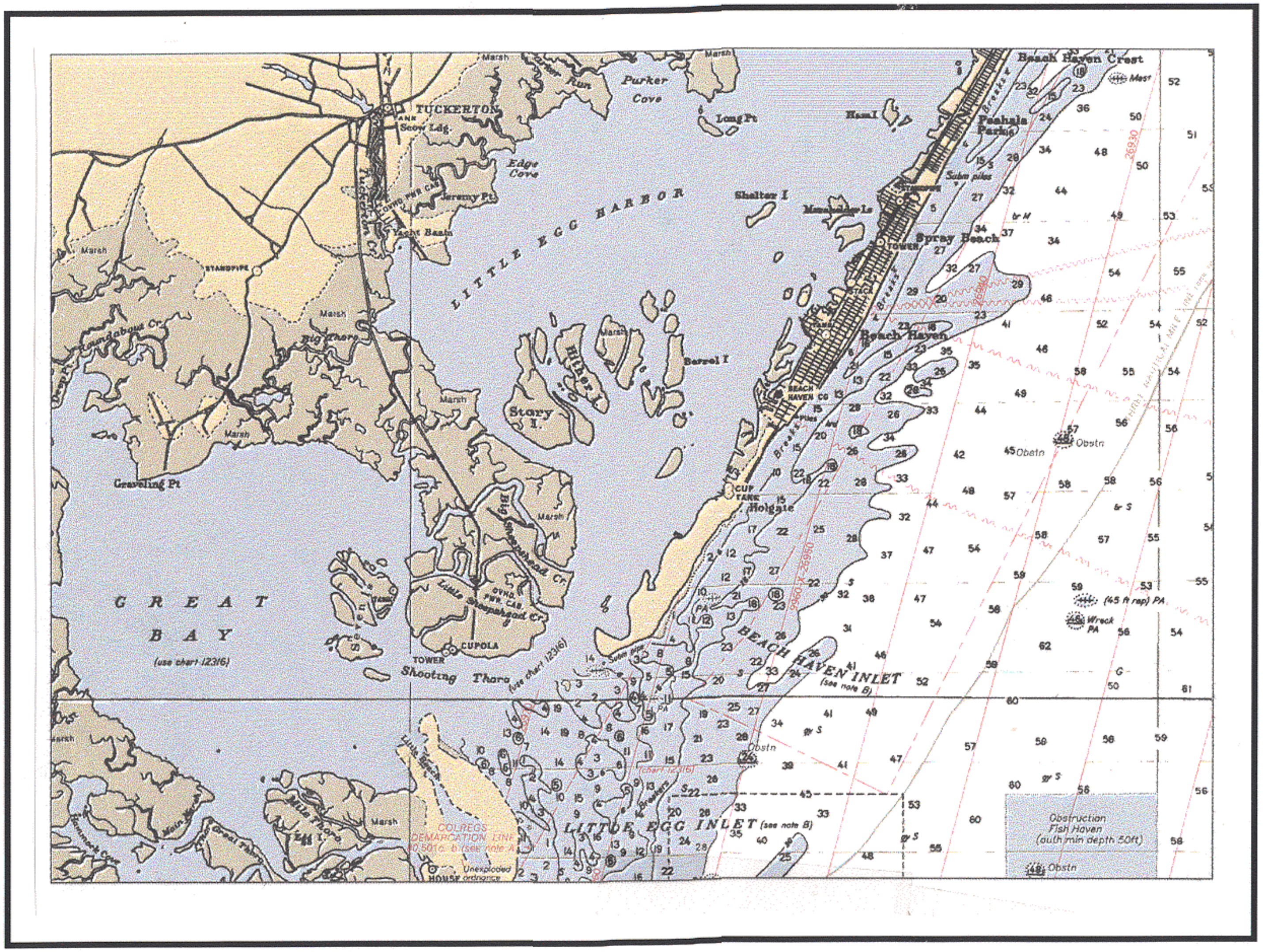

FIGURE 1-3A Beach Haven Inlet Complex

Access, Size, and Development Characteristics. New Jersey Route 72 connects from the mainland to the center of Long Beach Island by means of a causeway crossing Manahawkin Bay. The island has a total land area of approximately 5,090 acres and an average width of about 2,100 feet. Except for the Barnegat Lighthouse State Park at the north end of the island and the Forsythe National Wildlife Refuge at the south end, the major proportion of the island′s land surface (over 80 percent) is densely developed, see Figures 1-4 A through L. The zone of dense development extends southward for a distance of approximately 18.3 miles from the south shoulder of Barnegat Inlet. Residential development is the predominant land use throughout the incorporated areas of the island, with most commercial establishments fringing on several of the major traffic corridors. The developed oceanfront of Long Beach Island is characterized by a continuous row of separate residential dwellings with only a few interspersed hostelries. In general, the oceanfront buildings are located immediately behind or on the landward slope of the island′s single frontal dune line. The exception to this general developmental characteristic is found along a 3,000-foot reach of shore immediately south of the original Barnegat Inlet south jetty structure. Within this reach, the front row of residential structures is set over 200 feet landward of the frontal dune. In contrast at the southern-most end of the island, immediately adjacent to the developed limits the community of Holgate, and extending for an additional 2.5 miles to the Little Egg Inlet/Beach Haven Inlet complex, the island has remained in a pristine state. This 2.5-mile southern extremity of Long Beach Island constitutes the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge.

The island′s general pattern of oceanfront development is one in which the first row of structures is situated behind or on the landward slope of the dune line. There are significant differences along the length of the development with respect to such factors as property values, distance between buildings and the shoreline, and beach width and size of frontal dune. The level of detailed analysis performed in this Feasibility Study, particularly the level of assessment for

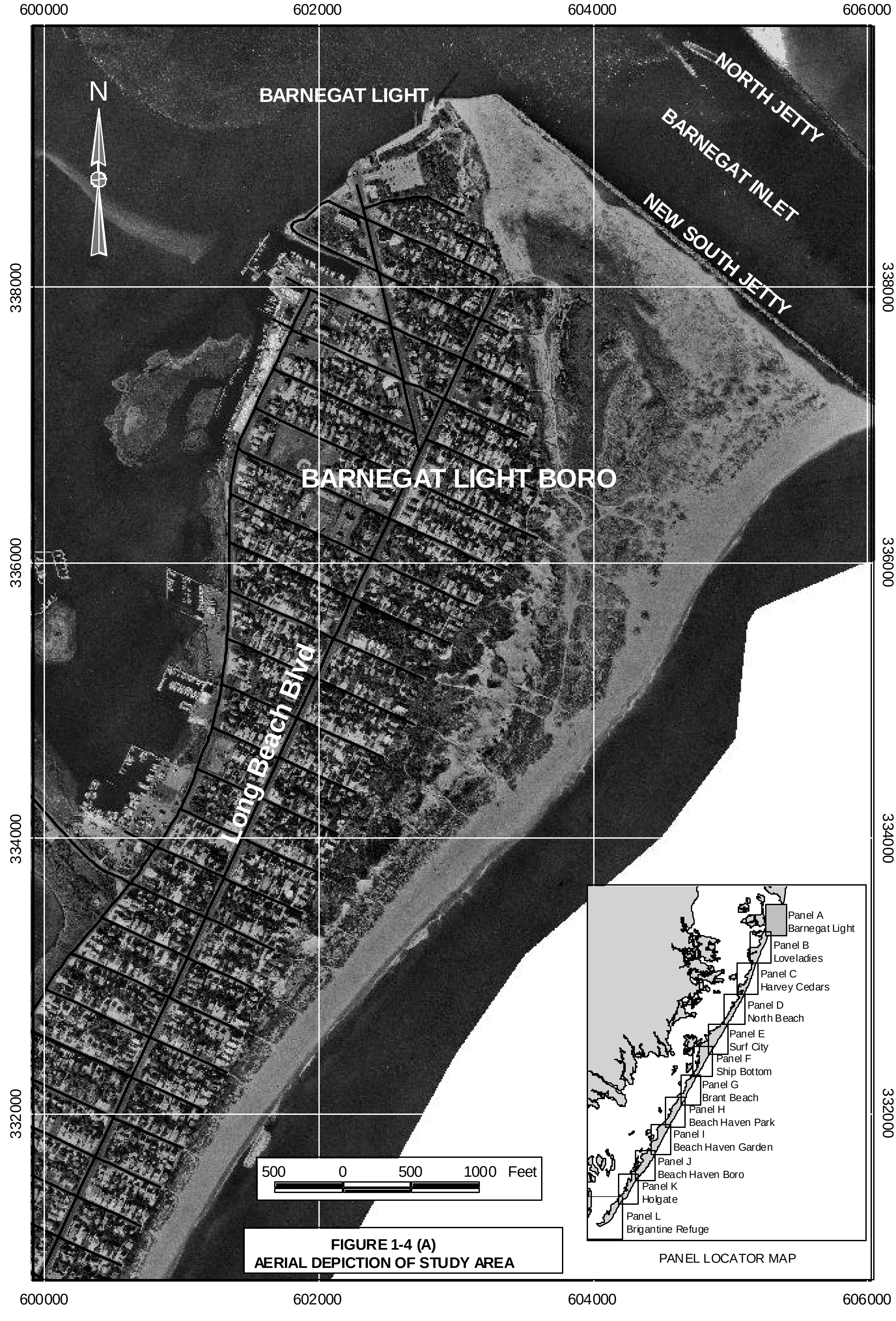

FIGURE 1-4 (A)
AERIAL DEPICTION OF STUDY AREA

FIGURE 1-4 (B)
AERIAL DEPICTION OF STUDY AREA

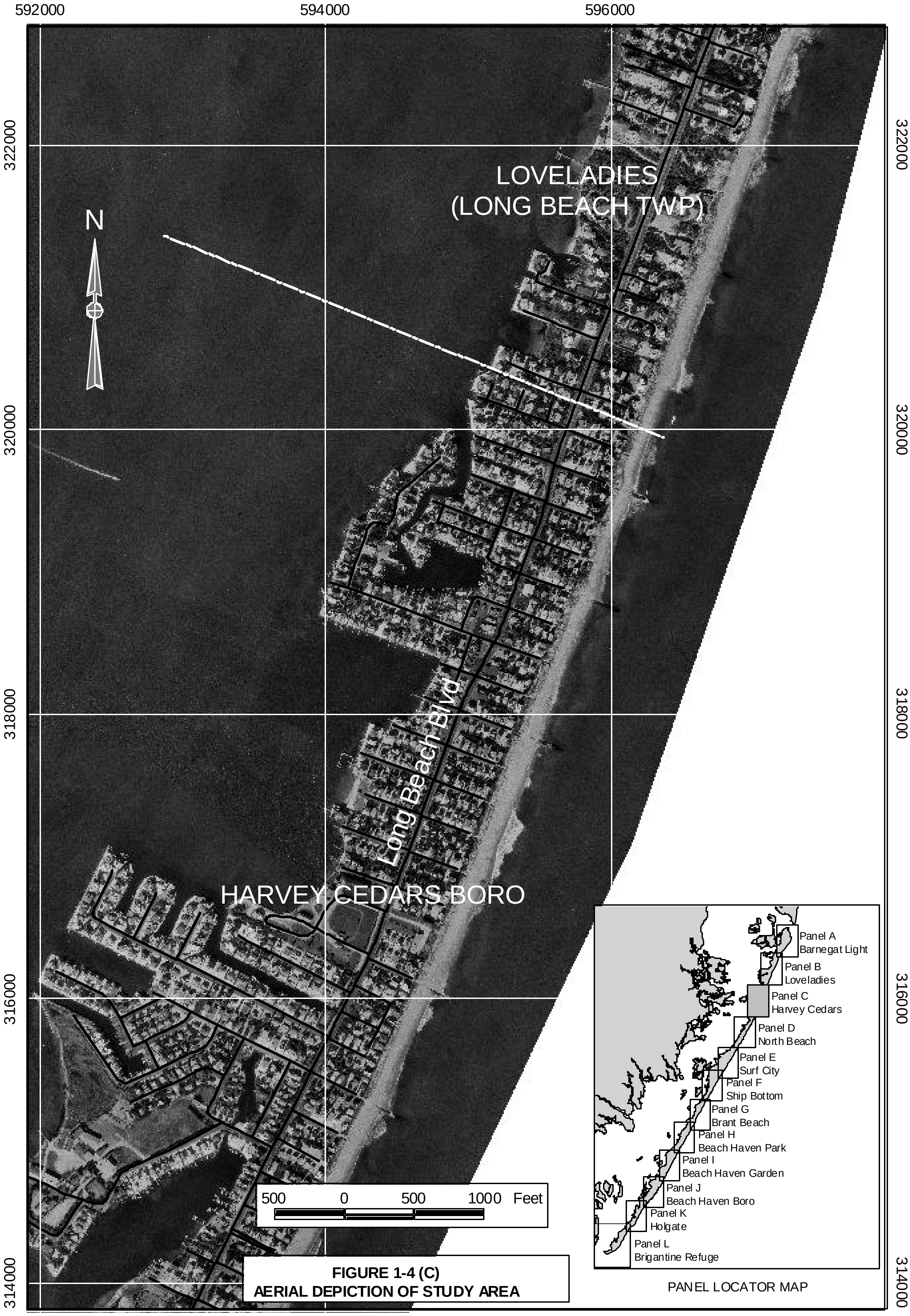

FIGURE 1-4 (C)
AERIAL DEPICTION OF STUDY AREA

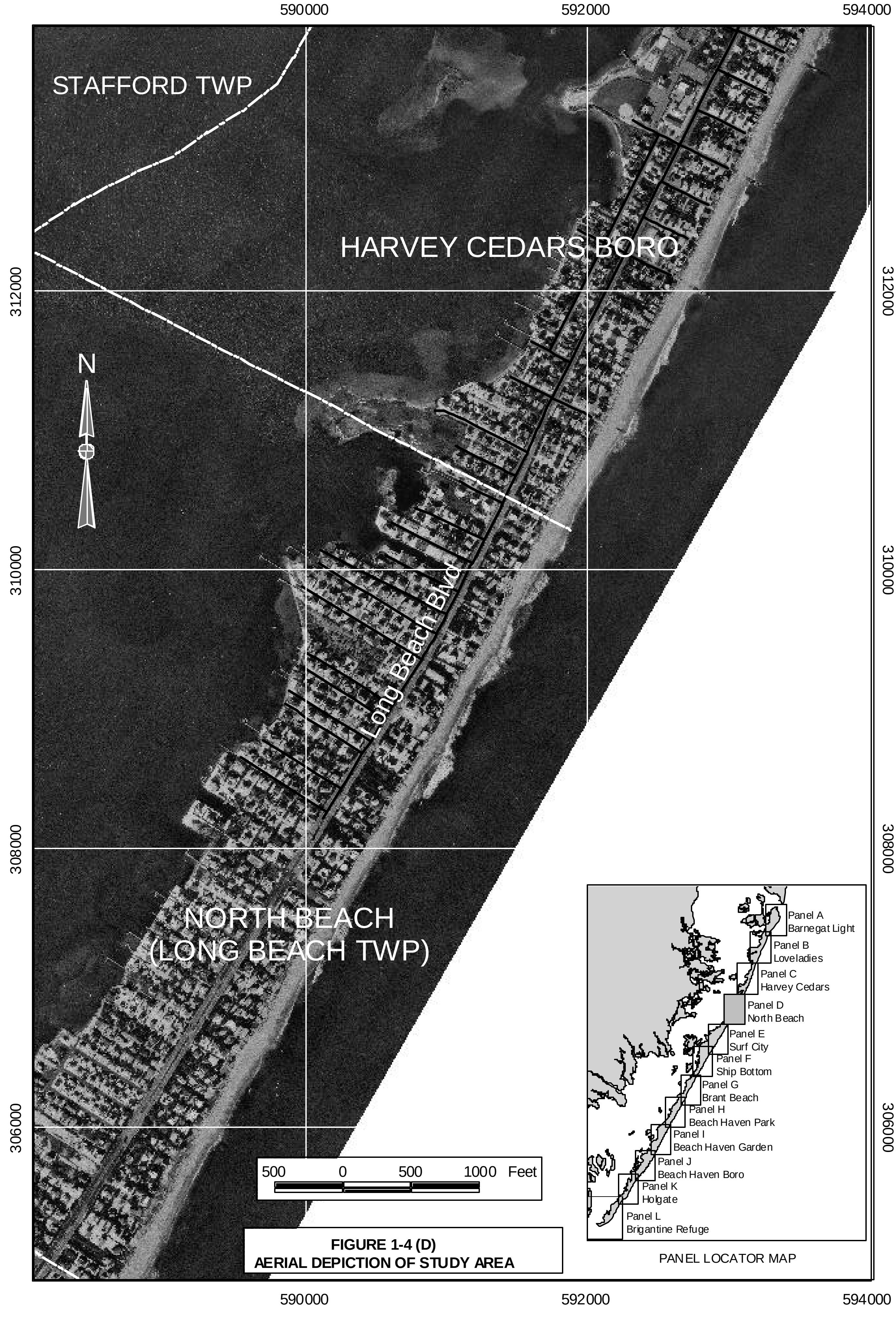

FIGURE 1-4 (D)
AERIAL DEPICTION OF STUDY AREA

FIGURE 1-4 (E)
AERIAL DEPICTION OF STUDY AREA

FIGURE 1-4 (F)
AERIAL DEPICTION OF STUDY AREA

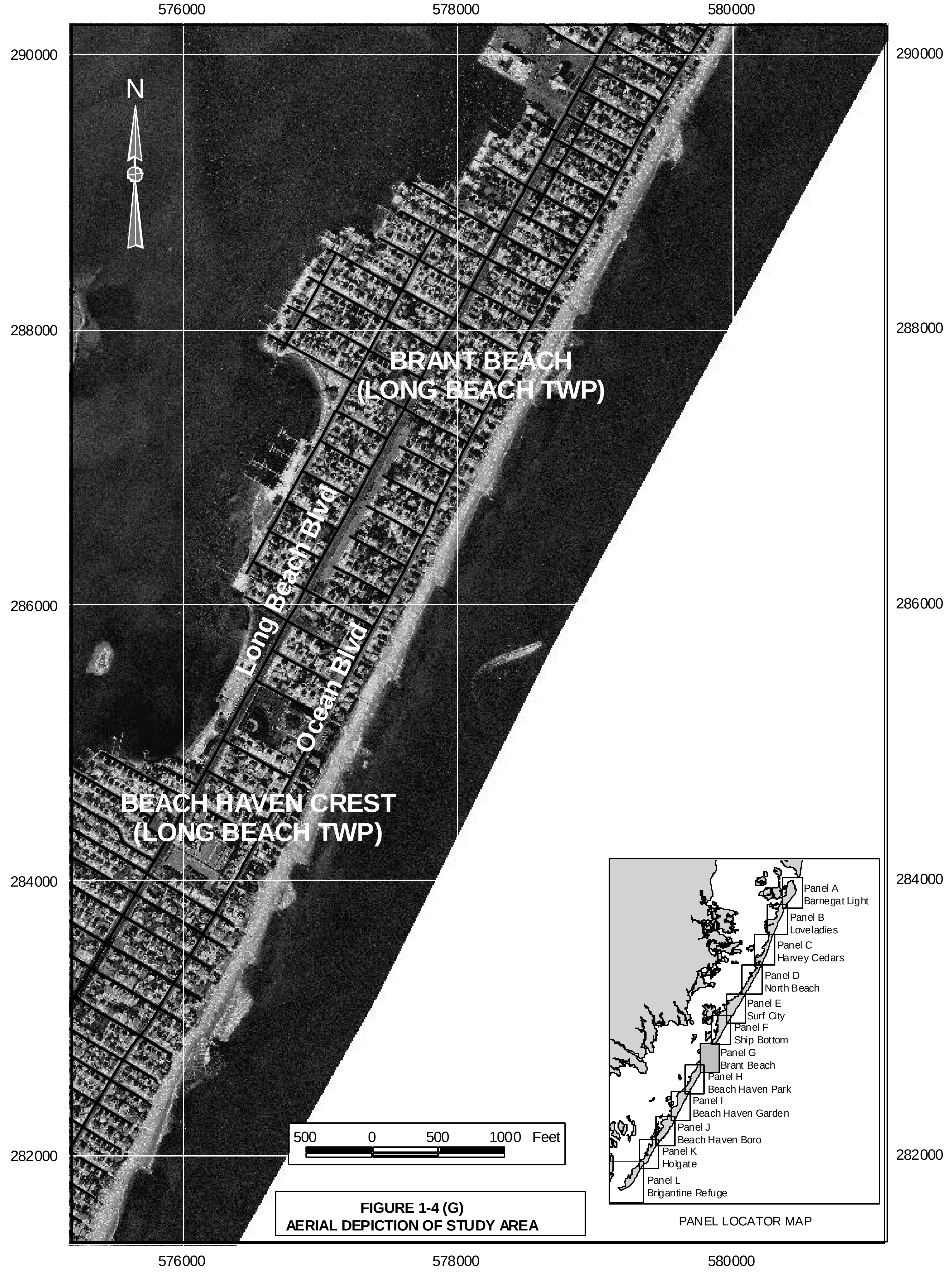

FIGURE 1-4 (G)
AERIAL DEPICTION OF STUDY AREA

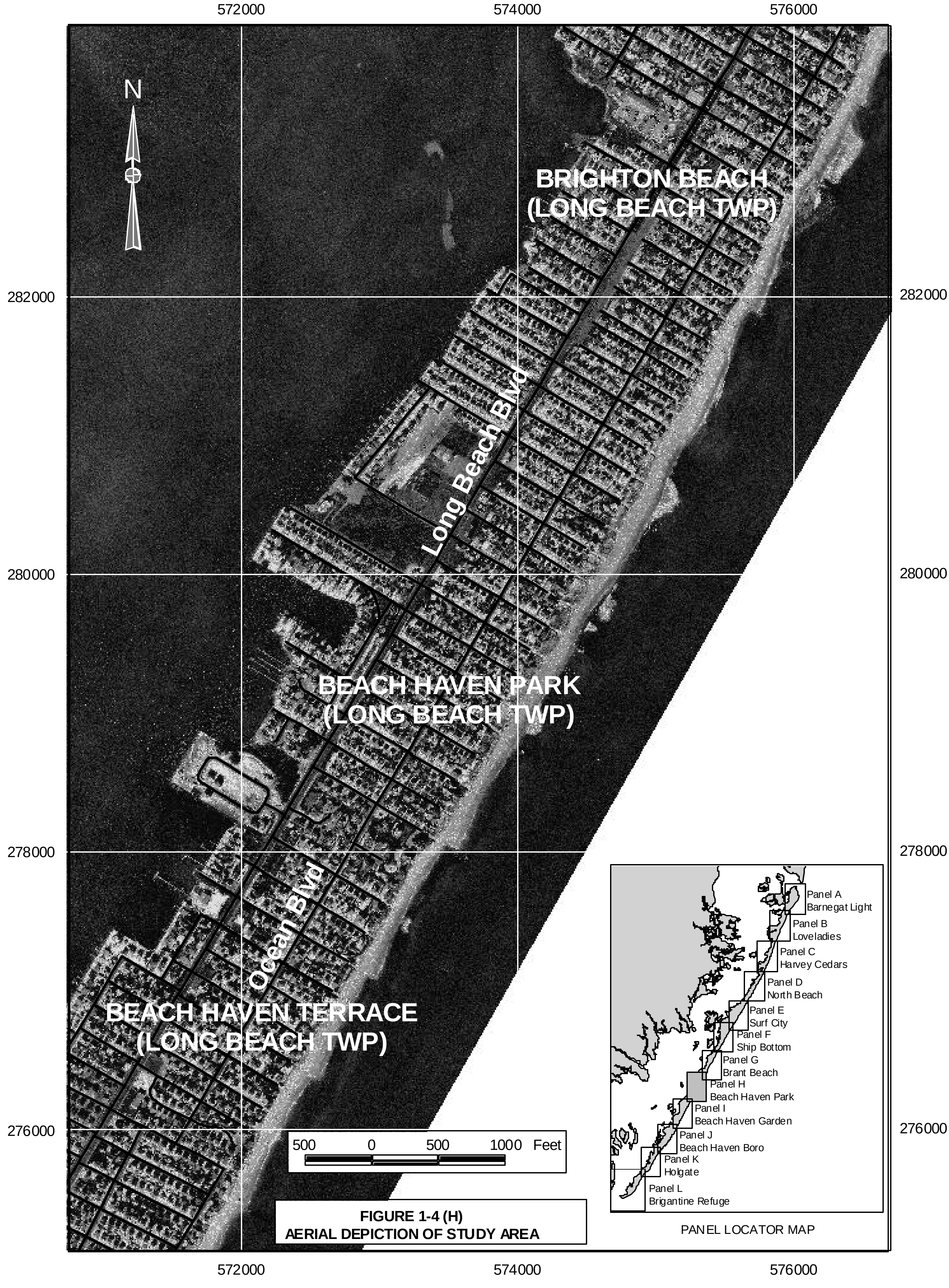

FIGURE 1-4 (H)
AERIAL DEPICTION OF STUDY AREA

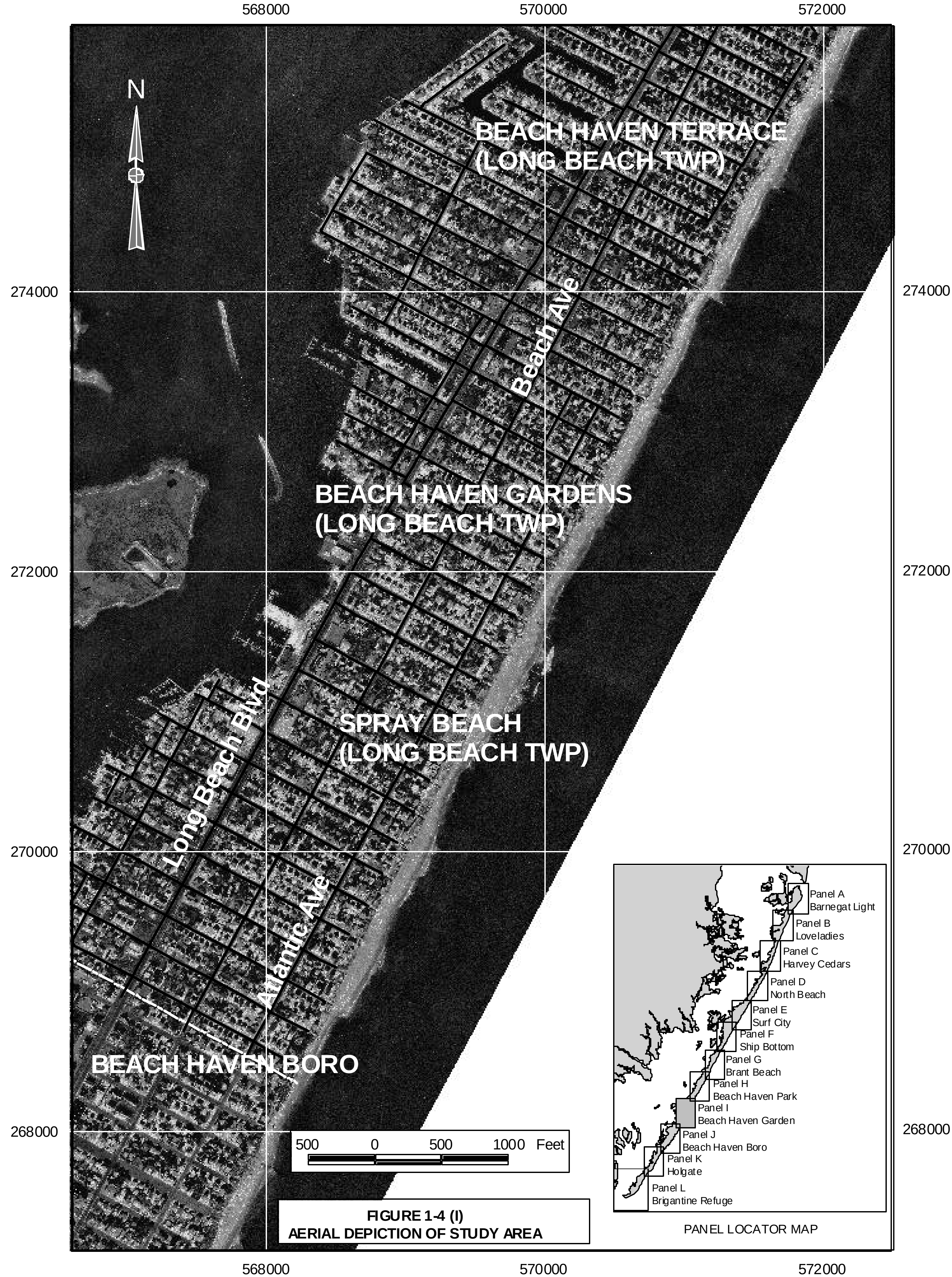

FIGURE 1-4 (I)
AERIAL DEPICTION OF STUDY AREA

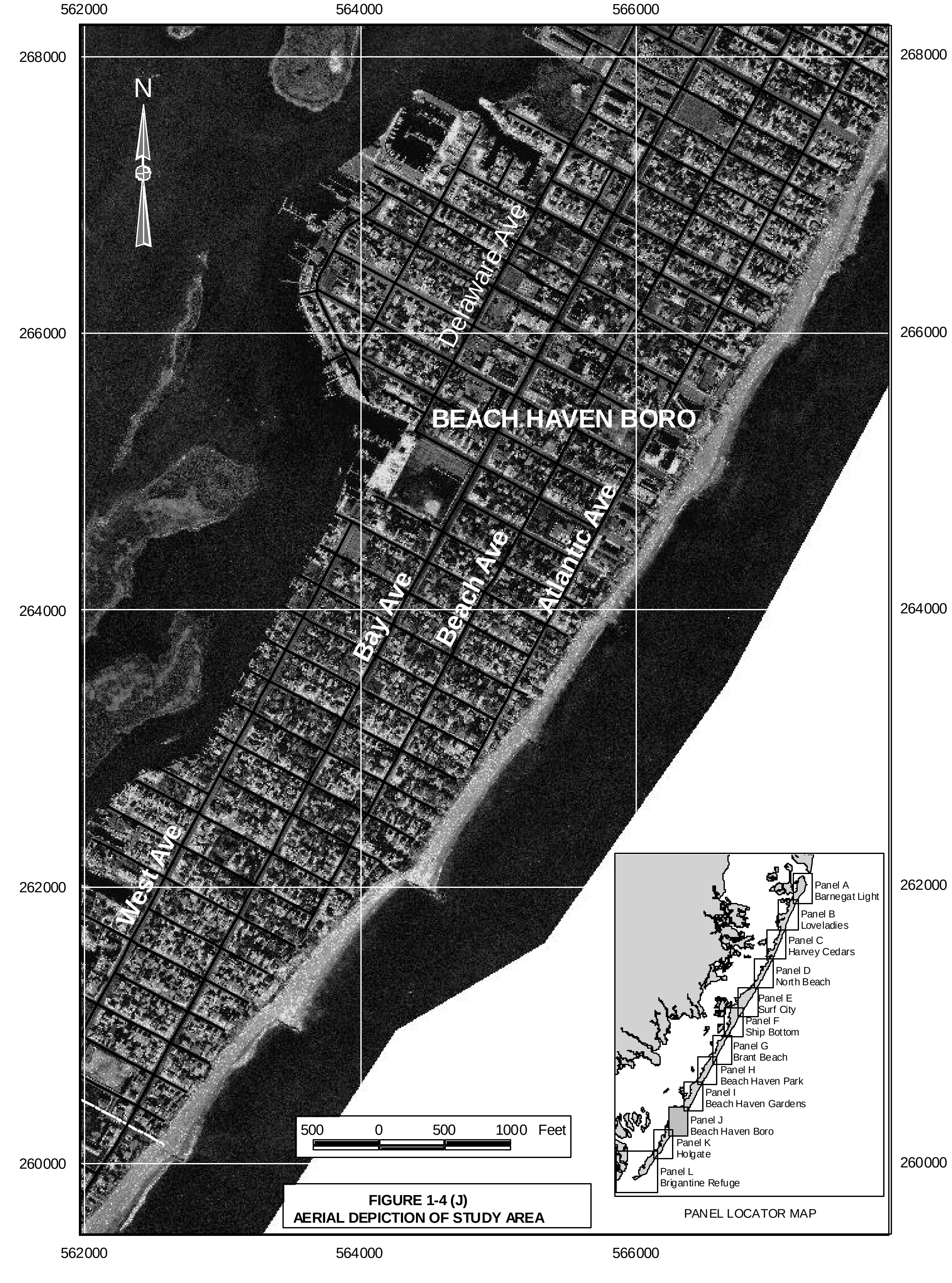

FIGURE 1-4 (J)
AERIAL DEPICTION OF STUDY AREA

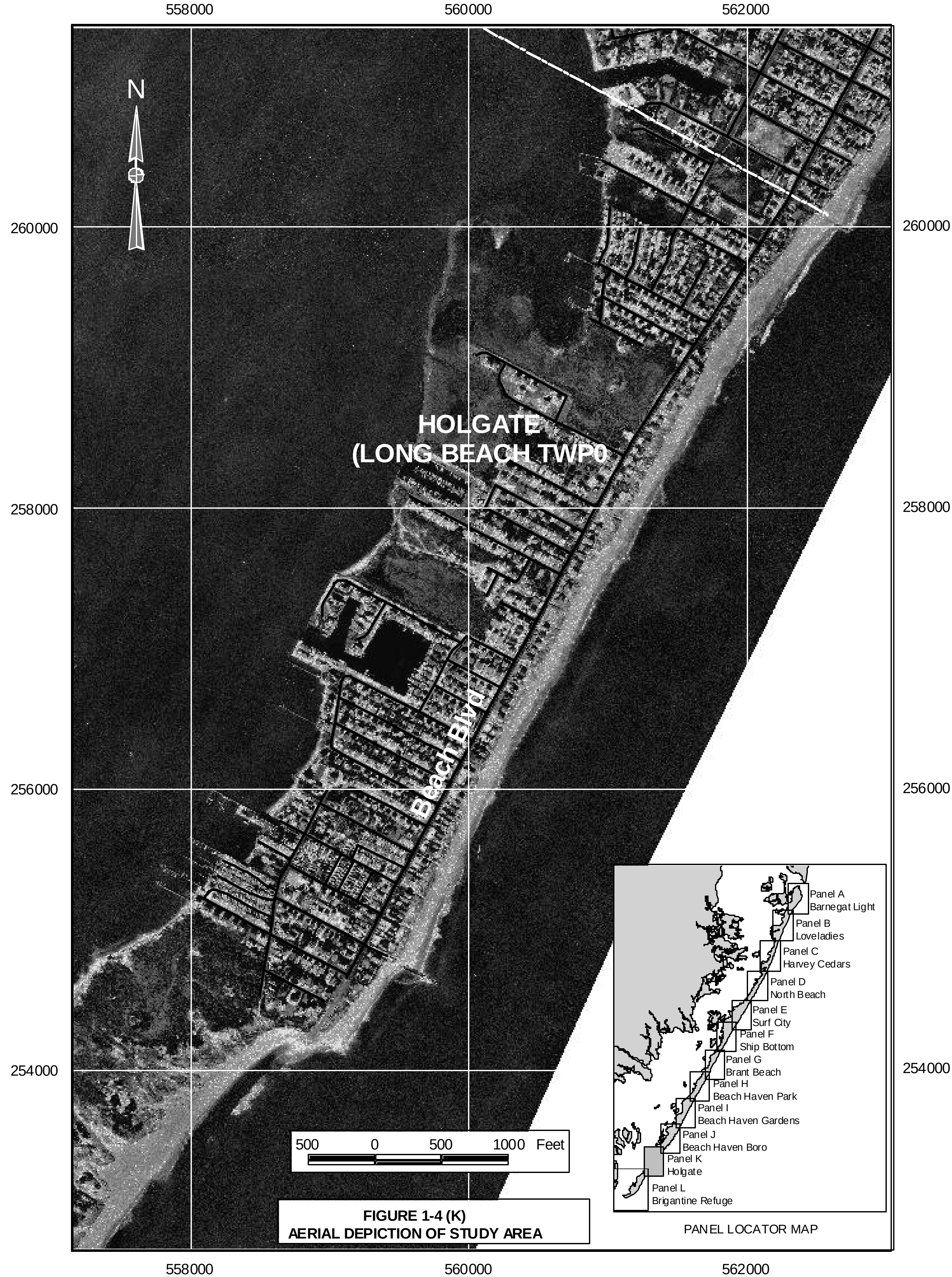

FIGURE 1-4 (K)
AERIAL DEPICTION OF STUDY AREA

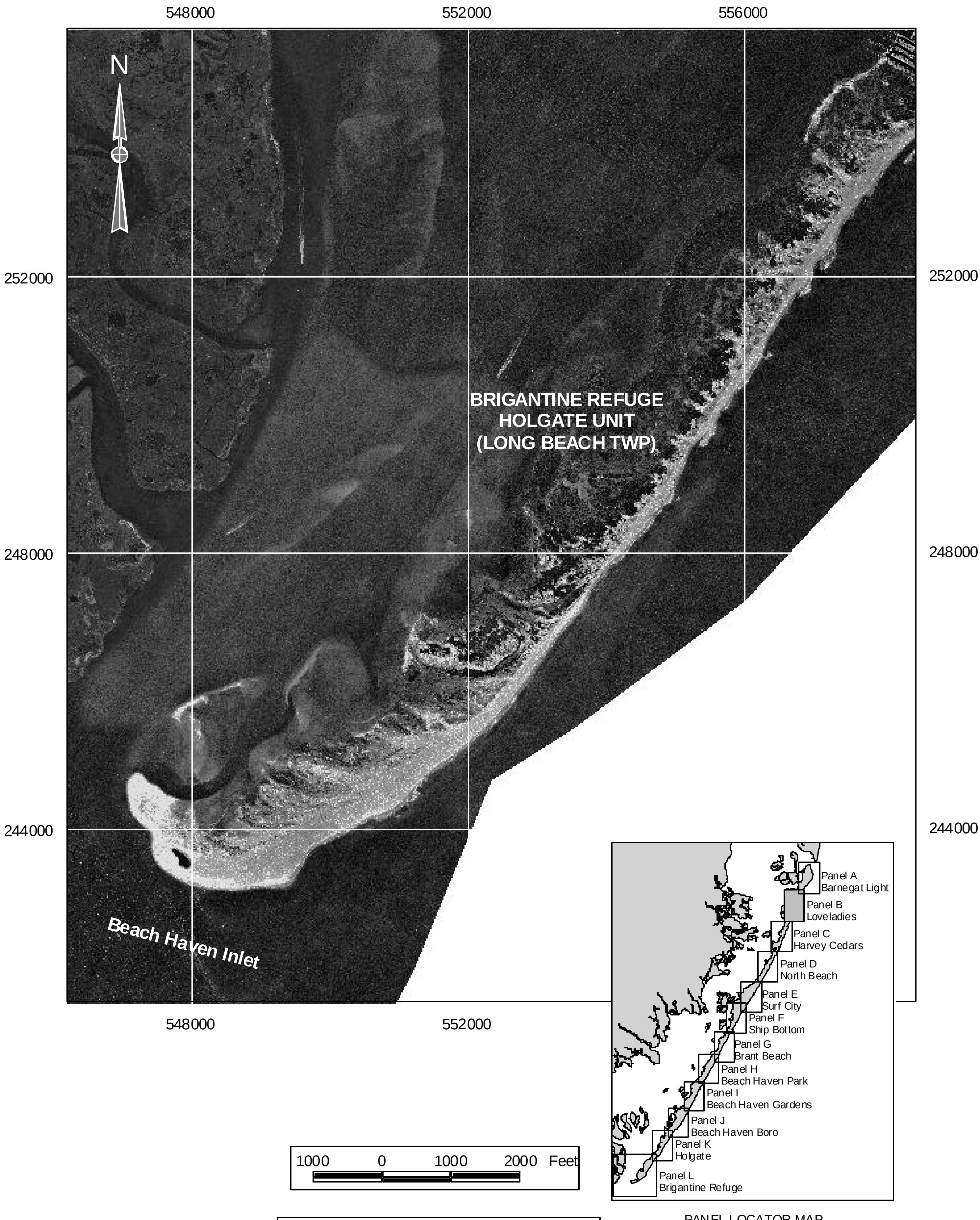

FIGURE 1-4 (L)
AERIAL DEPICTION OF STUDY AREA

storm effects and damage parameters, necessitated sectioning the island into units of shorefront, referred to as "BUNDY's" (Beach Unit Nomenclature for Distance Y, parallel to the beach). As shown in Figures 4-1 A and B, in Section 4.3, there are fifteen (15) primary BUNDY's created for use in analysis. The primary BUNDY's range in length from approximately 3,100 to 9,800 feet.

Political Jurisdictions and Population. The developed areas of Long Beach Island are divided into six political jurisdictions, the largest of which consists of four discontinuous units of the municipality of Long Beach Township (LBT). The other five incorporated areas, interspersed along the island, are the Boroughs of Barnegat Light, Harvey Cedars, Surf City, Ship Bottom, and Beach Haven. Within Long Beach Township, various communities have adopted place names as generally indicated on Figures 4-1 A and B. Typical views of the island are shown in Figures 1-5 and 1-6. The most recent estimates of the year-round population for Long Beach Island are approximately 8700. However, the number of year-round residents is very small in comparison to the summertime population, which burgeons with tourist and vacationing absentee property owners. In that regard, analysis of the recreational use of beaches in central New Jersey, conducted in 1996 by the State of New Jersey, reported beach use at Long Beach Island to be 3,846,000 per annum based on actual beach counts, and total visitors in the summer of 1996 at 7,832,660.

Basic Physical Characteristics. The basic physical characteristics of Long Beach Island are similar to those of many developed barrier islands found along the mid- and southern segments of the Atlantic Seaboard. The island's beach strand is comprised of quartz sand with median grain diameter of roughly 0.35 mm. The intratidal and swash zone, i.e., the foreshore, has a slope of about 1V to 11H and meets the beach berm at an elevation which varies from 7 to 8.5 feet above North American Vertical Datum (NAVD). The astronomical tide range at Long Beach Island is approximately 4.10 feet and mean sea level is about 0.77. feet below NAVD. The widths of the beach berm along the length of the island are highly variable over time, due to the presence of groins, which compartment the beach along the entire developed ocean frontage. Accordingly, the berm widths alternate from relatively broad to narrow at the ends of the groin compartments as dictated by alternating short-term changes in the directions of littoral transport.

The average beach and berm widths [the berm is defined as the beach between elevation +9.75 NAVD and +7.75 NAVD, which is consistent with the economic analysis for the pursposes of this study] along Long Beach Island are about 110 feet but may vary from as narrow as 30 feet to as broad as 139 feet. (This excludes the areas of Barnegat Light and Northern Loveladies, Long Beach Township, which have more extensive dune/berm profiles.) It is also of interest to note that a typical berm feature does not always exist. That is, on occasion, beach profile surveys reveal a continuous, upwardly sloping surface from the water line to the toe of the frontal dune situated at elevation 9.25 to 10.25 feet above NAVD. An exception to the island's relatively narrow beach berm is found along the northern-most 1 mile of shore located immediately south of the original Barnegat Inlet south jetty. In that area, the berm is relatively broad, having a width of about 200 feet but expanding to as much as 1600 feet in the vicinity of the original south jetty structure.

FIGURE 1-5 Southern Limits, LBI Beach Haven Township Aug 30, 1995

25

FIGURE 1-6 Loveladies, LBI and Harvey Cedars Aug 30, 1995

The island's Oceanside development is fronted by a single dune line which has base widths of 150 to 500 feet, and peak elevations that generally vary from 16 to 25 feet above NAVD. An exception to these basic dune characteristics is found along the area extending about 2 mile south of the original Barnegat Inlet south jetty. Along that particular area, a broad series of dunes and hummocks reach elevations as high as 26 to 31 feet above NAVD. Also, there are a few very limited reaches of shore, particularly in the southern end of the developed area, where there is little or no frontal dune. Along the frontal dune, vegetative cover ranges from dense to very sparse and use of sand fences is a common practice, employed by the local authorities, to enhance dune development and to fix the position of the dune line against wind-induced migration. Pedestrian access to the beach strand, over the dune line, is generally provided at street ends. Landward of the frontal dune, the densely developed land area is flat and generally has elevations in the range of 6 to 8 feet above NAVD.

Existing Oceanfront Shore Protection Structures. The shoreline reach extends 17.8 miles (94,150 ft) between the original Barnegat Inlet south jetty and the southern limits of development on the island. There are a total of 101 groin structures spaced at intervals that range from 750 to 1000 feet, with the average spacing being about 900 feet. At various times during the year certain groins are completely covered by sand. These permanent shore protection structures range in length from 250 to 420 feet, with the average length being 285 feet. The groins are constructed of timber or stone and, in some cases, a combination of these two materials. The horizontal inshore segments of most of the groins have crown levels at elevations of about 10 feet above mean low water datum (MLW datum) or roughly, 9.4 feet above NAVD. The groin compartments have beach berm elevations that vary over time, from +7.75 to +9.75 feet NAVD and, on occasions, the berms are sloped continuums of the foreshore. Since the groin crowns are generally above the berm levels as well as the surface of the foreshore, there is not a significant amount of sediment transport directly through the individual groin compartments. This results in frequent episodes of the alternating accretion and erosion at opposite ends of the compartments as alluded to above, in connection with variability in berm widths.

Long Beach Island is the northern most barrier island of New Jersey's chain of barrier islands. The beaches of LBI are typically narrower and steeper than the beaches of the barrier islands to the south. The direction of the net littoral drift on LBI, as estimated by CERC in 1968, is to the south, with a local area of reversal in the vicinity of Barnegat Inlet. Most beaches **north** of Long Beach Island, beyond the influence of Barnegat Inlet, experience net littoral drift to the north. A nodal point exists somewhere in the vicinity of Island Beach State Park, which is immediately north of Barnegat Inlet. Due to the geographical location of LBI, the narrowness of its beaches and orientation of its coastline, it often is one of the most damaged areas along the New Jersey coast during northeasters.

1.4 PRIOR STUDIES, REPORTS AND RELATED PROJECTS

There exist numerous planned, ongoing and completed shoreline programs and projects for the New Jersey coast. Various groups including the Federal government, the State of New Jersey, local municipalities, and private interests have initiated the work. A description and the status of these projects and studies are presented below.

Federal Involvement: The history of Corps involvement in the New Jersey Coast is long and involved. Before 1930, the Federal government involvement in shore erosion was limited to protection of public property. With the enactment of The River and Harbor Act of 1930 (Public Law 71-520, Section 2) the Chief of Engineers was authorized to make studies of the erosion problem in cooperation with municipal and state governments in order to devise a means of preventing further erosion of the shore. Until 1946, the Federal aid was limited to studies and technical advice. In that year, and again in 1956 (PL 84-826) and 1962 (PL 87-874), the law was amended to provide Federal participation in the cost of a project and allowed limited contribution to the protection of privately owned shores which would benefit the public.

Navigation Projects

Barnegat Inlet Navigation Project - Originally authorized under Rivers and Harbors Committee, Document 73-19 in 1933 and modified in Document 74-85 in 1936, provided for a navigation channel and two converging stone jetties constructed in 1939 and 1940. Federal involvement at Barnegat Inlet before and after construction of the jetties included construction of a timber and stone groin 180 feet long approximately 170 feet west of Barnegat Lighthouse in 1938 and construction of three timber groins to accompany two built by the State in Barnegat Light, each 165 feet long in 1943.

The inner 2700 feet of the north jetty was raised from -1 MLW to +8 MLW in 1974 to prevent sand and waves from passing across the jetty and into the inlet. In 1991 a 4270-foot long new south jetty was completed that was nearly parallel to the north jetty. This jetty was built to correct for shoaling and channel instability created by the inlet′s original configuration of converging jetties (see Figure 1-2).

Beach Erosion Control Projects

House Document 86-208 (1959) “Shore of New Jersey -Barnegat Inlet to Cape May Canal, Beach Erosion Control Study” provided for Federal participation in the costs of :

Constructing 180 feet of stone revetment and 90 feet of timber bulkhead west of the lighthouse;
Reconstructing and extending the stone groin just east of the lighthouse;
Constructing two new timber groins, south of the lighthouse; and widening 1,200 feet of beach by artificial placement pending demonstration of need.

Beachfill to provide a 50 foot wide berm at elevation +10 MLW for 3500 ft in Ship Bottom; 6900 ft in Brant Beach (Long Beach Township); and 3000 ft at Beach Haven.

The State of New Jersey placed 182,000 cubic yards and 115,000 cubic yards of beachfill in 1956 at Ship Bottom and Brant Beach respectively with reimbursement by the Federal Government for the Federal share of the project.

Construction of four groins in Holgate (Long Beach Township) Periodic nourishment at appropriate locations.

NOTE: No other work has been accomplished on this project as it has been placed on the list of deferred authorized projects in 1973 due to consideration of the project area in the comprehensive New Jersey Coastal Inlets and Beaches Study. Since then the project was deauthorized in 1990 by Section 1001, Public Law 99-662. Under the Authority of Public Law 81-875, emergency dune work and beach replenishment was done for nearly the entire length of Long Beach Island following the March 1962 “Five High” storm. This work was done in cooperation with Federal, State and local governments. See Table 1-1 for a listing of locations and quantities of fill placed in response to the 1962 storm.

Groin construction: a series of groins were constructed along the entire 18 miles of developed shoreline on Long Beach Island. A large portion of these groins were constructed in response to the March 1962 Storm under the Federal Accelerated Public Works Program (APW). Since 1955 a total of 97 groins were constructed at an approximate cost of $5,500,000. By the early 1970’s Long Beach Island had a total of 112 groins. A complete listing of the visible existing groins can be found in Section 2.7, Table 2-15.

Beach berm restoration and dune replenishment took place in August 1978 following a coastal storm in February 1978. A total of 1,000,000 cubic yards was placed on the beaches of Harvey Cedars and Loveladies. Construction was done under the authority of Public Law 84 -99 to restore the previously authorized and constructed beach erosion control project at Long Beach Island contained in House Document 86-208.

TABLE 1-1

Beach Fill Placed in Response to Storm of March 1962

Community	Cubic Yards	Linear Foot	Type of Project	Agency
Barnegat Light	375,000	8.475	Emergency Dune	Fed., State, & Munic.
Loveladies (LBT)	360,000	10,000	Emergency Dune	Federal
Harvey Cedars	355,000	9,000	Emergency Dune	Federal
North Beach (LBT)	46,000	4,800	Emergency Dune	Federal
Surf City	500,000	7,500	Dune Fill	Fed., State, & Munic.
Ship Bottom	539,000	7,350	Emergency Dune	Fed., State, & Munic.
Brant Beach to Beach Haven Line (LBT)	204.000	27,135	Dune Repair & Replacement	Federal
Beach Haven	405,000	9,670	Dune Fill	Fed., State, & Munic.
Holgate (LBT)	308,000	8,000	Emergency Dune	Fed, State, & Munic.

Studies

Monitoring of Completed Coastal Projects (MCCP)- ongoing study of Barnegat Inlet new south jetty performance, channel modifications, and possible effects on adjacent beaches, the inlet shore, and Back Bay. This effort is schedule to continue until fiscal year 1999.

Reports

Barnegat Inlet to Little Egg Inlet Reconnaissance Study - 1995: This study was the fifth site specific study conducted under the New Jersey Shore Protection Study. This first phase of the Corps's two-phase study planning process (the reconnaissance phase) addressed shoreline erosion and storm damage vulnerability of Long Beach Island, New Jersey. The study determined the potential for a Federal project, action and response which is engineeringly, economically, and environmentally feasible.

New Jersey Shore Protection Study - 1990: The Study was initiated in 1988 to investigate shoreline protection and water quality problems, which exist along the entire coast. Special interest focussed on physical coastal processes, those mechanisms occurring in the coastal zone, which result in the movement of water, wind and littoral materials. Upon the conclusion that existing numerical data was insufficient to provide long-term solutions, future comprehensive studies were proposed. The Limited Reconnaissance Phase of the New Jersey Shore Protection Study identified and prioritized those coastal reaches which have potential Federal interest based on shore protection and water quality problems which can be addressed by the Corps of Engineers (COE). Barnegat Inlet to Little Egg Inlet was one of the reaches identified to undergo the Corp's two-phase planning process.

Barnegat Inlet Phase I General Design Memorandum - 1981: Phase II GDM - 1984. These design documents were prepared to finalize planning and policy for a modification to the Barnegat Inlet project. Ultimately it was decided to pursue as a correction for a design deficiency with the original inlet jetty configuration. The arrowhead design of 1939-40 did not provide for a sufficiently stable channel and safe navigation through Barnegat Inlet.

New Jersey Inlets and Beaches, Barnegat Inlet to Longport -1974: Recommended the following project for Long Beach Island: beach fill with a 75 ft berm at +10 MLW, construction of one additional groin, modification of seven groins, reimburse the state for recent construction of 14 groins, maintenance of all groins, and periodic nourishment for the beachfill. Authorized for PED in 1976 and for construction in 1986.

Miscellaneous Report No. 80-9 Beach Changes at Long Beach Island, New Jersey, 1962-73: Coastal Engineering Research Center (CERC) report 1980. This report documents beach changes during the period after the March 1962 storm and during the time of heavy groin construction until 1972.

Beach Erosion Control Report On Cooperative Study (Survey) of the New Jersey Coast - Barnegat Inlet to The Delaware Bay Entrance to the Cape May Canal - 1957. This report eventually became House Document 86-208 detailed above under section II.

State Involvement

The state of New Jersey has been involved in providing technical and financial assistance to its shore towns for decades. The state officially tasked the Department of Environmental Protection, formerly the Department of Conservation and Economic Development, to repair and construct all necessary structures for shore protection in the early 1940's (N.J.S.A. 12:6A-1). An annual appropriation of one million dollars was established and maintained until 1977. Due to the devastation and erosion of the shoreline from frequent severe storms, an additional $30 million was appropriated in 1977. In addition to initiating their own research and construction efforts, the State of New Jersey also cost-shares portions of many Federal projects. Shore protection is currently handled by the NJDEP Division of Natural and Historic Resources, Engineering and Construction Element.

The issue of providing stable funding for shore protection at the state level had been raised on several occasions. Two major storms during the winter of 1991-92 prompted a Governor's Shore Protection Summit in February of 1992. As a result, the Shore Protection and Tourism Act of 1992 was passed, thereby creating the first stable source of funding for shore protection equaling, at minimum, $15 million annually.

The state of New Jersey has been involved with storm protection along the study area for some time. The state has provided localized beachfill during critical times in the past for nearly every community of Long Beach Island. In 1994-95 New Jersey spent approximately $3.7 million, of which Harvey Cedars contributed nearly $1 million, for a truck hauled beach fill of 525,000 cubic yards placed in Harvey Cedars. In 1997 Long Beach Township spent approximately $300,000 for truck hauled beach fill of 40,000 cubic yards and related work, placed in the community known as Brant Beach. In 1998 LBT spent over $500,000 in response to the 17 Northeasters that struck the island. The State has records of fills dating back to 1954. See Table 1-2 for a listing of fill locations and quantities performed by the state of New Jersey. New Jersey also played a major role in the completion of the groin field for LBI performed under the Accelerated Public Works program.

A performance account for the Harvey Cedar project can be found in the Final Report on Beach Nourishment Performance at Harvey Cedars, Ocean County, New Jersey, September 1994 to March 1996, Farrell, Speer, Hafner, Lepp. A final nourishment value of 520,000 cubic yards of sand was spread from the toe of the dune, across the beach, out to the limit of low tide.

TABLE 1-2

Beach Fills on LBI by State of New Jersey (1)

DATE	QUANTIT	LOCATION
04-54	114,693	Harvey Cedars
05-56	182,018	Ship Bottom
05-56	115,000	Brant Beach (LBT)
05-58	149,000	Harvey Cedars
08-58	75,000	Unknown
06-61	58,000	Harvey Cedars
07-61	72,498	Brant Beach (LBT)
07-61	60,000	Harvey Cedars
08-62	88,503	Barnegat Light
09-62	235,252	Harvey Cedars
09-62	79,348	Loveladies (LBT)
10-62	353,046	Harvey Cedars
10-62	216,619	Brant Beach (LBT)
11-62	224,382	Long Beach
12-62	92,371	North Beach (LBT)
01-63	260,000	Beach Haven
02-63	363,482	Ship Bottom
02-63	300,000	North Beach (LBT)
03-63	542,276	Surf City
03-63	397,818	Long Beach
06-63	181,376	Long Beach
07-63	150,470	Long Beach
01-92	183,000	Loveladies Fed/State
08-78	1,000,000	Loveladies/Harvey
05-95	525,000	Harvey Cedars

2. BASELINE EXISTING CONDITIONS.

2.1 SOCIO-ECONOMIC RESOURCES.

General: The purpose of the economic study is to investigate the potential financial impacts that may result due to the effects of hurricane and storms damages for the study area and evaluate the net benefits associated with potential project solutions. The study area is located in Ocean County, New Jersey and extends approximately 20 miles from Barnegat Inlet to Little Egg Inlet. The two inlets confine the mid-Atlantic barrier-island known as Long Beach Island. This island has 18 miles of developed shoreline and is subject to extensive storm damage as evidenced by major storms that occurred in 1944, 1962, 1984, 1985, 1991, January and December of 1992 and a battery of Northeasters in 1996 and 1997.

Economic Area: Ocean County is located in the Atlantic Coastal Plain in central New Jersey. Ocean County is one of four New Jersey counties with an Atlantic Ocean coastline. It is the second largest county in the state in terms of size, with a land area of approximately 636 square miles. The county has 45 miles of oceanfront and more than 150 miles of bay and estuaries. Toms River, in Dover Township, serves as the County Seat and is centrally located within Ocean County. The County lies on the periphery of two of the nations largest metropolitan centers. New York City is located approximately 60 miles to the north and Philadelphia lies 50 miles to the west from the County seat.

The County was created from lands divided from Monmouth County in 1850. For much of its early history, the County was a rural, agricultural and fishing center. During the latter part of the 1800's and through the 1900's, the resort industry of the New Jersey Shore was developed, and the commercial activities associated with the seasonal resorts quickly became the County's major economic base.

Ocean and Monmouth Counties, together, constitute a Primary Metropolitan Statistical Area (PMSA). It is one of the 336 metropolitan statistical areas recognized by the Office of Management and Budget (OMB) for federal statistical purposes. These defined areas are part of an economic nodal area that serves as a center of economic activity. The Bureau of Economic Analysis (BEA) defines functional nodal areas. In all BEA has identified 183 such centers. Commuting patterns are a major factor used in determining the economic relationship among counties. The Monmouth-Ocean, New Jersey PMSA is part of the New York, New York BEA Economic Area. This metropolitan region consists of southern Connecticut, southeastern New York State, and Northeastern New Jersey.

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Jersey PMSA is part of the New York, New York BEA Economic Area. This metropolitan region consists of southern Connecticut, southeastern New York State, and Northeastern New Jersey.

Major roads crossed in the Monmouth-Ocean PMSA are the Garden State Parkway, U.S. Highway 9, and Interstate 195. As per 1988 New Jersey Facts listing, Ocean County had a total of 2,368 public road mileage of which nine were Interstate mileage, 135 State highway, 559 County road, 1,629 Municipal road, and 36 other mileage. At the start of 1995, according to the New Jersey Department of Transportation, Bureau of Transportation Data Development, Ocean County had a total of 2,742 miles of roadway, a total increase of over 370 miles. The breakdown is as follows: 126 State highway, 620 County road, 1,958 Municipal road, and 38 Garden State Parkway miles.

Regional Population, Personal Income and Earning: Table 2-A displays "Population, Personal Income, and Earnings, 1973-1988 and Projected 1995-2040 and "Employment by Place of Work" (for the same time frame) for the New York, New York BEA area. It also displays all of the MSA's and PMSA's that are part of those economic defined areas. The population for the area is expected to steadily increase, by about 10% from 1995 to 2040. Per Capita income is expected to increase by about 40% and earnings by about 42%. Employment is expected to increase from about 11.1 million in 1995 to about 11.8 million in 2010 then to decrease by about 2.2% from the 1995 level in 2040. Most of this decline is attributed to manufacturing. Productivity gains in that sector will result in more earnings with fewer people.

Table 2-B displays the same for the Monmouth-Ocean PMSA. The population for this area is 5.5% of the BEA population. It is expected to increase by 23% from 1995 to 2040, at a higher rate than the BEA area. Per Capita income is expected to increase by about 34% and earnings by about 57%. Employment for the PMSA is about 4.3% of the BEA area. It is expected to increase from about 474,000 in 1995 to about 540,000 in 2010, then decrease to 522,000 in 2040, and a net increase of about 10% from the 1995 level. Though employment for manufacturing is expected to drop by about the same magnitude in both areas for 1995 to 2040, the service industry in the PMSA population is expected to increase by about 22%, while the BEA by only about 7%.

Local Development and Population: Development in Ocean County has traditionally focused along the coastal beaches and in urban and suburban concentrations in the corridor formed by the Garden State Parkway and U.S. Routes 9. Inland areas west of the Garden State Parkway are for the most part sparsely developed with large tracts of open space, forested and agricultural lands. Generally, development has occurred in the north-south direction along the Parkway and Route 9 Corridor. In addition, major interchanges along the Garden State Parkway have encouraged secondary east-west growth corridors. These include Routes 526 and 528 from Brick Township to Lakewood Township, Route 37 from Dover Township to Manchester Township and Lakehurst Borough and Route 72 in Stafford Township. I-95, which traverses the northern portion of the county, is emerging as a major east-west corridor as well.

The population in Ocean County according to the 1990 census count was about 433,000. In each of the last four decades, the county has led the state in population growth. In the ten years since 1980, the County grew by over 25 percent, adding 87,165 new residents. The increase in the population has been predominantly in the northeastern and central regions, and along the barrier islands. Only a small percent of this growth is due to the natural increase of the county's resident population. Most of the increase was attributed to migration from the northern portion of New Jersey.

The permanent population along the Long Beach Island has also experienced historical increases. The long established communities that encompass Long Beach Island (north to south) are Barnegat Light, Harvey Cedars, Surf City, Ship Bottom, Beach Haven Borough, and Long Beach Township. Long Beach Township collectively governs the communities of Loveladies, North Beach, Brant Beach, Holgate, and several other small areas to make up approximately 12 of the 18 miles of developed land. The 1997 (permanent) population of Long Beach Island is approximately 8,900. Long Beach Township with 39% of the inhabitants comprises the largest municipal population of the island. Table 2-1 shows the decennial historical population trend for the municipalities since 1930 and the percent increase in 1996 from that of 1990 and from 1995 to 1997. The population of Long Beach Island fluctuates seasonally, increasing during the summer season. According to the Ocean County Planning Board the ratio of the seasonal population to the permanent population for the coastal beach communities in Long Beach Island, per count available for the 1980's has been estimated to be 10:1.

TABLE 2-A

BEA REGIONAL PROJECTIONS TO 2040

New York, NY [BEA Economic Area 012]

Population, Personal Income, and Earnings, 1973–1988, and Projected, 1995–2040

	1973[1]	1979	1983	1988	1995	2000	2005	2010	2020	2040
Population as of July 1 (thousands)	18,443	17,931	18,108	18,513	19,157	19,528	19,886	20,249	20,873	21,101
Per capita personal income (1982 dollars)	12,907	13,483	14,587	17,687	19,182	20,246	21,113	21,866	23,125	26,799
	Millions of 1982 dollars									
Total personal income (place of residence)	238,051.3	241,763.2	264,137.1	327,426.2	367,472.5	395,368.7	419,868.2	442,763.5	482,678.7	565,486.4
By place of work										
Total earnings[3]	182,235.0	178,671.1	190,308.0	245,388.7	275,171.6	296,599.3	314,737.0	329,984.3	347,876.9	390,691.2
Farm	276.0	243.9	242.2	290.8	273.7	276.0	277.1	277.8	275.1	282.4
Nonfarm	181,959.0	178,427.2	190,065.8	245,097.9	274,897.9	296,323.3	314,459.9	329,706.5	347,601.8	390,408.8
Private	155,176.2	154,213.9	164,882.9	213,884.3	241,878.1	261,739.0	278,582.7	292,751.1	309,532.7	348,948.3
Agricultural services, forestry, fisheries, and other[4]	573.1	572.3	605.2	909.1	1,109.7	1,244.5	1,357.3	1,451.2	1,569.3	1,821.8
Mining	375.7	624.8	(D)	374.8	403.0	426.2	443.3	457.4	471.0	511.7
Construction	9,874.0	7,429.3	8,261.6	13,529.6	14,408.6	15,130.2	15,712.0	16,195.7	16,689.6	18,187.1
Manufacturing	40,879.2	38,898.3	37,161.4	37,879.9	38,787.6	39,920.9	40,876.3	41,773.7	42,551.8	45,656.6
Nondurable goods	21,144.4	19,827.7	19,404.6	20,162.2	20,889.8	21,702.7	22,327.6	22,867.9	23,368.8	25,195.5
Durable goods	19,734.8	19,070.6	17,756.8	17,717.6	17,897.7	18,218.1	18,548.7	18,905.7	19,183.0	20,461.1
Transportation and public utilities	16,060.2	16,425.5	15,886.3	17,324.4	18,906.5	20,051.2	20,950.1	21,745.7	22,616.8	24,947.6
Wholesale trade	14,455.2	15,651.5	(D)	20,379.2	22,368.4	23,772.1	25,101.6	26,343.2	27,815.0	31,316.9
Retail trade	16,877.9	14,982.9	15,097.4	18,751.9	21,186.3	22,987.3	24,459.6	25,635.9	27,022.5	30,367.4
Finance, insurance, and real estate	17,225.0	18,861.8	23,048.3	35,680.3	40,201.7	43,301.1	46,067.8	48,636.5	51,747.7	58,795.5
Services	38,855.7	40,767.4	48,212.6	69,055.3	84,506.4	94,905.7	103,614.7	110,511.8	119,049.1	137,343.9
Government and government enterprises	26,782.8	24,213.3	25,182.9	31,213.6	33,019.7	34,584.3	35,877.2	36,955.4	38,069.1	41,460.4
Federal, civilian	4,650.8	4,551.8	4,458.2	4,683.3	4,853.3	5,014.7	5,144.7	5,251.9	5,337.8	5,698.4
Federal, military	692.7	437.6	496.2	521.0	558.3	586.0	614.0	642.4	702.6	837.5
State and local	21,439.3	19,223.9	20,228.4	26,009.3	27,507.6	28,983.6	30,118.6	31,061.1	32,028.7	34,924.6

Employment by Place of Work, by Industry, 1973–1988, and Projected, 1995–2040

[Thousands of jobs]

	1973[1]	1979	1983	1988	1995	2000	2005	2010	2020	2040
Total employment	8,572.1	8,792.5	9,210.3	10,423.4	11,078.2	11,480.4	11,696.2	11,767.7	11,405.9	10,836.9
Farm	18.2	19.4	19.2	15.9	15.0	14.5	14.0	13.5	12.3	10.6
Nonfarm	8,553.9	8,773.2	9,191.1	10,407.4	11,063.1	11,465.9	11,682.2	11,754.2	11,393.6	10,826.2
Private	7,241.9	7,474.7	7,922.8	9,011.6	9,642.1	10,026.5	10,241.4	10,323.3	10,028.7	9,557.8
Agricultural services, forestry, fisheries, and other[4]	35.1	40.9	50.5	66.3	80.6	89.3	95.4	99.4	100.8	101.6
Mining	8.8	9.8	(D)	13.3	13.4	13.6	13.6	13.5	12.8	11.8
Construction	353.5	293.7	331.2	491.8	504.0	512.1	513.6	510.6	486.9	452.5
Manufacturing	1,765.7	1,646.3	1,488.0	1,358.4	1,304.5	1,282.3	1,254.1	1,225.2	1,141.4	1,028.7
Nondurable goods	943.4	862.2	790.7	730.1	709.6	703.7	691.2	676.6	632.0	571.6
Durable goods	822.3	784.1	697.3	628.3	594.9	578.6	562.9	548.6	509.4	457.1
Transportation and public utilities	571.2	555.7	551.1	597.0	623.3	638.0	642.5	642.2	616.9	579.1
Wholesale trade	545.5	614.3	(D)	699.5	735.4	754.6	768.7	779.0	762.3	733.3
Retail trade	1,205.9	1,230.8	1,284.2	1,450.8	1,557.8	1,632.1	1,672.7	1,686.9	1,640.6	1,568.4
Finance, insurance, and real estate	756.4	805.8	916.1	1,099.8	1,166.4	1,208.9	1,234.3	1,248.8	1,219.1	1,168.3
Services	1,999.7	2,277.5	2,656.5	3,234.7	3,656.6	3,895.6	4,046.5	4,117.7	4,048.0	3,914.2
Government and government enterprises	1,312.0	1,298.5	1,268.3	1,395.8	1,421.0	1,439.3	1,440.9	1,430.9	1,365.0	1,268.4
Federal, civilian	182.7	177.6	169.6	184.2	182.1	181.4	179.2	175.9	164.9	149.4
Federal, military	97.6	72.4	62.2	68.8	68.7	68.7	68.7	68.7	68.7	68.7
State and local	1,031.7	1,048.5	1,036.4	1,142.8	1,170.2	1,189.2	1,193.0	1,186.3	1,131.3	1,050.3

Constituent counties:[5]

Bergen–Passaic, NJ (PMSA–0875)
Bergen, NJ
Passaic, NJ

Bridgeport–Stamford–Norwalk–Danbury, CT (PMSA–1169)
Fairfield, CT

Jersey City, NJ (PMSA–3640)
Hudson, NJ

Middlesex–Somerset–Hunterdon, NJ (PMSA–5015)
Hunterdon, NJ
Middlesex, NJ
Somerset, NJ

Monmouth–Ocean, NJ (PMSA–5190)
Monmouth, NJ
Ocean, NJ

Nassau–Suffolk, NY (PMSA–5380)
Nassau, NY
Suffolk, NY

New York, NY (PMSA–5600)
Bronx, NY
Kings, NY
New York, NY
Putnam, NY
Queens, NY
Richmond, NY
Rockland, NY
Westchester, NY

Newark, NJ (PMSA–5640)
Essex, NJ
Morris, NJ
Sussex, NJ
Union, NJ

Orange County, NY (PMSA–5950)
Orange, NY

Poughkeepsie, NY (MSA–6460)
Dutchess, NY

Nonmetropolitan portion
Sullivan, NY
Ulster, NY
Pike, PA

TABLE 2-B

BEA REGIONAL PROJECTIONS TO 2040

Monmouth–Ocean, NJ (PMSA–5190)

Population, Personal Income, and Earnings, 1973–1988, and Projected, 1995–2040

	1973[1]	1979	1983	1988	1995	2000	2005	2010	2020	2040
Population as of July 1 (thousands)	750	842	878	969	1,049	1,100	1,146	1,189	1,251	1,295
Per capita personal income (1982 dollars)	11,403	12,625	14,560	17,782	18,962	19,884	20,604	21,186	22,166	25,376
	Millions of 1982 dollars									
Total personal income (place of residence)	8,547.6	10,625.9	12,787.8	17,239.4	19,889.5	21,868.9	23,613.7	25,184.4	27,730.5	32,855.9
By place of work										
Total earnings[3]	4,381.0	4,882.7	5,194.1	7,661.8	8,948.0	9,885.4	10,697.2	11,382.6	12,236.5	14,050.4
Farm	32.6	20.2	23.6	30.5	26.4	25.9	25.4	25.0	24.1	23.9
Nonfarm	4,348.3	4,862.5	5,170.4	7,631.4	8,921.6	9,859.6	10,671.8	11,357.6	12,212.4	14,026.5
Private	3,231.1	3,685.6	3,973.5	6,165.1	7,329.3	8,165.4	8,890.1	9,500.8	10,266.4	11,864.0
Agricultural services, forestry, fisheries, and other[4]	33.6	39.4	36.7	72.4	88.7	99.8	109.2	117.2	127.0	146.6
Mining	15.7	22.8	22.9	13.4	14.9	15.9	16.8	17.5	18.3	20.1
Construction	442.0	376.4	365.6	761.2	805.2	844.6	877.3	905.2	932.8	1,010.7
Manufacturing	550.8	628.2	614.0	680.1	691.1	707.4	721.8	736.0	747.1	797.5
Nondurable goods	260.2	285.1	268.1	288.3	292.4	300.0	305.4	309.9	313.2	334.5
Durable goods	290.6	343.1	345.9	391.8	398.7	407.4	416.4	426.0	434.0	463.0
Transportation and public utilities	235.5	254.1	291.1	533.3	608.6	661.8	706.3	746.0	793.6	896.8
Wholesale trade	114.7	175.9	214.4	388.0	474.6	534.5	590.9	643.3	710.3	832.4
Retail trade	652.4	703.7	713.9	979.5	1,156.8	1,288.2	1,400.2	1,493.2	1,608.7	1,849.3
Finance, insurance, and real estate	195.1	287.4	229.1	404.5	485.0	542.0	591.0	634.7	690.9	811.5
Services	991.1	1,197.7	1,485.9	2,332.9	3,004.6	3,471.3	3,876.6	4,207.8	4,637.9	5,499.2
Government and government enterprises	1,117.2	1,176.9	1,196.9	1,466.3	1,592.3	1,694.1	1,781.6	1,856.7	1,945.9	2,162.5
Federal, civilian	350.3	413.5	414.3	449.5	473.0	494.0	511.6	525.4	540.3	582.6
Federal, military	185.1	76.6	102.7	112.4	121.2	127.6	134.1	140.7	154.4	184.6
State and local	581.9	686.8	679.9	904.3	998.1	1,072.5	1,135.9	1,189.6	1,251.3	1,395.3

Employment by Place of Work, by Industry, 1973–1988, and Projected, 1995–2040

[Thousands of jobs]

	1973[1]	1979	1983	1988	1995	2000	2005	2010	2020	2040
Total employment	255.2	299.1	332.7	424.9	473.8	505.2	526.6	539.6	535.4	521.7
Farm	1.8	2.1	1.8	1.5	1.5	1.4	1.4	1.3	1.2	1.1
Nonfarm	253.4	297.0	330.8	423.4	472.4	503.7	525.3	538.2	534.2	520.7
Private	194.7	234.0	268.5	353.7	399.3	428.3	448.5	460.9	458.9	449.1
Agricultural services, forestry, fisheries, and other[4]	2.5	3.1	3.9	6.3	7.7	8.6	9.3	9.7	9.9	10.0
Mining	.5	.4	.5	.6	.6	.6	.6	.6	.6	.6
Construction	18.8	16.9	18.3	31.2	32.0	32.6	32.9	32.8	31.3	29.0
Manufacturing	29.4	32.0	31.3	30.5	29.1	28.5	27.8	27.1	25.1	22.6
Nondurable goods	14.7	14.7	14.2	13.7	13.4	13.3	13.0	12.8	11.9	10.8
Durable goods	14.7	17.3	17.1	16.8	15.7	15.2	14.7	14.3	13.2	11.8
Transportation and public utilities	10.2	10.7	12.3	20.2	22.3	23.5	24.3	24.8	24.5	23.6
Wholesale trade	6.0	9.9	13.0	17.8	20.7	22.4	23.8	25.0	25.5	25.5
Retail trade	52.6	63.7	69.5	85.6	95.8	102.9	107.6	110.4	109.7	107.0
Finance, insurance, and real estate	14.8	20.9	23.2	33.9	38.3	41.2	43.3	44.8	45.0	44.4
Services	59.8	76.3	96.5	127.7	152.8	167.9	178.9	185.7	187.2	186.4
Government and government enterprises	58.6	63.0	62.3	69.7	73.1	75.5	76.8	77.3	75.3	71.6
Federal, civilian	12.9	13.0	14.2	15.6	15.9	16.2	16.2	16.2	15.4	14.2
Federal, military	13.1	7.1	7.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
State and local	32.7	42.9	40.3	45.2	48.4	50.5	51.8	52.4	51.1	48.6

Constituent counties:

Monmouth, NJ
Ocean, NJ

Footnotes:

(D) Not shown to avoid disclosure of confidential information; estimates are included in higher level totals.
1. Earnings and employment estimates for 1973 are based on the 1967 Standard Industrial Classification (SIC); estimates and projections for all other years are based on the 1972 SIC.
2. Footnote not applicable.
3. Earnings by place of work consists of wage and salary disbursements, other labor income, and proprietor's income.
4. "Other" consists of wages and salaries, or employment, of U.S. residents working for international organizations and foreign embassies and consulates located in the United States.
5. PMSA refers to "Primary Metropolitan Statistical Area."

5

TABLE 2-1
Historical Population Trends in Municipalities on Long Beach Island

Municipality	Incorporation Date	1930	1940	1950	1960	1970	1980	1990	July 1995	July 1996	July 1997	% Change ‘90-‘97
Barnegat Light Borough	1904	144	225	227	287	554	619	675	690	697	701	3.9%
Beach Haven Borough	1890	715	746	1050	1041	1488	1714	1475	1500	1501	1501	1.8%
Harvey Cedars Borough	1894	53	74	106	134	314	363	362	380	382	382	5.5%
	1899	355	425	840	1561	2910	3488	3407	3518	3535	3538	3.8%
Ship Bottom Borough	1925	277	396	533	717	1079	1427	1352	1358	1361	1364	0.9%
Surf City Borough	1884	76	129	291	419	1129	1571	1375	1409	1413	1420	3.3%
Total		1620	1995	3047	4159	7474	9182	8646	8855	8889	8906	3.0%

Sources:
1) 1990 Census of Population and Housing, Historical Population Counts and STF-1A
Ocean County Historical Survey, 1991
2) Ocean County Planning Department

Acreage and Population Density for LBI: Table 2-2 shows the square mileage, acreage, ocean front mileage, bay front mileage, and population densities for the six municipalities of LBI. The total incorporated municipalities are 7.91 square miles, or 5,062 acres with about 20.6 miles of ocean frontage and 37.2 miles of bay frontage. The population density for the incorporated municipalities of LBI is 1,126 per square mile.

Other than the municipalities mentioned above there are also major State and Federal land holdings on Long Beach Island. Barnegat Inlet State Park, about 32 acres, managed by New Jersey Parks and Forestry bounds the north end of the island and borders Barnegat Inlet. The Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge, nearly two miles of undeveloped beach, forms the southern tip of the island and borders Beach Haven Inlet. The U.S. Department of Interior; Fish and Wildlife Service manages the refuge.

Tourism: Tourists dollars contribute directly and indirectly to the regional economy. In 1997, the New Jersey Travel Research Program reported that travel and tourism generated about 400,000 jobs in the state with a total payroll of $6.7 billion, and $2.2 billion in state and local taxes. Tourism and recreation data for Ocean County was extracted from the New Jersey Travel Research Program, 1997 Travel Year, conducted by the Center for Survey and Marketing Research/ Longwoods International. Table 2-3 displays the total expenditure by county and the number of jobs generated by travel and tourism.

Travel and tourism expenditures in Ocean County totaled $1.73 billion in 1997, up from $1.65 billion in 1996. As a result, the county ranked 3rd in New Jersey in terms of the dollars spent by travelers, up from 7th in 1993. This figure includes money spent by both day and overnight visitors, and those renting shore cottages. For 1994, shore cottage rentals accounted for 14% of all expenditures in Ocean County, for a total of nearly $179 million. Shore rentals include only those registered with realtors and cover just the 10-week summer high season. This figure is estimated to capture between 75% and 95% of the total.

The total figure of $1.65 billion breaks down as follows: restaurant meals, $509 million; retail, $505 million; lodging, $262 million; automobile expenses, $230 million; recreational activities, $132 million, and local transportation, $10 million. Tourism in the county, including shore rentals, generated almost about 40,000 jobs with a payroll totaling $619 million, making it the 6th largest county in terms of tourism employment. These figures include just those employed directly as a result of tourism. When including the indirect employment that results as tourism expenditures ripple through the economy, these figures rise to about 35,900 jobs with a payroll of almost $504 million.

Ocean County's tourism infrastructure included hotels, motels and resorts with a combined inventory of 4,097 rooms, with an annual occupancy rate of 54.0% (for 1997). There were also 1,166 campsites in the county, which operates an annual occupancy of 47.5%. An estimated 1.6 million travelers stayed overnight in Ocean County in 1994, not including those staying with friends or relatives. These figures include approximately 739,000 visitors from out-of-state. Long Beach Island was the most popular place to visit for overnight travelers in Ocean County, followed by Seaside Heights, the Six Flags Great Adventure theme park and the Pine Barrens.

In addition to providing employment in Ocean County itself, the county's travel and tourism industry in 1994 also generated significant state taxes: a total of over $75 million attributable directly to tourism and $131 million when direct impacts are considered. Local taxes attributable to indirect tourism impacts totaled over $58 million. These figures include taxes generated by shore rentals.

TABLE 2-2

Acreage and Population Density for Long Beach Island

Municipality	Square Miles	Acres	Ocean Frontage	Bay Frontage	Population Density
Barnegat Light Borough	0.70	448	2.14	8.00	970.06
Beach Haven Borough	1.00	640	1.92	2.61	1,531.61
Harvey Cedars Borough	0.55	352	2.02	3.72	692.74
Long Beach Township	4.30	2,752	11.74	18.64	666.07
Ship Bottom Borough	0.71	454	1.33	2.15	1,965.30
Surf City Borough	0.65	416	1.43	2.12	1,960.81
TOTAL	7.91	5,062	20.58	37.24	1,126.00(AVG.)

Ocean County Planning Department

TABLE 2-3

STATE OF NEW JERSEY TOURISM EXPENDITURE
1997 TRAVEL YEAR
Ranking by Expenditure

County	$ Billion	Employment (000's of jobs)
Atlantic	8.24	124.1
Cape May	2.32	38.8
Ocean	1.73	53.2
Monmouth	1.68	45.2
Bergen	1.62	52.2
Middlesex	1.29	42.6
Essex	1.33	42.3
Morris	1.15	32.2
Hudson	0.81	26.2
Union	0.82	24.8
Burlington	0.81	20.9
Camden	0.76	25.9
Mercer	0.82	24.0
Somerset	0.61	17.8
Passaic	0.42	16.1
Sussex	0.28	7.7
Gloucester	0.25	10.5
Hunterdon	0.15	4.9
Cumberland	0.14	5.5
Warren	0.14	4.6
Salem	0.09	3.4

SOURCE: New Jersey Travel Research Program
Center for Survey and Marketing Research
Longwood International

A 1994 report on coastal water quality issued by the National Resources Defense Council, headquartered in Washington, D.C., stated that New Jersey's 127 miles of sandy beach ranked third nationally both in coastal revenue and beach quality. Ocean water quality is a primary focus of the report. The states clean coastal environment has helped turn tourism into a $13 billion industry.

As part of the New Jersey coastline, Long Beach Island plays an important role in generating part of New Jersey's 79.6 billion coastal annual dollars. Roughly half of the entire state's economy is generated through fishing, boating, restaurants and all activities related to the coast. In New Jersey, $164.5 million is spent annually on boating and equipment. The seafood industry generates $96.3 million annually with recreational fishing bringing in $649 million a year. These figures are from the state Commerce and Economic Development Department's 1995 reports.

Local Business and Employment: There is a broad spectrum of industry in Ocean County. They include agriculture, construction, transportation, wholesale trade, retail trade, finance, insurance, and real estate, and services. According to 1995 data, industries employing over 4,000 people are Health Care Services (18,259), Eating and Drinking Places (9,076), Food Stores (6,581), and Amusement and Recreational Services (4,951). Industries with more than 400 businesses are Special Trade Contractor's (982), Health Services (849), Eating and Drinking Places (717), and General Building Contractors (481).

From 1990 to 1994, the number of jobs within Ocean County increased by 7.8%, to 121,900 jobs. This increase was the second highest growth rate in New Jersey. Employment projections by the New Jersey Department of Labor show Ocean County as one of the fastest growing employment areas of the State. Job growth within the county is projected to increase by 27,000 jobs, or 22.5%, from 1994 to 2005. Growth will continue primarily in the service occupations and professional and technical field.

Table 2-4 shows the labor force and unemployment rate for the municipalities on Long Beach Island from 1991 to 1996. The average unemployment rate for Long Beach Island was 4.6% for both 1995 and 1996. The county average was 6.2% for both 1995 and 1996; the state average, 6.4% and 6.2%. The U.S. average for 1995 and 1996 was 5.6% and 5.4% respectively. In accordance with Economic Guidance, "Areas Eligible for NED Benefits from employment of Previously Unemployed Labor Resources for Fiscal Year 1997", Ocean County does not qualify as an area of "substantial and persistent unemployment".

Structure Occupancy in Long Beach Island: The communities of Long Beach Island have structure units that are occupied seasonally and those that are occupied year round. Table 2-5 displays the total units from 1990 and the change from 1980. The total units of the island have increased from 16,624 in 1980 to 18,279 in 1990, or about 10%. Occupied units increased from 4,062 units in 1980 to 4,136, about a 2% increase in 1990. Under a third of the structures per the 1990 census are occupied year round. Housing units that are actually occupied are referred to as households. Households are classified as married couple families, single persons, non-families, and other families. The first three classifications are self explanatory; Non-families includes two or more unrelated householders living together; other families refer to two or more householders related by blood, without children.

Table 2-6 shows ownership status of occupied housing structures by units for the municipalities of Long Beach Island for both owner occupied and renter occupied units. Detached units are the most prevalent housing units on the island comprising about three-quarters of the structures. Table 2-7 displays the median value of specified owner occupied housing units in Long Beach Island by classified value ranges and municipality. The County median value for owner occupied housing units for 1990 was $126,000. The median owner occupied values of housing units for the six municipalities on LBI range from $198,700 to $317,300, 1.6 to 2.5 times above the County median. Table 2-8 displays the contract rent (monthly) of specified renter occupied units for Long Beach Island by $250 dollar classification ranges. About one half of the structures are in the $500 to $749 rental range. About 2% are above the $1,000 range.

Household sizes are calculated by dividing the number of persons in households by the number of households. Table 2-9 displays the persons per household for Long Beach Island. The person per households′ ratio has decreased for each of the boroughs and township from 1980 to 1990. The average person to household ratio decreased from 2.26 as per the 1980 census to 2.08 for 1990. The Ocean County averages for the same period declined from 2.67 to 2.54. Table 2-10 displays the median household, median family, and per capita income for the municipalities of Long Beach Island from the 1990 Census. Per Capita for the six municipalities ranged from $15,907 to $25,973. On a per capita basis all the municipalities show a higher per capita than the county's' per capita average of $15,598.

TABLE 2-4

Municipal Labor Force Estimates for Long Beach Island and Ocean County

		Labor Force							Employment					
Municipality		1991	1992	1993	1994	1995	1996		1991	1992	1993	1994	1995	1996
		365	308	309	313	324	333		335	304	305	310	321	330
		944	734	725	735	756	777		852	666	668	680	704	724
		238	173	171	173	177	183		217	154	155	158	163	168
		1,905	1,662	1,652	1,676	1,729	1,777		1,723	1,565	1,571	1,598	1,655	1,702
		869	636	630	638	658	676		802	588	590	600	622	639
		913	600	598	607	628	646		816	578	580	590	611	629
Total for Long Beach Island		5,234	4,113	4,085	4,142	4,272	4,392		4,745	3,855	3,869	3,936	4,076	4,192
Total for Ocean County		186,248	194,878	192,742	195,254	201,143	206,724		172,404	178,377	179,054	182,095	188,633	193,996

		Unemployment							Employment					
Municipality		1991	1992	1993	1994	1995	1996		1991	1992	1993	1994	1995	1996
		30	4	4	3	3	3		8.2%	1.3%	1.3%	1.0%	0.9%	0.9%
		92	68	57	55	52	53		9.7%	9.3%	7.9%	7.5%	6.9%	6.8%
		21	19	16	15	14	15		8.8%	11.0%	9.4%	8.7%	7.9%	8.2%
		182	97	81	78	74	75		9.6%	5.8%	4.9%	4.7%	4.3%	4.2%
		67	48	40	38	36	37		7.7%	7.5%	6.3%	6.0%	5.5%	5.5%
		97	22	18	17	17	17		10.6%	3.7%	3.0%	2.8%	2.7%	2.6%
Total for Long Beach Island		489	258	216	206	196	200		9.3%	6.3%	5.3%	5.0%	4.6%	4.6%
Total for Ocean County		13,844	16,501	13,688	13,159	12,510	12,728		7.4%	8.5%	7.1%	6.7%	6.2%	6.2%

NJ Department of Labor, State Data Center, Office of Demographic and Economic Analysis Bureau of Labor Force Statistics, Local Area Unemployment Statistics, 1993

TABLE 2-5

Comparison of Total and Occupied Housing Units, 1980 and 1990

		Total Units	
Municipality	**1980**	**1990**	**Change**
Barnegat Light Borough	1084	1187	8.7%
Beach Haven Borough	2379	2569	7.4%
Harvey Cedars Borough	1194	1121	-6.5%
Long Beach Township	7836	8836	11.3%
Ship Bottom Borough	1781	2084	14.5%
Surf City Borough	2350	2482	5.3%

		Occupied Units	
	1980	1990	Change
Barnegat Light Borough	260	330	21.2%
Beach Haven Borough	789	659	-19.7%
Harvey Cedars Borough	166	176	5.7%
Long Beach Township	1530	1661	7.9%
Ship Bottom Borough	608	649	6.3%
Surf City Borough	709	661	-7.3%

		Percent Occupied (Year Round Only)	
		1980	1990
Barnegat Light Borough		24.0%	27.8%
Beach Haven Borough		33.2%	25.7%
Harvey Cedars Borough		13.9%	15.7%
Long Beach Township		19.5%	18.8%
Ship Bottom Borough		34.1%	31.1%
Surf City Borough		30.2%	26.6%

1990 Census of Population and Housing, STF-1A (Profile 1)

TABLE 2-6

Occupied Housing Units by Ownership Status and Number of Units in Structure

Municipality	Detached Units	One unit (Attached)	Two Units	3-4 Units	5+ Units	Mobl. Home or Trailer
	Owner Occupied					
Barnegat Light Borough	233	1	29	1	4	0
Beach Haven Borough	402	20	46	10	8	1
Harvey Cedars Borough	121	4	18	0	0	0
Long Beach Township	1,172	15	163	6	0	6
Ship Bottom Borough	406	9	51	5	3	0
Surf City Borough	400	7	84	1	2	0
Total	2,734	56	391	23	17	7
	Renter Occupied					
	Detached Units	One Unit (Attached)	Two Units	3-4 Units	5+ Units	Mobl. Home or Trailer
Barnegat Light Borough	37	6	14	1	0	0
Beach Haven Borough	66	8	41	28	10	0
Harvey Cedars Borough	22	1	4	3	1	0
Long Beach Township	119	4	117	22	3	1
Ship Bottom Borough	56	3	81	14	8	0
Surf City Borough	50	0	100	2	0	0
Total	350	22	357	70	22	1

Source: 1990 Census of population and Housing, STF-1A (Profile 8).

TABLE 2-7

Value of Specified Owner Occupied Housing Units in Long Beach Island

Municipality	Total Units	Less than $50,000	$50,000 to $99,000	$100,000 to $149,999	$150,000 to $199,999	$200,000 to $299,999	$300,000 or more	Median
Barnegat Light Borough	206	1	2	8	24	105	66	$258,000
Beach Haven Borough	395	1	18	45	69	141	121	$236,200
Harvey Cedars Borough	119	0	0	4	7	44	64	$317,300
Long Beach Township	1,113	4	9	74	211	422	393	$254,100
Ship Bottom Borough	391	2	12	58	127	139	53	$198,700
Surf City Borough	384	4	13	39	113	159	56	$210,500
Total for specified units	2,608	12	54	228	551	1,010	753	

Source: 1990 Census of Population and Housing, STF-1A (Profile 7).

TABLE 2-8

Contract Rent of Specified Renter Occupied Housing Units in Long Beach Island, 1990

Municipality	Rental units with cash rent	Less than $150	$250 to $499	$500 to $749	$750 to $999	$1,000 or more
Barnegat Light Borough	44	2	9	28	5	0
Beach Haven Borough	131	8	61	54	6	2
Harvey Cedars Borough	23	2	8	13	0	0
Long Beach Township	244	8	106	110	12	8
Ship Bottom Borough	159	14	56	81	5	3
Surf City Borough	138	10	41	80	7	0
Total for Specified units	739	44	281	366	35	13

Source: **1990 Census of Population and Housing, STF-1A (Profile 7).**

TABLE 2-9

Changes in Persons per Household, 1980 and 1990

		1990 Census		
Municipality	**Total Units**	**Occupied Units**	**Persons**	**Persons/ Household**
Barnegat Light Borough	**1,187**	**330**	**657**	**1.99**
Beach Haven Borough	**2,569**	**659**	**1,460**	**2.22**
Harvey Cedars Borough	**1,121**	**176**	**362**	**2.06**
Long Beach Township	**8,836**	**1,661**	**3,407**	**2.05**
Ship Bottom Township	**2,084**	**649**	**1,352**	**2.08**
Surf City Borough	**2,482**	**661**	**1,375**	**2.08**
Total	**18,279**	**4,136**	**8,613**	**2.08**
			1980 Census	
Municipality	**Total Units**	**Occupied Units**	**Persons**	**Persons/ Household**
Barnegat Light Borough	**1,084**	**260**	**604**	**2.32**
Beach Haven Borough	**2,379**	**789**	**1,799**	**2.28**
Harvey Cedars Borough	**1,194**	**166**	**365**	**2.20**
Long Beach Township	**7,836**	**1,530**	**3,416**	**2.23**
Ship Bottom Township	**1,781**	**608**	**1,430**	**2.35**
Surf City Borough	**2,350**	**709**	**1,569**	**2.21**
Total	**16,624**	**4,062**	**9,183**	**2.26**

Source: 1990 Census of Population and Housing.

TABLE 2-10

1990 Census Income Characteristics for Long Beach Island

Municipality	Median Household	Median Family	Per Capita	Percent Below Poverty Level All Persons	Persons 65+
Barnegat Light Borough	$37,955	$44,643	$25,973	7.23%	
Beach Haven Borough	$31,371	$41,458	$18,527	3.57%	
Harvey Cedars Borough	$35,781	$42,143	$21,482	5.62%	
Long Beach Township	$31,775	$41,453	$21,545	4.49%	
Ship Bottom Township	$29,205	$35,268	$17,782	8.62%	
Surf City Township	$28,009	$34,861	$15,907	7.49%	
Ocean County	$33,110	$39,797	$15,598	6.00%	

Source: 1990 Census, Census of Population and Housing, STF-3, 1990 CPH-L-81, Table 3 (Income in 1989)

2.2 ENVIRONMENTAL STUDIES

Affected Environment

Background Information: Two inlets enclose the study area situated along the mid-Atlantic coast of New Jersey, Barnegat Inlet and Little Egg Inlet. The two inlets enclose the barrier-island known as Long Beach Island. Barnegat Inlet State Park encloses the northern end of the island and the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge forms the southern tip, bordering the community of Holgate, a section of Long Beach Township. The land use/cover type for the project area would be described as urban, range herbaceous, range shrub, range mix, beach/dune, and wetland non-forest.

The general coastal environment is typical of coastal barrier-island and trapped bay conditions. The barrier-island complex consists of a long, narrow barrier-island (Long Beach Island) of low elevation separated from a barrier spit (Island Beach) of similar relief by a tidal inlet (Barnegat Inlet). This type of complex is a common feature along coastal plains with a gentle slope and a tidal range of less than 4 meters. The islands are faced with sandy beaches and upland dunes, which help to shield the barrier-island complex. Long Beach Island is characterized by urban development, however the bay edges are frequently guarded by tidal wetlands. Seashore and water-oriented summer recreation is the predominant land-use including residential rentals and support services for commercial establishments.

The New Jersey coastline including Long Beach Island has a long history of severe erosion subjecting the shoreline to storm damage from wave attack and tidal inundation. Along the shoreline, there are a total of 99 visible groin structures spaced at intervals that range from 750 to 1000 feet. The groins are constructed of timber, stone, or a combination of the two.

The Barnegat Bay, a 75-square-mile estuary, is a crucial link in the Atlantic flyway for migratory waterfowl. These wetlands serve as the winter grounds for 35% of the total flyway's population of black duck (*Anas rubripes*), and 70% of the flyway's American brant (*Branta bernicla*) population. Furthermore, the bay itself is important nesting, feeding, and migratory habitat for 287 other species of waterfowl and birds. The Barnegat Bay system, including the estuary as well as its contiguous streams and adjacent wetlands, provides nursery grounds for many coastal fish populations and supports large recreational and commercial fisheries for fin and shellfish. These resources comprise the centerpiece of a thriving tourist industry and as such, are critical to the economic, as well as environmental health of southern New Jersey.

Climate: The climate of the coastal study area is generally referred to as continental, characterized by cold winters and moderately hot summers. The mean temperature during the summer months varies between the mid 60's to the mid 70's, making this area an ideal resort for escape from the oppressive heat and humidity often experienced in the nearby inland suburban and urban centers. Air masses change frequently during the spring and fall. Summer weather patterns are influenced by maritime tropical air masses, in which high-pressure systems dominate and remain stable for several days at a time. Weather systems in the winter are generally more intense because of rapidly moving fronts and continental, polar air masses. The average annual temperature ranges between 86 ^{0}F in July to 24 ^{0}F in January with a mean of 55 ^{0}F.

Precipitation, about 45 inches annually, is well distributed throughout the year, with generally more that three inches reported every month. The driest month is October, with rainfall varying between 2.5 and 3.0 inches. Temporary droughts or periods of subnormal rainfall are not uncommon for the area.

Water Quality: Measuring levels of the following generally indicates water quality: nutrients (nitrogen/phosphorus), pathogens, floatable wastes, and toxins. Rainfall is an important parameter for studying water quality; runoff leads to non-point source pollution and fresh water (rainfall, ground water seepage, runoff, and river discharge) can ultimately affect hydrodynamic circulation in the ocean. Total and fecal coliform bacteria are used as indicators for pathogens in measuring water quality. When the fecal coliform level exceeds state criteria (i.e. greater than 200 per 100 ml of water) for two consecutive water samples taken 24 hours apart, beach closures may result. From 1988 to 1997 there were no ocean beach closings at any beach on Long Beach Island due to high levels of fecal coliform (Loftin, 1997). In 1987 there was a discretionary closing from Point Pleasant through Long Beach Island during the last part of May. This was due to extensive wash-up of floatable debris including plastics, grease coated organic particles and decomposing remnants of a major algal bloom.

Water quality in Barnegat Inlet, the Atlantic Ocean, and other surface waters in the study area are generally good. Exceptions are occasional waste discharges or offshore oil spills. Intentional overboard discharge of solid waste and sewage from recreational boats may degrade water quality in the Bay. The discharge of this contamination makes water unsanitary for swimming and may cause closure of shellfish beds. The state of New Jersey has classified the water along the ocean side of Long Beach Island as approved for the harvest of oysters, clams and mussels, except for one mile of beach off of Surf City that is rated prohibited. It is expected that the primary cause of non-point source pollution be related to development on land and/or the activities that result from land development. Sources might include run-off of petroleum products, fertilizers and animal wastes from roadways and lawns. When it is generated on land, such non-point source pollution is carried by rainwater, which can drain to surface or ground water and ultimately reach the ocean.

a. **Beach Closures and Water Quality Monitoring**. The New Jersey Department of Environmental Protection′s Office of Enforcement Coordination has documented beach closures for both the ocean and bay side beaches of New Jersey from 1987. Documenting and monitoring was established in response to two major incidents in 1987.

b. In late May 1987, a noxious brown algae (*Nannocloris atomus*) forced the closing of about 35 miles of beaches, from Central Ocean County to Atlantic City. It has been speculated that the algae bloom probably occurred because of excessive loading of nutrient-laden sewage.

c. On August 14, 1987, a 50 mile-long slick of garbage and debris, including hazardous hospital waste inundated 30 miles of New Jersey beaches from Point Pleasant to Holgate. The beaches in the area were forced to close for up to three days at the height of the tourist season causing significant economic losses. Seventeen coastal communities were eventually affected by the pollution. The New Jersey Chamber of Commerce reported that these and other pollution incidents caused business losses in the range of 10-40%. The source of the slick is still unknown.

d. These and other previous incidents led to the inclusion of coastal water quality investigations in the New Jersey Shore Protection Study resolutions by the House of Representatives and the Senate in December of 1987. Public outcry prompted the American Shore and Beach Preservation Association meeting on August 20, 1987, a mass beach protest on September 5, 1987 and extensive and continuous media coverage.

e. In the summer of 1993, the nearshore coastal waters off of New Jersey had greater water clarity and fewer floatables than in previous years. The NJDEP and USEPA observed water of increased clarity from Sandy Hook to Cape May Point for most of the summer. The natural force attributed to water clarity included lack of rainfall (71% of normal) and more westerly winds than usual throughout the summer.

f. The Cooperative Coastal Monitoring Program (CCMP) is an organization developed between the New Jersey Department of Environmental Protection (NJDEP), the New Jersey Department of Health (DOH) and local health agencies. For the purposes of this study, the local participants are the Ocean County and Long Beach Township health departments. Under the Cooperative Coastal Monitoring Program administered by the NJDEP, the local County Health Departments enforce the County Environmental Health Act (N.J.A.C. 7:18) through procedures set forth in the New Jersey Sanitary Code, Chapter IX Public Recreation Bathing N.J.A.C. 8:26-1 et. seq. June 1988. These regulations govern microbiological water quality standards, using the fecal coliform count sampling. To determine whether coastal waters are suitable for bathing, the CCMP compares concentrations of fecal coliform bacteria against NJDEP surface water quality standards established in N.J.A.C. 7:9-4.1.

g. Under the CCMP the local municipal health agencies select the locations for the monitoring stations in consultation with the DEP and the DOH. Testing stations are located where they can best evaluate ambient water quality at recreational beaches. Local municipal health agencies conduct weekly sampling of coastal waters during the beach season, under agreement with the NJDEP. If both the preliminary and the confirming sample from a recreational station exceed the primary contact standard, DOH standards require the health agency to close the waters of the associated recreational beach to primary activities such as swimming and wading, N.J.A.C. 8:26-8.8.

h. or recreational beaches, the health agency also surveys the area visually and collects additional samples ("bracket samples") at either side of the station to determine the extent of the pollution and possible pollution sources. The results of the bracket samples determine the extent of the closing along the shore and the number of beaches closed.

i. New Jersey′s state water quality standards and beach testing program are considered to be the most rigorous in the United States. Under State standards, a 100-millimeter sample-about 4 ounces of water drawn from any swimming area- must contain no more than 200 colonies of fecal coliform bacteria. Two consecutive samples are taken 24 hours apart, and if the samples contain over 200 colonies, beach closures may result.

j. Coliform bacteria are not harmful in themselves, but it is an indicator of possible pollution because the bacteria come from the intestinal tracts of warm-blooded animals. The presence of coliform show that other disease-causing bacteria may also be present.

k. Elevated total and fecal coliform counts along the coast of New Jersey may result from failing septic tanks, waste water treatment plant discharges, combined sewer overflows, storm water drainage, runoff from developed areas, domestic animals, wildlife and sewage discharge from boats.

l. Point source discharges from coastal wastewater treatment facilities can affect water quality at bathing beaches. Accordingly, the NJDEP routinely monitors the treatment of effluent at these facilities, to ensure that they operate in accordance with the requirements of their permits.

m. Individual Boroughs provided sewage treatment for Long Beach Island in the past. The treatment stations were abandoned and/or turned into lift stations when the island consolidated systems under the Ocean County Utilities Authority. There are approximately eight pump stations, seven monitoring stations and three abandoned treatment stations located on the island. Sewage is pumped off the island and treated on the mainland. After treatment, the effluent is pumped from the treatment station on the mainland back to the island. The effluent connects to an outfall extending one mile into the Atlantic Ocean off 5^{th} Street in Ship Bottom. The Ocean County Utilities Authority operates these pipes and the outfall. In addition, there are approximately six-abandoned sanitary sewer outfalls varying in size from 12 in. to 24 in. the location of which can be seen under the Existing Utilities Section of this report.

n. Statewide, bacteria-related closings of ocean beaches decreased from 1988 through 1991 and increased in 1992 and 1993. These closings are generally attributable to storm water discharges rather than discharges from waste water treatment facilities. No wastewater treatment facilities discharge directly to barrier island or Back Bay waters, although freshwater systems that input to the bays may receive these discharges. Storm water can be contaminated during overland flow during rainfalls and during transport through underground conveyance systems before being discharged into a waterway. Within the study area storm water runoff is independent of the sewage system; it is handled individually by each borough and exits to the bay via underground drainage pipes.

Beach and Dune Habitat: Beaches and dunes are linked together to form the "littoral active zone". Even though there is active sand exchange occurring between them, the two systems are quite distinct. The beach/surf zone being a marine, wave-driven system, and the dune field a primarily wind-driven terrestrial ecosystem. Coastal dune fauna is generally not indigenous but display high diversity, while the floral species are typically unique to the area with moderate diversity.

Some common flora to expect on the beach and dune areas of the barrier-island system include, American beach grass (*Ammophila breviligulata*.), sea-rocket (*Cakile edentula*), seaside goldenrod (*Solidago sempervirens*), poison ivy (*Toxicodendron radicans*), bay berry (*Myrica pensylvanica*), groundsel-bush (*Baccharis halimifolia*), sand myrtle (*Leiophyllum buxifolium*) and marsh elder (*Iva fructescens*).

Intertidal and Nearshore Zone: The organisms inhabiting the beach intertidal zone have evolved special locomotory, respiratory, and morphological adaptations that enable them to survive in this extreme habitat. Most are excellent and rapid burrowers and tolerant to environmental stress. Typical invertebrate infauna would include mole crab (*Emerita talpolida*), haustorid amphipods (*Haustorius* spp.), coquina clam (*Donax variablilis*), and spinoid worm (*Scolelepis squamata*). The epifaunal blue crab (*Callinectes sapidus*), and lady crab (*Ovalipes ocellatus*) are also found in the intertidal zone. These invertebrates are prey to various shore birds and nearshore fishes.

Long Beach Island has groins that represent an artificial rocky intertidal zone. Some typical algae found growing on the groins are sea lettuce (*Ulva lactuca*), hollow green weeds (*Enteromorpha* spp.), rockweeds (*Fucus* spp.), and laver (*Porphyra* spp.). In addition to providing a hard substrate for the attachment of benthic macroalgae, the groins also contain suitable habitat for a number of aquatic and avian species. Typical invertebrates that might be attached to these groins are blue mussel (*Mytilus edulis*), skeleton shrimp (*Caprella* spp.), little gray barnacle (*Chthamalus fragilis*), northern rock barnacle (*Balanus balanoides*), and striped anemone (*Haliplanella luciae*). If the groin is made of wood the following wood boring species might be found: gribbles (*Limnoria tripunctata*), and shipworm (*Teredo navalis*). These structures are also used by various finfish for feeding and shelter.

Offshore Sand Habitat: Four borrow areas have been examined for use (Figure 2-1). Areas B and E are located partially in areas that have been identified, by the New Jersey Department of Environmental Protection, as Prime Fishing Areas, as defined by the Rules on Coastal Zone Management N.J.A.C. 7:7E as amended July 18, 1994 (Figure 2-2). Area D ends at the three nautical mile limit of New Jersey State waters, and could extend outside this limit if greater quantities of sand are required. The community composition of the four LBI borrow areas and the LBI reference area were similar (Versar, 1998). The full benthic evaluation report can be found in the Environmental Appendix. Polychaete worms followed by molluscs and arthropods (specifically crustaceans) dominated the areas. Oligochaete worms also contributed substantially to the faunal composition of the areas. The mean abundance of the top 10 dominant taxa of each borrow area contributed from 69% of the total mean abundance at Area B to more than 88% at Area E (Table 2-11). In general, the dominant polychaetes were small, surface dwelling organisms. The small bristle worm, *Polygordius* spp., was either the first or the second most dominant polychaete in each area (Table 2-11). Other dominant polychaetes included the small capitellid, *Mediomastus ambiseta,* and the small syllid, *Parapionosyllis longicirrata,* (Table 2-11). The dominant crustacean was the very small (<5 mm as an adult) tanaid, *Tanaissus psammophilus* (Table 2-11). The majority of the molluscs were also dominated by the small bivalve′s *Donax variabilis, Petricola pholadiformis,* and *Tellina agilis* (Table 2-11). Another dominant bivalve, the surf clam *Spisula solidissima,* had some clams that reached lengths greater than 2 cm in all four areas (Table 2-11).

TABLE 2-11

Mean abundance ($\#/m^2$) of the 10 most abundant taxa in each LBI borrow area and the LBI reference area.

Taxon	Area A	Area B	Area D	Area E	LBI Reference Area
Nemertinea					
Nemertinea	197.5	56.8	77.8	120.5	161.9
Annelida : Polychaeta					
Aricidea cerrutii	67.4	174.2	98.5	2.3	11.4
Asabellides oculata	471.5	1.3	3.4		34.1
Caulleriella sp. B (Blake)	322.7	5.1	29.6	72.7	39.8
Hesionura elongata	13.6	16.4	124.0	17.1	36.9
Mediomastus ambiseta	766.5	27.8	7.6	2.3	289.8
Annelida : Oligochaeta					
Oligochaeta	401.2	90.9	197.0	252.3	522.7
Mollusca : Bivalvia					
Donax variabilis	186.4	2.5	0.7	235.2	
Petricola pholadiformis	1898.3	159.1	117.1	14.8	761.4
Spisula solidissima	474.8	568.2	183.2	442.0	349.4
Tellina agilis	305.8	79.6	37.9	1.1	519.9
Arthropoda : Tanaidacea					
Tanaissus psammophilus	367.4	334.6	417.4	513.6	250.0
Arthropoda : Isopoda					
Chiridotea coeca	43.0	11.4	6.2	109.1	5.7
Arthropoda : Amphipoda					
Protohaustorius wigleyi	25.2	107.3	31.7	8.0	28.4
Echinodermata : Echinoidea					
Echinoidea	36.4	328.3	424.2	172.7	210.2

Diversity indices, as measured by the Shannon Wiener Index and the Simpson's Dominance Index, indicate a relatively diverse, evenly distributed community structure within the four LBI borrow areas. Shannon Wiener Diversity Index (*H*), which includes a measure of taxa evenness, ranged from a low of 2.6 at Area E to a high of 3.4 at Area D (Table 2-12). Simpson's Dominance Index (*D*) followed the same pattern as *H* where the lowest value, 0.70, occurred at Area E and the highest value, 0.86, occurred at Area D (Table 2-12).

The macrobenthic assemblages present in the LBI borrow areas were similar to the assemblages of the LBI reference area and other regional studies. More than 80% of the taxa present in the four borrow areas were also present in at least one of the LBI reference or regional areas. This indicates that none of the proposed borrow areas contain a unique or rare benthic assemblage and the faunal assemblage of the borrow areas is common to the New Jersey coast.

Table 2-12.
Mean condition (except for total number of taxa) of the benthic macroinvertebrate community at the four LBI borrow areas and reference areas.

Standard error of estimate in parenthesis. Capital letters indicate which borrow area is significantly different from the reference area.

Parameter	**Area A**	**Area B**	**Area D**		**LBI Reference Area**	
Total number of taxa	121	69	92	57	84	
Number of Taxa (#/Sample)	22.69 (1.11)	18.06 (1.04)	19.61 (0.95)	16.10 (1.43)	23.13 (2.01)	E
Shannon-Wiener Index	2.89 (0.11)	3.22 (0.09)	3.44 (0.06)	2.57 (0.18)	3.40 (0.07)	A,E
Simpson's Dominance Index	0.74 (0.02)	0.83 (0.01)	0.86 (0.01)	0.70 (0.04)	0.85 (0.12)	A,E
Total Abundance (#/m^2)	8147 (1038)	2903 (496)	3112 (467)	5084 (1168)	5310 (1198)	
Amphipod Abundance (#/m^2)	516 (92)	269 (45)	128 (25)	170 (45)	315 (64)	D
Bivalve Abundance (#/m^2)	2897 (452)	843 (108)	376 (98)	709 (131)	1827 (504)	D,E
Polychaete Abundance (#/m^2)	3611 (764)	869 (326)	1377 (317)	2964 (1017)	1869 (518)	
Total Biomass (g/m^2) AFDW	32.70 (14.95)	3.04 (1.26)	3.38 (0.67)	4.61 (1.27)	3.82 (1.61)	
Amphipod Biomass AFDW (g/m^2)	0.12 (0.02)	0.20 (0.04)	0.12 (0.03)	0.25 (0.06)	0.11 (0.05)	E
Bivalve Biomass AFDW (g/m^2)	29.32 (14.98)	1.49 (0.51)	1.14 (0.27)	3.88 (1.24)	1.39 (0.75)	A
Polychaete Biomass AFDW (g/m^2)	0.97 (0.23)	0.33 (0.13)	0.40 (0.16)	0.28 (0.08)	2.01 (1.69)	B,D,E

The Atlantic surf clam, *Spisula solidissima*, was collected from all the LBI borrow areas using both the Young grab sampler and the hydraulic clam dredge. Juvenile and small adult surf clams were collected in more than 92% of the stations in the LBI borrow areas using a Young grab device. Mean abundance of surf clams collected ranged from 183/m^2 at Area D to 568/m^2 at Area A (Table 2-13). The abundance of clams greater than 2 cm in length also varied by borrow area. Biomass followed the same pattern as number of larger clams, in that Area A had the greatest mean biomass (29g/m^2) and Area D had the lowest (0.9g/m^2) (Table 2-13).

Table 2-13

. Mean abundance and biomass of the surf clam in grab samples from the four LBI borrow areas and

Parameter	Area A	Area B	Area D	Area E	LBI	
Mean abundance (#/m^2)	474.8 (7.05)	568.2 (103.0)	183.2 (42.9)	442.0 (120.9)	349.4	B
Mean abundance of clams longer than 2 cm (#/m^2)	29.1 (49.8)	1.4 (5.3)	0.9 (0.7)	3.9 (13.3)	5.7	A
Mean Biomass (g/m^2) (AFDW)	155.8 (14.98)	12.6 (0.50)	0.7 (0.27)	(1.24)	1.15	

Table 2-13a is a summary of adult surf clam stocks. Densities of surf clams ranged from 65.6 clams/100 ft^2 at Area E to 0.4 clams/100 ft^2 in Area B. The total surf clam stock ranged from 12.0 million clams in Area A to 0.05 million clams in Area B. The average number of bushels collected from the four LBI borrow areas were variable relative to the regional surveys conducted by the New Jersey Department of Environmental Protection (NJDEP, 1995). The average number of bushels for Area A, which had the greatest average number of bushels collected per tow, was about 70% greater than the regional average. The average number of bushels collected from Areas B and D were less than a third of the regional average. Borrow Area E most closely approximated the regional average of about 12 bushels collected/tow. Surf clams of the four LBI borrow areas were of comparable size relative to those of the regional Atlantic Coast.

Table 2-13a

. Summary of adult surf clam stocks of the four LBI borrow areas collected using a commercial hydraulic clam dredge.

Borrow Area	Area (acres)	# of Dredge Tows	Mean # of Clams/Tow	Mean Area Dredged/ Tow (sq. ft.)	Mean Density (Clams/100 sq. ft.)	Total Surf Clam Stock (million)
A	845.86	18	1475	4224	32.6	12.0 $\pm$ 4.4
B	272.78	7	21	4305	0.4	0.05 $\pm$ 0.06
D	509.69	11	198	4118	4.1	0.9 $\pm$ 1.1
E	273.08	5	1791	3951	65.6	7.8 $\pm$ 8.0

Ten additional mega and macroinvertebrate taxa were collected by the clam dredge tows (**Table 2-13b**). The most frequently collected invertebrate was the moon snail, which was present in 70% of all tows. All other invertebrates were collected at frequencies less than 40% for all tows.

Table 2-13b. Additional # of macroinvertebrates collected in dredge tows conducted at the LBI borrow areas

Borrow Area	Moon Snail	Horse-shoe Crab	Lady Crab	Hermit Crab	Green Crab	Spider Crab	Star-fish	San-dollar	Jelly-fish	Tube-worm
A	116	56	26	4	3	9	54		3	5
B	4		2			2				1
D	7		5	1		6	2	1	1	
E	1	2				2				

Wetlands: Wetlands are very important in flood control, help to preserve water quality, are significant as wildlife habitats, and contribute to the maintenance of finfish and shellfish populations. Long Beach Island is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. There are wetlands in the study site at Barnegat Light. They can also be found in adjacent areas. All wetlands within the back bays of the project area are classified as both US Fish and Wildlife Service "priority wetlands" and North American Waterfowl Management Plan "focus areas."

Salt meadow cordgrass (*Spartina patens*) and salt grass (*Distichlis spicata*) dominate the high marsh zone, which is slightly, lower in elevation than the transition zone. This zone is typically flooded by spring high tide.

The critical edge, or upland edge of the wetlands, is crucial for the survival of those coastal zone species that rely on this habitat for breeding, food source, cover, and travel corridors. It also acts as a buffer from non-point source pollution and activities affecting wildlife. Plants typical of the transition zone include upland and marsh species including marsh elder, groundsel-bush, bayberry, saltgrass, sea-blite (*Sueda maritima*), glasswort (*Salicornia spp.*), poison ivy, and common reed (*Phragmites australis*). As the critical edge disappears and wetlands are fragmented or isolated, the diversity of wildlife that depends on it decreases. As further development of the Barnegat Bay shoreline is expected, the continued existence of brackish tidal saltmarsh and coastal wetlands (fringe wetlands) is threatened; consequently elimination of habitat and degradation of water quality due to non-point sources of pollution might increase.

Finfish: Important recreational and commercial fish in the project area include: American eel (*Anguilla rostrata*), white perch (*Morone americana*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*), fluke (*Paralichthys dentatus*), bluefish (*Pomatomus saltatrix)*, spot (*Leiostomus xanthurus*), summer flounder (*Paralichthys dentatus*), northern puffer (*Sphoeroides maculatus*), weakfish (*Cynscion regalis*), Atlantic menhaden (*Brevoortia tyranus*), scup (*Stenotomus chrysops*), striped bass (*Monroe saxatilis*), Atlantic sturgeon (*Acipenser oxyrhynchus*), spiny dogfish (*Squalus acanthias*), and winter flounder (*Pseudopleuronectes americanus*). Other fish found within the area, many which are important forage fish, include bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), three spine stickleback (*Gasterosteus aculeatus*), northern pipefish (*Syngnathus fuscus*), winter skate (*Raja ocellata*), clearnose skate (*Raja eglanteria*), southern stingray (*Dasyatis americana*), and northern kingfish (*Menticirrhus saxatilis*).

Nearshore areas along the Atlantic coast provide a migratory pathway and spawning, feeding and nursery area for many fish sought by sport fishermen common to the Mid-Atlantic region including black sea bass (*Centropristis striata*), striped bass, summer flounder, winter flounder, bluefish, Atlantic mackerel (*Scomber japonicus*), tautog (*Tautoga onitis*), scup, Atlantic menhaden, weakfish, and American shad (*Alosa sapidissma*). In addition, shipwrecks and artificial reefs along the coast provide habitat for a variety of fish including: Atlantic cod (*Gadus morhua*), red hake (*Urophycis chuss*), spotted hake (*Urophycis regia*), white hake (*Urophycis tenuis*), black sea bass, pollock (*Pollachius virens*), mackerel, and bluefish. Shoal areas along the Atlantic coast are very productive areas for finfish. Such bathymetric contours provide important structure and feeding areas for finfish. Groins also provide structure within nearshore shallows that provide sites for attachment of sessile organisms on which finfish feed.

Essential Fish Habitat: The 1996 Magnuson-Stevens Act defines Essential Fish Habitat (EFH) as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” The project may have an effect on EFH for the following species or species groups: northeast multispecies (groundfish such as cod, haddock, flounders), Atlantic scallops, sea herring, monk fish, Atlantic salmon, summer flounder, scup, black sea bass, bluefish, squid, mackerel, butterfish, surf clams, ocean quahogs, dogfish, tilefish, highly migratory species (tuna, sharks), Atlantic billfishes, red drum, Spanish mackerel, king mackerel and golden crab. The Atlantic Fishery Management Council and the National Marine Fisheries Service have identified EFH for these species and the Corps has included the impact assessment in Section 5.9 of this report. Of the species listed surf clams are known to be present at all of the borrow sites. Two of the four borrow sites have been defined by the “Rules on Coastal Zone Management N.J.A.C. 7:7E as amended July 18, 1994” as prime fishing areas. These shoals attract many different fish species, including some of species and species groups that fall under EFH.

2.3 WILDLIFE:

Due to the developed nature of the project site, most of the wildlife that can be found in the area would be either transient in nature or very adaptable to human intervention. The following is a list of faunal species that might be found at or around the project site.

Amphibians:

American toad - *Bufo americanus*
leopard frog - *Rana pipens*

Reptiles:

common snapping turtle - *Chelydra serpentine*
dimondback terrapin- *Malaclemys terrapin terrapin*
Kemp's Ridley turtle - *Lepidochelys kempii*
oggerhead turtle - *Caretta caretta*
eastern garter snake - *Thamnophi sirtalis*
smooth green snake - *Opheodrys vernalis*
hawksbill turtle - *Eretmochelys imbricata*
green turtle - *Chelonia mydas*

Mammals:

raccoon - *Procyon lotor*
striped skunk - *Mephitis mephitis*
white-footed mouse - *Peromyscus leucopus*
eastern grey squirrel - *Sciurus carolinensis*
woodchuck - *Marmotoa monax*
house mouse - *Mus musculus*

Norway rat - *Rattus norvegicus*	eastern cottontail - *Sylvilagus floridanus*
marsh rice rat - *Oryzomys palustris*	muskrat - *Ondatra zibethicus*
river otter - *Lutra canadensis*	possum - *Didelphia marsupialis*
shorttail shrew - *Blarina brevicauda*	least shrew - *Cryptotis parva*
starnose mole - *Condylura cristata*	masked shrew - *Sorex cinereus*
little brown bat - *Myotis lucifugus*	silver-haired bat - *Lasionycteris*
noctivagans	
eastern pipstrel - *Pipistrellus subflavus*	big brown bat - *Eptescius fuscus*
red bat - *Lasiurus cinereus*	eastern chipmunk - *Tamias striatus*
eastern muskrat - *Ondatra zibethicus*	longtail weasel - *Mustela frenata*
mink - *Mustela vison*	gray fox - *Urocyon cinereoargenteus*

Birds: Migratory shorebirds are a Federal trust resource responsibility of the U. S. Fish and Wildlife Service. Wetland areas in the vicinity of Long Beach Island provide high quality habitat for a variety of migratory shorebirds. Shorebirds that use the beaches and associated estuarine wetlands in the vicinity of Long Beach Island include: clapper rail (*Rallus longirostris*), American oystercatcher (*Haematopus palliatus*), eastern willet (*Catoptrophorus semipalmatus*), sanderling and sandpiper (*Calidris* spp.), American bittern (*Botaurus lentiginosus*), and least bittern (*Ixobrychus exilis*). The Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge on the southern end of Long Beach Island provides important resting and feeding areas for migrating shore birds.

Colonial nesting waterbirds nest on islands and marshes in Barnegat Bay, Manahawkin Bay, and Little Egg Harbor adjacent to Long Beach Island. Coastal marshes provide feeding habitat, while islands in the back bay area provide nesting habitat that is protected from mammalian predators. Colonial nesting waterbirds present within the project area include: little blue heron (*Florida caerulea*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violaceus*), herring gull (*Larus agentatus*), laughing gull (*Larus atricilla*), common tern (*Sterna hirundo*), least tern (*Sterna antillarum*), black tern (*Chilidonias niger*), and black skimmer (*Rynchops niger*). Fourteen species of colonial nesting waterbirds were found nesting in 31 separate colonies in the back bay areas of Long Beach Island during a 1984 - 85 U.S. Fish and Wildlife Service survey. The beaches of Barnegat Light were noted as an area that supported a large waterbird colony.

Migratory waterfowl are also a Federal trust resource responsibility of the U.S. Fish and Wildlife Service. Areas adjacent to the project area are important resting and feeding areas for migratory waterfowl on the Atlantic flyway. The back bays of Long Beach Island provide habitat for mute swan (*Cygnus olor*), Canada goose (*Branta canadensis*), Atlantic brant (*Branta bernicla*), American black duck (*Anas rubripes*), green-winged teal (*Anas crecca*), blue-winged teal (*Anas discors*), greater scaup (*Aythya marila*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), oldsquaw (*Clangula hyemalis*), and red-breasted merganser (*Mergus serrator*). Other waterfowl that can be found in the area are mallard (*Anas platyrhynchos*), and the following sea ducks: common eider (*Somateria mollissima*), white-winged scoter (*Melanitta fusca*), surf scoter (*Melanitta perspicillata*), and black scoter (*Melanitta nigra*).

Several raptors occur year-round in the project area including the northern harrier (*Circus cyaneus*). The peregrine falcon (*Falco peregrinus*) is known to nest and feed in the surrounding area. The osprey (*Pandion haliaetus*) and short-eared owl (*Asio flammeus*) are temporary residents of the marshes along Long Beach Island. A variety of other raptors such as Cooper's hawk (*Accipiter ccoperii*), sharp-shinned hawk (*Accipiter Striatus*), broad-winged hawk (*Buteo platypterus*), red-shoulder hawk (*Buteo lineatus*), and bald eagle (*Haliaeetus leucocephalus*) are transient visitors that rarely stay within the project area for any significant length of time.

Other birds that might be found in the project area include: red-winged black bird (*Agelaius phoenicius*), barn swallow (*Hirundo rustica*), sharp tailed sparrow (*Ammodramus caudacutus*), seaside sparrow (*Ammodramus maritimus*), swamp sparrow (*Melospiza georgiana*), fish crow (*Corvus ossifragus*), American crow (*Corvus brachyrhynchos*), boat-tailed grackle (*Quiscalus major*), and double-crested cormorant (*Phalacrocorax auritus*).

Threatened and Endangered Species: Federally threatened and/or endangered species of birds under the jurisdiction of the US Fish and Wildlife Service that may be found in the vicinity of the study area include piping plover (*Charadrius melodus*), peregrine falcon (*Falco peregrinus*), and the bald eagle (*Haliaeetus leucocephalus*). Only the piping plover nests directly in the project area.

The peregrine falcon (*Falco peregrinus*), a Federally-listed endangered species, is known to nest on the Barnegat Division of Edwin B. Forsythe National Wildlife Refuge in Stafford Township, Ocean County, New Jersey. Peregrine falcons tend to prefer marshes and riparian habitats for feeding, as these areas attract shorebird and passerine prey.

Several aquatic Federally, listed endangered and threatened species under the jurisdiction of the National Marine Fisheries Service may occur within the Long Beach Island project site including the Federally-listed threatened loggerhead (*Caretta caretta*), and the endangered Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles.

Endangered right whales (*Eubalaena glacialis*) and humpback whales (*Megaptera novaeangliae*) are present in the mid-Atlantic waters, off the coast of New Jersey in late winter through early spring. Their occurrence has been attributed to northward migrations toward the Gulf of Maine. However, a recent investigation indicated that juvenile humpback whales have been sighted in shallow coastal waters of the Delaware and Chesapeake Bays. Finback whales (*Balaenooptera physalus*) are the most likely species to occur in the coastal waters of New Jersey. Finback whales increase in relative abundance in late winter and spring, east of the Delaware peninsula. They may be found in New Jersey coastal waters in all seasons.

The harbor porpoise (*Phocoena phocoena*) has been proposed for listing as threatened under the Endangered Species Act. While mid-Atlantic waters are the southern extreme of their distribution, stranding data indicate a strong presence of harbor porpoise off the coast of New Jersey, predominately during spring.

The northern diamondback terrapin (*Malaclemys terrapin terrapin*), considered a "species of special concern", is known to occupy Barnegat Bay. The diamondback terrapin occupies brackish tidal marshes and nests on sandy bay beaches.

A variety of state-listed endangered and threatened species inhabit the beaches of Long Beach Island. Several raptors occur in the vicinity of the project area including the state-listed endangered northern harrier (*Circus cyaneus*), and short eared owl (*Asio flammeus*), and the state-listed endangered osprey (*Pandion haliaetus*), and barred owl (*Strix varia*). The state listed threatened black rail nests in emergent tidal marshes in the project area. The State-listed endangered black skimmer (*Rynchops niger*), roseate tern (*Stena dougallii*), and least tern (*Sterna antillarum*) also occur along the beaches of the project area.

Visual: The shoreline along the ocean side of Long Beach Island can be described as a high-energy beach. It is virtually an uninterrupted linear view of wide berms and rolling dunes. Groins that are perpendicular to the berm only break the view. Primarily buildings are behind or built into the dunes and do not break the visual flow. There are no high-rise buildings along the oceanfront, which alter the view. Views of the ocean and beach, from these building are quite soothing and tranquil.

Air Quality and Noise Level: The project area is residential in nature. The air quality is good since there are no major sources of emissions in the area. Noise at the project site is dominated by the sound of crashing waves and birds. These sounds are not disturbing to animals or human users of the area.

2.4 CULTURAL RESOURCES

In preparing the FEIS, the Corps consulted with the New Jersey State Historic Preservation Office (NJ SHPO) and other interested parties to identify and evaluate historic properties in the project area in order to fulfill its cultural resources responsibilities under the National Historic Preservation Act of 1966, as amended, and its implementing regulations, 36 CFR Part 800. As part of this work, a cultural resources investigation was conducted in selected project areas. The results of this investigation are presented in the draft report entitled *Phase I Submerged and Shoreline Cultural Resources Investigations and Hydrographic Survey, Long Beach Island, Ocean County, New Jersey* (Hunter Research, Inc. et al, 1998). Copies of this report are on file at the Philadelphia District Office. The following brief discussion has been taken directly from the above referenced report and summarized. For more detailed information on the history of Long Beach Island, the reader may wish to refer directly to this report and to other studies listed in the reference section of the FEIS.

Previous cultural resource surveys have been completed in and close to the project area. In 1977 an archeological survey was conducted by R. Allen Mounier in conjunction with a proposed waste water collection facility for the town of Manahawkin and vicinity. As part of this investigation, Bonnet Island, a small body of land located in Manahawkin Bay, was subjected to a program of background research, field inspection and limited subsurface testing. Several historic cultural resources were identified on the mainland, however, none were located on Bonnet Island or within the general vicinity of the project area (Mounier 1977).

In 1990, A. K. Mounier completed a second investigation along a proposed transatlantic telecommunications cable alignment which was to cut across Manahawkin Bay and traverse Long Beach Island along Bergen Avenue in North Beach. No cultural resources of interest were found within the project corridor. Mounier noted severely disturbed landscapes on Long Beach Island from the ocean to the bay (Mounier 1990).

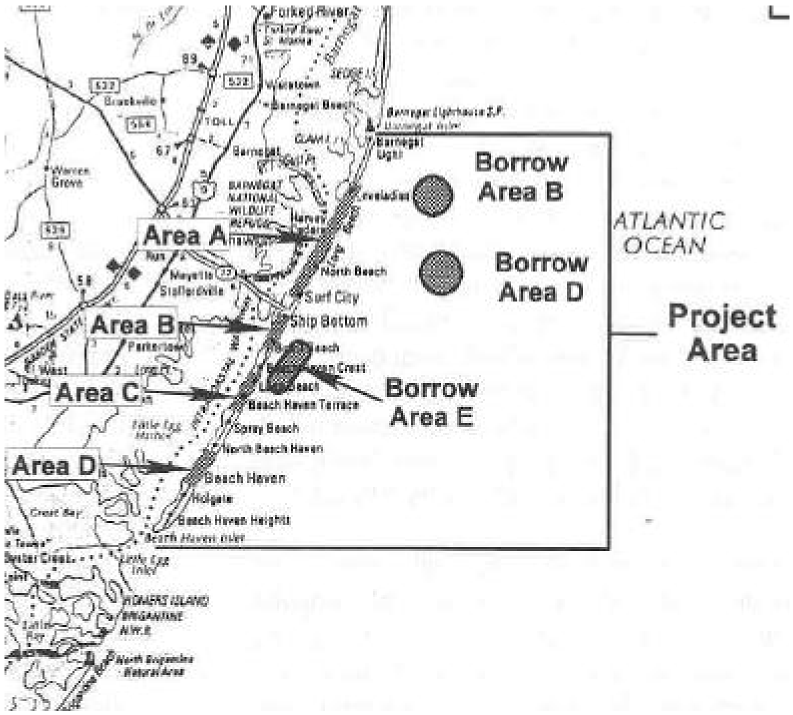
A statewide survey of archeological resources conducted in the early part of this century (Skinner and Schrabisch 1913) and more recent cultural resource investigations have not identified any prehistoric sites either within the tidal zone of the current project area or on Long Beach Island itself. However, prehistoric artifacts have occasionally been recovered from the floor of Manahawkin Bay and many prehistoric sites are known to exist nearby on the mainland.

No potentially significant historical archeological resources have been previously documented along the tidal shoreline and tidal zone of the current project area. Numerous shipwrecks, however, are known to have occurred along the beaches of Long Beach Island. A list of documented shipwrecks in the Long Beach Island vicinity is provided in Appendix A in Hunter's report (Hunter Research, Inc. et al, 1998).

Examination of maps and files of the New Jersey Historic Preservation Office indicate that there are several historic resources in the project vicinity currently listed in the State and National Registers of Historic Places. These are the Barnegat City Public School (now the Barnegat Light Museum), Barnegat Lighthouse, the Beach Haven Historic District, Converse Cottage, Sherbourne Farm and the Dr. Edward H. Williams House. The last four properties are all included within the Beach Haven Multiple Resource Area. In 1981, the New Jersey Historic Sites Survey inventoried the historic resources of Long Beach Island and generated an additional list of potentially eligible properties (see Table 1.1 in Hunter Research, Inc. et al, 1998). Of these previously identified historic properties, the only ones located in close proximity to the present study area are the Barnegat Lighthouse, the Ship Bottom Historic District and Aunt Hill. The Barnegat Lighthouse is a mid-19th century 150-foot tall lighthouse located at the extreme northern tip of the island. The light keeper's house at 7 East 5th Street in Barnegat is a typical example of a late 19th century Long Beach Island cottage. The Ship Bottom Historic District is a district composed primarily of late 19th-century and early 20th-century summer cottages which on its east abuts the beach front. Aunt Hill is another late 19th-century cottage and is notable for being one of the oldest buildings in Spray Beach. Of these resources only the Barnegat Lighthouse is actually listed in either the State or National Registers, and none are located directly on the beach or in the tidal zone.

As part of the present feasibility study, a cultural resources investigation was conducted in selected project areas located along an 18-mile stretch of the Atlantic coastline between Barnegat Inlet and Little Egg Inlet (Hunter Research, Inc. et al, 1998; see Figure 1-1). The locations investigated include four shoreline and near-shore areas with a combined total length of 10.5 miles and adjacent underwater near-shore areas totaling 320 acres (Areas A-D). In addition, three potential offshore sand borrow areas totaling approximately 1,055 acres were also investigated (Borrow Areas B, D and E). The fieldwork involved visual inspection and remote sensing. Visual inspection and magnetic survey were conducted within the four, shoreline areas at low tide. Comprehensive magnetic, acoustic and bathymetric remote sensing and hydrographic surveys were conducted within the four near-shore sand placement areas, as well as within the three proposed offshore sand borrow areas.

Figure 2-1. Selected Projects Areas Investigated for Cultural Resources



The visual inspection of shoreline areas A-D was conducted at periods of low tide. The majority of historic features identified along the shoreline included stone and composite wood and stone jetties and groins spaced at regular intervals. Other 20th century materials noted in the area include wood pilings, stone outcrops, and remnants of wooden walkways. A late 19th century historic cottage was identified adjacent to, but outside of, the project area in Area A. No prehistoric or historic archeological material was identified on the surface.

The purpose of the pedestrian magnetometer survey within the same shoreline areas A-D was to detect and delineate anomalies that might be related to buried historic cultural materials, with a particular emphasis on shipwrecks. In total, five magnetic targets exhibiting shipwreck characteristics were identified (Targets MA-1, MA-3, MA-4, MA-7, MD-4).

Underwater areas located immediately offshore from the four, shoreline survey areas A-D and the three offshore potential borrow areas were investigated using remote sensing techniques. The survey was conducted to locate, identify and preliminarily assess the significance of submerged cultural resources that might be affected by proposed dredging and disposal activities. The underwater survey was designed to generate sufficient magnetic, acoustic and bathymetric remote sensing data to identify anomalies caused by submerged cultural resources. Inspection of the remote sensing records confirmed the presence of four potentially significant targets: three along near-shore Survey Area A (Targets 4:735, 4:816 and 4:1009) and one in offshore Borrow Area D (Target 7:614).

2.5 GEOTECHNICAL ANALYSIS.

Geomorphology. The study area of the central coast of New Jersey lies within the coastal plain province of Eastern North America. In New Jersey, the province extends from a line through Trenton and Perth Amboy southeastward for approximately 150 miles to the edge of the continental shelf. The land portion of the province is bounded on the northeast by the Raritan Bay and on the west by the Delaware River. The line of maximum elevation runs from the Navesink Highlands southeastward to the Mt. Holly area. The land rises gradually from the sea as a moderately dissected plain to an elevation of approximately 300 feet in the center, from where it slopes toward the Delaware River and Raritan River drainage systems. The submerged portion of the plain slopes gently southeastward at 5 or 6 feet per mile for nearly 100 miles to the edge of the continental shelf. The surface of the shelf consists of broad swell and shallow depressions with evidence of former shorelines and extensions of river drainage systems.

The Atlantic coastal shelf is essentially a sandy structure with occasional silty, gravelly or stony deposits. It extends from Cape Cod to Florida, and is by far the world's largest sandy continental shelf.

Physiography. The New Jersey shore line can be divided into those sections where the sea meets the mainland, at the northern and southern ends of the State, and where the sea meets the barrier beach, in the central portion of the State. The barrier beach extends from Bay Head, down the coast for approximately 90 miles and is continuous, except for the interruption by 10 inlets. The shoreline of the study area, extends for approximately 18 miles, from the lower of Island Beach State Park to Holgate at the southern tip of Long Beach Island and lies entirely within the barrier beach section.

Barrier Beaches. The New Jersey barrier beaches belong to a landform susceptible to comparatively rapid changes. In this study area the barrier islands range in width from 600 feet to about 5,000 feet. Landward of the barrier beaches and inlets of the study area are tidal bays, which range from three to five miles in width. Natural processes have filled these bays until much of their area is covered with tidal marshes. The remaining water area consists of smaller bays connected by watercourses called thorofares. Four geologic processes are considered to be responsible for the detritus (or loose material) in the bay area. Stream sedimentation contributes a small amount of upland material; waves washing over the barrier during storms, direct wind action blowing beach and dune sand into the lagoon, and the work of tidal currents, which normally bring more sediments in suspension from the ocean on flood tide than on ebb tide. The vegetation of the lagoon, both in marsh and bay, serves to trap and retain the sediments.

Drainage of the Coastal Plain. The stream drainage system of the New Jersey coastal plain was developed at a time when sea level was lower then at present. The subsequent rise in sea level has drowned the mouth of coastal streams where tidal action takes place. This tidal effect extends up the Delaware River to Trenton, NJ, a distance of 134 miles. The formation of the barrier beaches removed all direct stream connection with the ocean between Barnegat Bay and Cape May. These streams now flow into the lagoons formed in the back of these barrier beaches and their waters reach the Atlantic Ocean by way of the inlets. The significance of these features of the drainage system to the problem area is that the coastal plain streams, whose upper courses carry little sediment, lose that little sediment in their estuaries, and in the lagoons, and supply virtually no beach nourishment to the ocean front.

Surficial Deposits. The coastal plain of New Jersey consists of beds of gravel, sand and clay, which dip gently towards the southeast, and certain fossils showing them to be of the Cretaceous, Tertiary, and Quaternary ages. The older and lower layers appear at the surface along the northwest margin of the coastal plain and pass beneath successively younger strata in the direction of their dip. The parallel outcrops of successive strata make this a "belted coastal plain". Since the formations dip toward the southeast, successively younger layers appear along the shore and progresses southward. Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier beaches fringe the coast. These formations have contributed to the sands of the present beaches. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations.

The Cape May formation, consists largely of sand and gravel deposited during the last interglacial stage, when the sea level stood 30 to 40 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. In most places along the New Jersey coast, there is a capping of a few feet of Cape May formation. This capping is of irregular thickness and distribution, but generally forms a terrace about 25 to 35 feet above sea level. The barrier beaches, being of relatively recent origin, are generally composed of the same material as that found on the offshore bottom.

Subsurface Geology. The Atlantic coastal plain consists of sedimentary formations overlying a crystalline rock mass known as the "basement". Well drilling logs indicate the basement surface slopes at about 75 feet per mile, to a depth of more than 6,000 feet near the coast. Geophysical investigations have corroborated well-log findings and have permitted determination of the profile seaward to the edge of the continental shelf. A short distance offshore, the basement surface drops abruptly but rises again gradually near the edge of the continental shelf. Overlying the basement are semi-consolidated beds of lower Cretaceous sediments. The beds vary greatly in thickness, increasing seaward to a maximum thickness of 13,000 feet then decreasing to 8,000 feet near the edge of the continental shelf. On top of the semi-consolidated material lie unconsolidated sediments of Upper Cretaceous and Tertiary formation. The materials are in relatively thin beds on the land portion of the coastal plain. The thickness increases to a maximum of 5,000 feet near the edge of the continental shelf.

Geologic History. The sea successfully advanced and retreated across the 150-mile width of the Coastal Plain during the Cretaceous and Quaternary time. Many sedimentary formations were deposited, exposed to erosion, submerged again and buried by younger sediments. The types of sorting, the stratification, and the fossil types in the deposits indicate that deposition took place offshore as well as in lagoons, estuaries and on beaches and bars. Considerable changes in sea level continued to take place during Pleistocene time. Glacial periods brought a lowering in sea level as water was locked up in the huge ice masses. As the sea level fell to a beach line miles seaward of the present shoreline, Pleistocene sediments were deposited in valleys cut into older formations. The water released through glacial melt during interglacial periods brought a rising of sea level and beaches were formed far inland of the present shore.

Potential Borrow Areas/Sand Sources. For years the barrier island beaches of New Jersey have constantly experienced beach erosion. The most prominent and environmentally acceptable defense for the shoreline in New Jersey has been beach sand renourishment. Beach fill can be acquired from a number of different sources. The cheapest compatible source of sand fill material is always the objective, especially when larger quantities of sand fill are required. The selection of the appropriate beach fill sand is an intricate process which has many factors, such as: grain size compatibility with the native beach material, the sand borrow source's location and quantity, and the environmental impacts of using the borrow source.

Pertinent information on the following potential borrow areas and sand sources was compiled from the 1982 USACE Coastal Engineering Research Center (CERC) report entitled, "Sand Resources on the Inner Continental Shelf off the Central New Jersey Coast". A subsurface investigation was performed on the potential borrow area shoals in June of 1996. The investigation consisted of taking vibratory borings within the potential borrow area sites. In 1998, more vibratory borings were performed adjacent to several of the borrow areas in an attempt to expand them. Figure 2-1 is a location map that shows the approximate locations of the vibracore borings and the potential borrow areas.

There are no viable land sources of borrow sand for the large quantity required for this project. Offshore and inlet sources are the only potentially feasible alternatives for sand borrow. Inlet borrow sources can be a viable sources depending on the quantity of material they possess. Usually inlets need periodic maintenance dredging to facilitate boat traffic; however, the quantity of sand material dredged at any one time is very small in comparison to a typical beach renourishment project.

Offshore Borrow Areas. The offshore borrow areas located within three miles of Long Beach Island are the most feasible sources of sand. In general, subsurface investigations indicate that shoals usually contain the proper grain sized material that is compatible with the sand material on the beaches. The subsurface investigations in 1982, 1996, and 1998 indicate that finer material exists outside of the shoals. The investigation performed in 1996 by the COE indicated specific sections of each shoal as having usable or non-usable material for beach fill. There are even zones of the majority of the shoals that have finer unusable material. Five borrow areas (A, B, D1, D2, and E) have been delineated as sources of beach fill for this project. The potential borrow areas are all located offshore of Long Beach Island at distances given below. The New Jersey Geologic Survey is in concurrence with the findings of these aforementioned investigations performed by the USACE. (See pertinent correspondence Appendix B.) Some of the original borrow areas, Areas A through F (see Figure 2-2), were not pursued due to the interference of AT&T submarine telephone cables or incompatible material. Site G has incompatible material based on the 1982 report, and thus, was not considered any further. Sites C and F were discarded due to the heavy interference from the cables. Although site D has some interference from cables, the majority of the site can still be utilized. A certain tolerance for the proximity to the cable will be approved by AT&T prior to any dredging in Area D and D2. The study used a 1000 feet buffer area for the purposes of the construction estimates. Adherence to the buffer zone is critical due to the high cost of cable repair (approx. $750,000). Area D spans the imaginary three nautical mile line off of the coast, which delineates the start of Federally controlled waters. Area D is split into two sections, D1 and D2, by the three-mile line.

Using data from the past investigations, sites A, B, D1, D2, and E have been selected as the potential borrow areas for the feasibility study. Borrow material quantities were calculated based on the information obtained from the vibracore borings and available hydrographic surveys.

Borrow Area "A". Site A is an ebb shoal located 0.25 statute miles offshore from Barnegat Inlet. This site is approximately 3.0 miles long by 1.5 miles wide. Borrow area A is considered a back up source of material due to its moderate compatibility with the beach material. This site has an estimated 2,200,000 c.y. of suitable material.

Borrow Area "B". Site B is centered off Loveladies at a distance of about 1.7 statute miles and has a length of approximately 2.2 miles and width of 0.8 miles. Calculations show that this site has approximately 3,640,00 c.y. of suitable material for the proposed beach fill.

Borrow Area "D". Site D, the larger of the potential borrow sources, is centered approximately 2.5 miles off Harvey Cedars and has a length of 1.3 miles and width of 0.6 mile. This site has an estimated 12,000,000 c.y. of suitable material.

Borrow Area D2. Site D2 is located approximately 3.5 miles off Harvey Cedars and has a length of 1.6 miles and a width of 0.5 mile. The portion of the site, which is outside of the three-mile line (D2), is located in Federal waters and authorized use of the site is controlled by the Minerals Management Service of the U.S. Department of the Interior. The usage of this portion may incur a cost per acre, which could render it cost prohibitive. This site has an estimated 12,000,000 c.y. of suitable material.

Borrow Area "E". Site E, is centered off Ship Bottom at a distance of about 1.0 statute mile and has an approximate length of 2.5 miles and width of 0.3 mile. This site has approximately 9,350,000 c.y. of suitable material for the proposed beach fill.

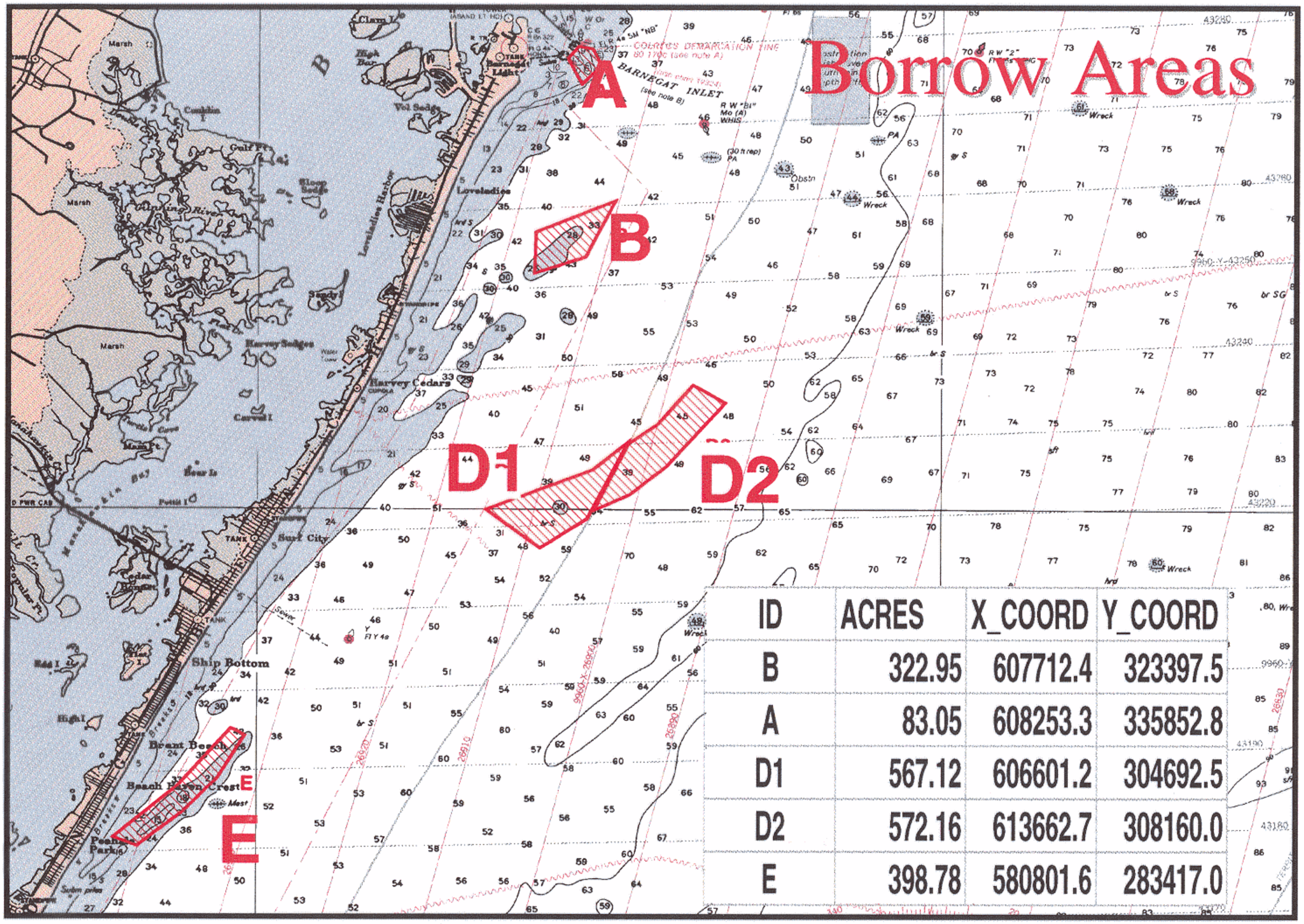
To accurately reflect the precise current locations of the potential offshore sites, hydrographic surveys were completed. The current data characterizing the potential borrow areas are listed in Table 2-14.

Table 2-14

Borrow Area	Location, (miles off coast)	Estimated Quantity cu.yds.x10^6	Maximum Dredge Depth (elevation)	Borrow Mean Diameter (mm)	Beach Mean Diameter (mm)	Overfill Factor R_a	Renourishment Ratio R_j
Area A	0.25 at Barnegat	2.2	-34.0	0.24	0.32	1.6	1.0
Area B	1.7 at Loveladies	3.64	-43.0	0.43	0.32	1.0	1.0
Area D1	2.5 at Harvey Cedars	12.0	-57.0	0.35	0.26	1.0	1.0
Area D2	3.5 at Harvey Cedars	13.0	-57.0	0.35	0.26	1.0	1.0
Area E	.0 at Brant Beach	9.35	-45.0	0.30	0.21	1.0	1.0

NOTE: The native beach material mean grain size diameter varies between 0.37mm and 0.22mm.

The grain size of the sand along the coast of the project area varies from north to south. The grain size in the northern region is approximately 0.32mm. The grain size in the central region is approximately 0.26mm. The grain size drops further still in the southern region to approximately 0.21mm. The average value of sand grain sizes on the beaches of Long Beach Island is 0.271 millimeters (or 1.88 phi units). A grain size sensitivity analysis was performed to show the importance of the relationship between the grain size of the borrow material and the grain sizes of the native beach material (see Figure 2-3). For this analysis, the native beaches grain size assumed to be 0.271mm. Typical values of the grain size for the material found off of the shoals in this area are less than 0.24mm, which are located on the right side of the chart in Figure 2-3. It is evident from Figure 2-3 that the project costs increase significantly as the grain size of the borrow material decreases slightly less than the grain size of the native beach material.



ID	ACRES	X_COORD	Y_COORD
B	322.95	607712.4	323397.5
A	83.05	608253.3	335852.8
D1	567.12	606601.2	304692.5
D2	572.16	613662.7	308160.0
E	398.78	580801.6	283417.0

FIGURE 2-2 Long Beach Island Proposed Borrow Area Usage

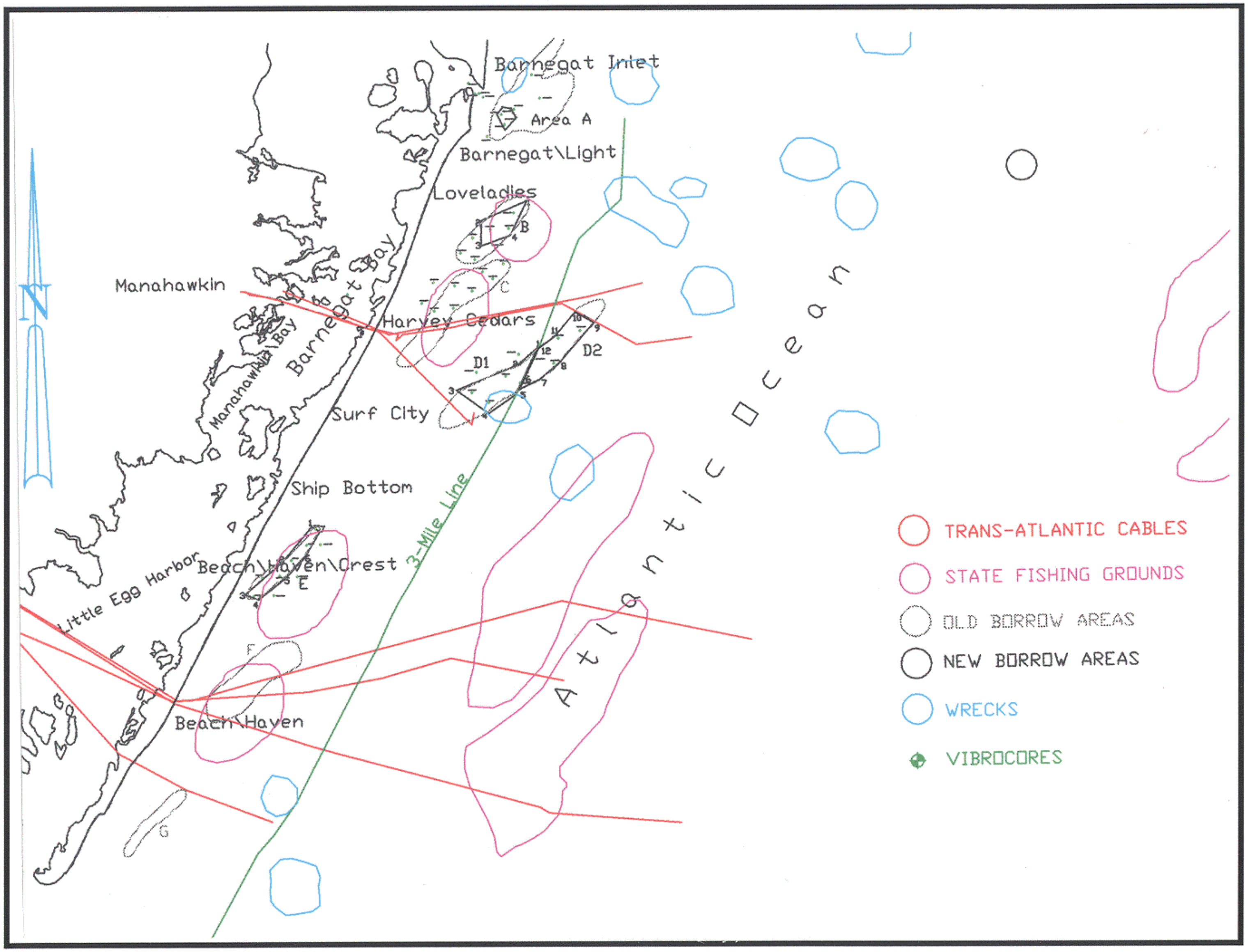


FIGURE 2-3 Prime Fishing, Under Water Cables, Potential Borrow Area

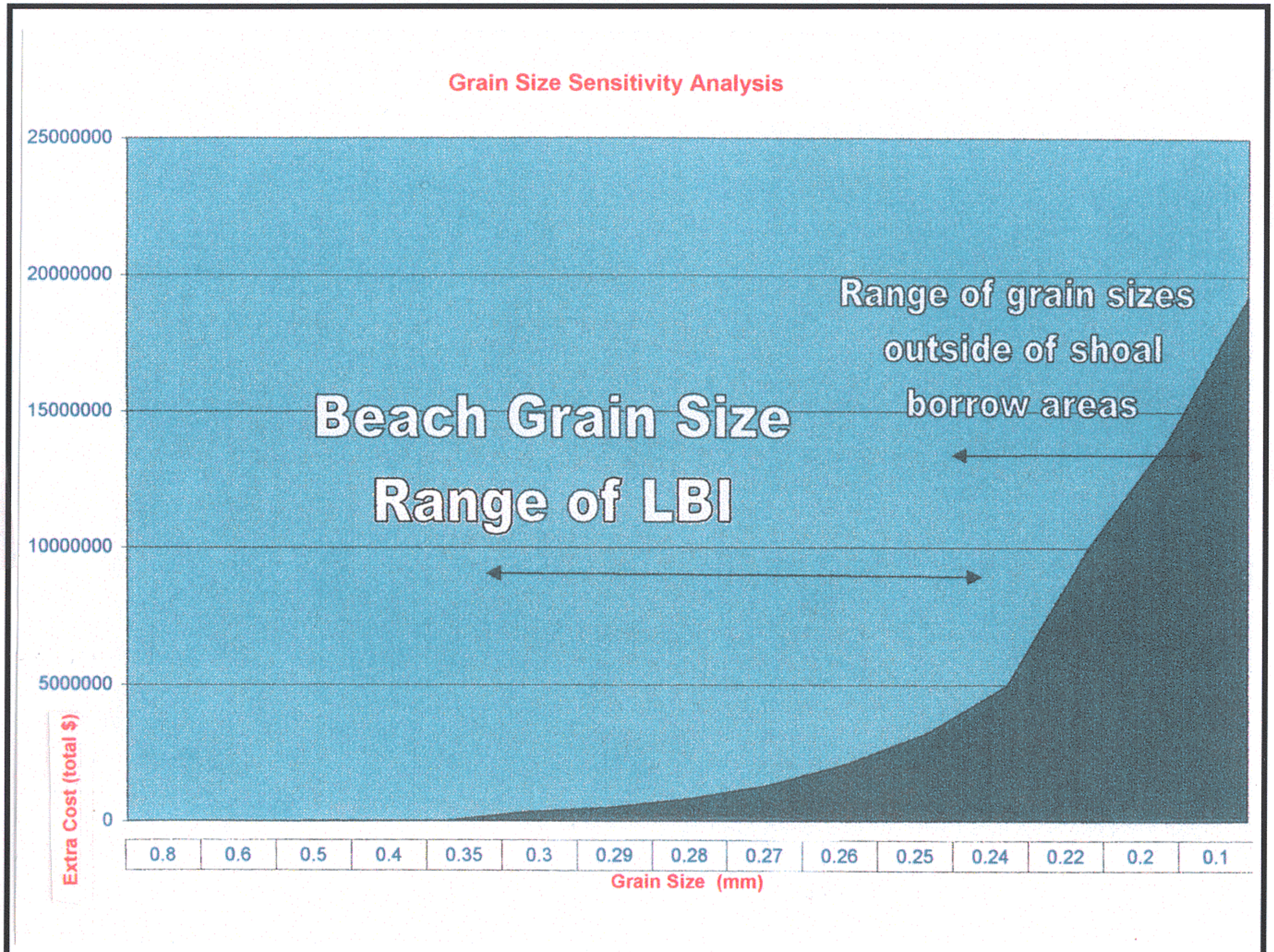


FIGURE 2-4 Grain Size Sensitivity Analysis

49

2.6 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE (HTRW

Federal and state databases were referenced to perform an HTRW Preliminary Assessment of the project area. The search encompassed the coastal area from Barnegat Inlet to Little Egg Inlet. The Preliminary Assessment included a literature search of known sites in the study area. Sites in the study appear on the lists in the databases if there is a known or potential source of contamination. The literature search also provided Sanborn Fire Insurance Maps from different years. These maps provide a perspective of when structures were constructed or demolished. The results of the preliminary assessment point out 12 potentially contaminated sites. These sites are:

AMOCO Station	Surf City
Beach Haven Laundry	Beach Haven
The Boat Yard	Beach Haven
CAUSEWAY BOAT RENTALS	Manahawkin
Residence (1301 Long Beach Blvd.)	Beach Haven
MOBIL OIL STATION	Ship Bottom
Residence (115 Dolphin Ave.)	Beach Haven
SICO CO.	Long Beach Island
SUNOCO Station	Ship Bottom
The Boat Yard	Harvey Cedars
Township of Long Beach	Beach Haven
U.S. Coast Guard Station	Beach Haven

These 12 sites are potentially contaminated either by a previous leak in an underground storage tank, or by the generation of non-hazardous waste. None of these sites are located on the beach, or close enough to have any impact on the project. Therefore, there is considered to be no HTRW contamination potential in the project area.

Ordnance and Explosive Waste (OEW). There are no known areas of past or present military activity involving explosives within the project area. The U.S. Army Formerly Used Defense Site (FUDS) database was searched for potential sources of unexploded ordinance in the project area. There are no known areas of past or present military activity involving explosives within or impacting the project area. There is no suspected OEW within the project area, including the potential sand borrow sources based on the findings of the magnetometer survey and historic literature search. There is limited potential to find unexploded ordnance in the off-shore borrow areas along the coast of LBI, due to World War I and World War II naval activities. Generally, very small metallic objects, such as the shells of small ammunition rounds, may escape detection by a magnetometer survey; however larger objects such as, sunken metallic pieces of ships or larger ammunition shells will probably be detected by a magnetometer survey.

Underground Cables. There are several Trans Atlantic telephone (T.A.T.) cables crossing the beach and off shore zone within the study area. The cables are owned by several interests and maintained by AT&T Inc. Coordination with AT&T has taken place to identify the locations of the cables. The approximate locations of the cables in relation to the proposed borrow areas can be seen in Figure 2-2.

Two 1-in. diameter transatlantic fiber optic cables (T.A.T. 9 and T.A.T. 11) cross the north end of Long Beach Island. T.A.T. 9 was installed in 1991 and T.A.T. 11 was installed in 1993. The cables leave Manahawkin, N.J. and continue through Barnegat Bay to the Long Beach Island. Both cables are 100 ft. apart and are buried 6 ft. under the bay bottom. The cables continue eastward passing through the Barrier Island in the vicinity of Bergen Avenue in Harvey Cedars. Exiting the Barrier Island, the cables continue just under the ocean floor to approximately 3 miles into the Atlantic Ocean where they separate to continue on to different destinations.

There are three cable crossings in which the cables have been retired and no longer in use.

A 4-in. diameter copper coaxial transatlantic cable (Bermuda "A" Cable) installed in 1962 crosses to the island in the same general area as T.A.T. cables 9 &11. South of the groin off Bergen Avenue in Harvey Cedars, the cable continues eastward to Bermuda. The cable was retired by AT&T in 1990 and is no longer active.

A 4-in. diameter transatlantic copper coaxial cable (TAT 3) was installed in 1963, intersecting the island at Taylor Avenue in Beach Haven. Off Taylor Avenue the cable continues eastward to England. The cable was retired in 1986 and is no longer active.

A 4-in. diameter copper coaxial cable (T.A.T. 4) was installed in 1965 and crosses the island at the Leeward Avenue at the southern end of Beach Haven. Off Leeward Avenue the cable continues eastward to France. The cable was retired in 1987 and is no longer active.

A 4-in. diameter copper coaxial transatlantic cable (T.A.T. 7) was installed in 1983 and crosses the island at Taylor Avenue in Beach Haven. The cable continues eastward off Taylor Avenue to Europe. The cable was slated for retirement in June 1994.

A 1-in. diameter transatlantic fiber optic cable (T.A.T. 8) was installed in 1988. This cable also intersects the Barrier Island in the same area as T.A.T. 7. Off Taylor Avenue in Beach Haven, the cable continues eastward to Europe.

2.7 PRIOR AND EXISTING SHORE PROTECTION MEASURES.

Stabilization of the South Shoulder of Barnegat Inlet. The first efforts to control shore erosion on Long Beach Island had taken place prior to 1920. Those early efforts involved stabilization structures along the south shoulder of Barnegat Inlet to arrest the inlet′s southward migration, and oceanfront erosion control measures involving the construction of a "jetty" (groin) at Surf City and two "hurdle" structures at Beach Haven. Beginning in 1926, concentrated efforts were taken by the State and Federal governments to stabilize the south shoulder of Barnegat Inlet by means of groins, revetments, and bulkheads. This work was accomplished in various stages up to 1956 and included repairs and restorations as well as new work. By 1956 they achieved the stabilization of 3,000 lineal feet of inlet shoreline. Nine groins and approximately 1,250 lineal feet of bulkheads between the lighthouse and the land anchor point of the original bulkhead were used. These protective structures are now land-locked in the area that has filled with littoral material, between the new and original south jetty structures. The 4,270 feet long new south jetty was constructed from 1987 to 1991 nearly parallel to the existing north jetty to correct for shoaling and channel instability created by the original converging configuration of the Barnegat Inlet jetties.

Placement of Oceanfront Fixed Structures in the Period 1920-1940. The ocean shoreline, south of the original Barnegat Inlet south jetty, has a history of shore protection concerns and actions which began essentially at the same time it became evident that action was needed to address the southward migration of Barnegat Inlet. Apart from the work prior to 1920, records indicate that the State and local communities constructed at least six groins on Long Beach Island in the latter half of the 1920′s, see USACE, 1974 [Ref. 2]. Four of these groins were built in Harvey Cedars, and two in Beach Haven. The Holyoke Avenue groin has been and issue for the Township due to the erosion occurring south of the structure. Groin modification recommendations are discussed in the Plan Formulation section, 4-4. Though protective measures along the oceanfront may have been implemented in the 1930′s, there is no documentation of additional shore protection works until 1940, at which time, two timber bulkheads, having a composite length of 950 feet, were constructed at Harvey Cedars. Completion of the bulkheads was followed in 1946 by construction of a 250-foot long timber bulkhead at Brant Beach (LBT) and others. They consist of; construction of one groin in Holgate (LBT) in 1947; construction of one groin at the north end of Brant Beach in 1949 (LBT); and, also in 1949, construction of one groin at the south end of Beach Haven Park (LBT).

Placement of Oceanfront Fixed Structures in the 1950′s. Shore protection measures at Long Beach Island, in the decade of the 1950′s, began with the construction, in 1950, of two timber bulkheads, having a combined length of 560 feet, at Brant Beach (LBT). As an alternative to bulkhead construction, a gravel-fill dike having a length of 2,800 feet was constructed at Surf City in the period 1953-1954. At Beach Haven, two groins were constructed in 1953, and one groin in 1956 along with a 200-foot long timber bulkhead. At the southern end of the island in Holgate (LBT), four groins were built in 1957 and one groin in 1958.

Placement of Oceanfront Fixed Structures in the 1960′s and Present Conditions. The decade of the 1960′s was, by far, the study area's most prolific period in the construction of shore protection measures, due to the March 1962 storm. A vast number of groins were built. At present, there are 101 groin structures that compartment the shoreline along the developed oceanfront of Long Beach Island. Of the 101 existing groins, 86 of the structures were constructed in the 1960′s, and most of these, i.e., 69 groins, were built in the period 1963-1964.

The Long Beach Island groin structures are spaced at intervals that range from 750 to 1,000 feet, with the average spacing being 900 feet. The groin lengths range from 250 to 420 feet, with an average length of 285 feet. This results in an average spacing-to-length ratio of about 3 to 1, which is at the upper end of spacing-to-length relationships usually applied in groin field planning and design. The horizontal inshore segments of most of the groins have crown levels at elevations of about 8.2 feet above NGVD and are generally above the level of the natural beach berm and foreshore surface elevations; thereby, obviating any significant littoral transport directly through the respective groin compartments.

Most of the groins, 75 in number, are of composite stone and timber construction. Additionally, 26 groins are constructed of stone, 1 groin is of timber construction, 1 groin is comprised of stone and sand bags, and 1 groin was built with a combination of stone and surplus steel submarine defense netting. A visual inspection of the structural conditions of the island′s existing, oceanfront groins was conducted by the USACE, Philadelphia District in 1990 and again in July of 1996. The finding of the 1990 inspection, given in qualitative terms, were that: 17 groins (16%) were in good condition; 63 groins (61%) were in fair condition 22 groins (21%) were in poor condition; and 2 groins (2%), in Barnegat Light, were covered by beach material and not visible for inspection. In 1996 an additional qualitative term "excellent" was included to reflect those groins which require no maintenance. The structure inventory findings indicate that: 21 groins were in excellent condition, 58 groins were in good condition; 14 groins were in fair condition and 4 groins were of poor condition, indicating that they are in immediate need of repair to restore functionality. Only 99 groins were visible at the time of inventory. It should be noted that groins are the only types of fixed shore protection measure that presently exist along the oceanfront of Long Beach Island. The timber bulkheads and gravel-filled dike, mentioned previously, were all destroyed by the severe storm of March 1962. Remnants of bulkheads constructed before 1962 remain in some other sections of Long Beach Island. However, all are either damaged beyond functional use or are completely buried under the existing dune. It should be noted also that most of these remaining bulkheads are small scale and were originally designed to protect one home. The Real Estate section found in Appendix B documents private homeowners′ decks, boardwalks and or stairways located on the top of dune providing access to the beach.

A detailed evaluation of Long Beach Island′s coastal structures was made in 1971 as part of a larger Federal inventory of the entire East Coast. The Philadelphia District Corps of Engineers updated this inventory and reassessed the condition of the coastal structures on Long Beach Island in 1990 via site inspection as part of a larger Corps of Engineers limited reconnaissance study of the New Jersey coast from Manasquan Inlet to Cape May. The results of the Long Beach Island portion of that survey can be found in Table 2-15. **Figures 2-41 through 2-52** (see end of this section) are a representative sampling of groins along LBI.

Groin ID	Length (N)	LOCATION	ST_NAME	SHOALS LENGTH	Field LENGTH	Dist from end to c.l. Dune	MHW Peak El	CONTYPIN	CONST TYPE Seaward	PROFILE	CONDITION	PERMEABILITY
1	9253	Loveladies	LAYLIA	116.55	40	277.2	2.50	stone	stone	LEVEL	good	High
2	890	Loveladies	DOLPHIN	143.32	75	270.6		wood	stone	SLOPED	good	Medium
3	820	Loveladies	Seaview Drive North	175.23	150	250.8	1.00	wood	stone	SLOPED	good	Medium
4	877	Loveladies	Arts Lane/Sandy Cove	222.75	170	281.4	5.00	wood	stone	LEVEL	fair	Low
5	807	Loveladies	Coast Ave	252.78	182	298.4	6.00	wood	stone	SLOPED	fair	Low
6	700	Loveladies	Tidal/Riviera	184.49	170	284.9	1.50	wood	stone	SLOPED	fair	Low
7	884	Loveladies	Pompano/Oceana Drs.	193.69	170	305.0	0.00	wood	stone	LEVEL	good	Low
8	818	Loveladies	Nautilus/September L	187.66	146	305.0	2.00	wood	stone	SLOPED	good	Low
9	898	Loveladies	Panorama South	185.70	170	302.0	2.50	wood	stone	SLOPED	good	Low
10	866	Loveladies	Windrift	194.32	148	298.0	2.00	wood	stone	SLOPED	good	Medium
11	876	Loveladies	South of Longview Ln	224.66	180	291.1	0.75	wood	stone	SLOPED	poor	Medium
12	858	Loveladies	North of Seashell Ln	170.27	110	270.1	1.50	wood	stone	SLOPED	fair	Low
13	861	Loveladies	Seashell Ln	190.34	148	285.6	1.50	wood	stone	SLOPED	excellent	Low
14	796	Harvey Cedars	85th St	225.10	200	310.4	5.00	stone	stone	SLOPED	excellent	High
15	777	Harvey Cedars	82nd St	211.29	200	324.3	4.00	stone	stone	SLOPED	excellent	High
16	1049	Harvey Cedars	78th St	251.48	200	327.9	3.00	stone	stone	SLOPED	excellent	High
17	1044	Harvey Cedars	74th. St	190.87	200	321.0	3.50	stone	stone	SLOPED	excellent	High
18	867	Harvey Cedars	Sussex Ave	203.51	200	338.2	4.00	stone	stone	SLOPED	fair	High
19	893	Harvey Cedars	Essex Ave	201.16	200	340.2	2.00	stone	stone	SLOPED	fair	High
20	793	Harvey Cedars	Mercer Ave	193.37	200	320.4	3.50	stone	stone	SLOPED	poor	High
21	992	Harvey Cedars	Burlington Ave	204.69	200	302.4	2.00	stone	stone	SLOPED	poor	High
22	922	Harvey Cedars	Salem Ave	229.52	200	337.6	5.00	stone	stone	SLOPED	poor	High
23	865	Harvey Cedars	Cumberland Ave	224.88	225	318.3	2.50	stone	stone	SLOPED	poor	High
24	1158	Harvey Cedars	Bergen Ave	255.41	200	331.9	5.00	stone	stone	SLOPED	fair	High
25	1041	North Beach		214.51	154	297.9	1.30	wood	stone	SLOPED	fair	Medium
26	810	North Beach		232.59	170	294.0	1.20	wood	stone	SLOPED	excellent	High
27	804	North Beach		275.80	120	311.4	1.00	wood	stone	SLOPED	fair	Medium
28	803	North Beach		202.50	170	304.9	1.10	wood	stone	SLOPED	fair	Medium
29	797	North Beach		201.15	166	317.7	1.50	wood	stone	SLOPED	good	Medium
30	806	North Beach		172.99	144	298.3	1.60	wood	stone	SLOPED	good	Medium
31	795	North Beach		174.03	88	274.0	1.60	wood	stone	SLOPED	good	Medium
32	802	North Beach		248.42	135	339.[illegible]	[illegible]	[illegible]	stone	SLOPED	fair	Medium

Table 2-15 Groin Inventory Listing – 1997

55

33	1145	Surf City		212.78	146	302.3	1.50	wood	stone	SLOPED	fair	Medium
34	1045	Surf City	19th St	250.55	153	296.7	2.20	wood	stone	SLOPED	fair	Medium
35	1073	Surf City	15th St	251.05	160	294.8	5.00	wood	stone	SLOPED	good	Medium
36	1064	Surf City	11th St	223.81	160	304.8	2.00	wood	stone	SLOPED	fair	Medium
37	1058	Surf City	7th St. North	235.30	165	331.3	4.00	wood	stone	SLOPED	good	Medium
38	1121	Surf City	3rd St. North	235.14	158	314.9	2.00	wood	stone	SLOPED	good	Medium
39	1053	Surf City	1st St South	227.34	150	303.6	2.00	wood	stone	SLOPED	excellent	Medium
40	1053	Ship Bottom	5th St	183.39	117	290.2	0.60	wood	stone	SLOPED	good	Medium
41	1044	Ship Bottom	9th St	203.39	150	287.3	0.40	wood	stone	SLOPED	good	Medium
42	1065	Ship Bottom	13th St	216.24	130	314.2	1.60	wood	stone	SLOPED	excellent	Medium
43	1057	Ship Bottom	17th St	221.29	92	304.9	0.60	wood	stone	SLOPED	good	Medium
44	1059	Ship Bottom	21st St	176.29	50	277.4	0.60	wood	stone	SLOPED	good	Medium
45	1051	Ship Bottom	25th St	174.36	70	276.2	1.40	wood	stone	SLOPED	good	Medium
46	936	Ship Bottom	29th St	179.38	124	287.2	0.90	wood	stone	SLOPED	good	Medium
47	985	Ship Bottom	34th St	158.96	74	273.0	2.00	wood	stone	SLOPED	good	Medium
48	780	Long Beach Township	38th St	215.24	200	282.5	3.00	stone	stone	SLOPED	good	High
49	818	Long Beach Township	42nd St	150.11	112	219.5	3.00	wood	combo	SLOPED	good	Medium
50	803	Long Beach Township	46th St	192.87	160	257.5	2.00	wood	wood	SLOPED	needs attention	High
51	806	Long Beach Township	50th St	186.02	120	223.3	-0.50	wood	combo	SLOPED	poor	Medium
52	791	Long Beach Township	Sumner Ave/ 54th	174.89	120	223.1	1.50	wood	combo	SLOPED	fair	Low
53	760	Long Beach Township	Selfridge Ave/57th	179.63	108	260.9	4.00	wood	stone	SLOPED	fair	Low
54	740	Long Beach Township	Stanton Ave/ 60th	226.52	120	281.5	2.00	wood	combo	SLOPED	poor	High
55	759	Long Beach Township	Goldsborough Av/63rd	188.26	163	247.9	0.30	wood	stone	SLOPED	fair	Medium
56	751	Long Beach Township	Goodrich Ave/ 66th	232.63	120	305.6	5.00	wood	stone	SLOPED	good	Medium
57	747	Long Beach Township	Stockton Ave/ 69th	182.43	172	243.3	6.00	wood	stone	SLOPED	good	Medium
58	754	Long Beach Township	Coughlan	173.13	158	239.7	5.50	wood	wood	SLOPED	excellent	Low
59	817	Long Beach Township	CULVER	207.41	140	285.7	3.00	wood	wood	SLOPED	excellent	Low
60	620	Long Beach Township	WINIFRED	162.56	140	247.4	4.00	wood	wood	SLOPED	excellent	Low
61	1034	Long Beach Township	New York	182.24	115	294.5	1.30	wood	stone	LEVEL	good	High
62	881	Long Beach Township	SAILBOAT	169.73	80	266.0	0.40	wood	stone	LEVEL	good	Medium
63	1042	LBTnshp	MARINERS	156.93	128	269.6	0.30	wood	stone	SLOPED	good	Medium
64	849	Long Beach Township	MURIEL	162.25	65	276.6	2.50	wood	stone	LEVEL	good	High
65	833	Long Beach Township	TEXAS	194.84	130	294.4	2.00	wood	stone	SLOPED	good	Medium
66	888	Long Beach Township	Nebraska	230.33	200	319.1	5.00	stone	stone	SLOPED	good	Low

Table 2-15 Groin Inventory Listing – 1997

67	1100	Long Beach Township	S. Carolina	180.78	176	264.2	0.50	wood	wood	SLOPED	excellent	Low
68	826	Long Beach Township	Mississippi	214.30	172	292.3	0.60	wood	wood	SLOPED	poor	Low
69	1067	Long Beach Township	Hollybanks	242.18	146	313.8	2.00	wood	stone	SLOPED	excellent	Medium
70	735	Long Beach Township	Ryerson	182.22	85	284.1	2.00	wood	stone	SLOPED	good	Medium
71	920	Long Beach Township	Indiana	164.05	85	277.3	0.70	wood	stone	SLOPED	good	Medium
72	880	Long Beach Township	Delaware	182.12	100	272.1	2.50	wood	stone	LEVEL	good	Medium
73	902	Long Beach Township	31st	222.50	85	294.9	0.90	wood	stone	LEVEL	good	Medium
74	923	Long Beach Township	27th	197.76	85	273.1	1.50	wood	stone	LEVEL	good	Medium
75	1075	Long Beach Township	23rd	159.89	100	271.1	-0.50	wood	stone	LEVEL	good	Medium
76	1005	Long Beach Township	19th	109.26	50	254.1	4.00	stone	stone	LEVEL	good	Medium
77	1000	Long Beach Township	15th	157.09	125	272.9	4.00	wood	stone	LEVEL	good	Medium
78	1215	Beach Haven	Tenth st	153.01	125	294.3	2.50	stone	stone	LEVEL	good	Medium
79	1016	Beach Haven	Seventh st	120.61	125	263.1	2.00	stone	stone	SLOPED	good	Medium
80	1019	Beach Haven	Third st	140.87	65	288.2	2.50	stone	stone	SLOPED	good	Low
81	1267	Beach Haven	Amber	196.57	70	332.6	2.00	stone	stone	SLOPED	fair	Medium
82	1119	Beach Haven	ocean	212.78	80	344.5	2.00	stone	stone	SLOPED	good	Medium
83	1031	Beach Haven	Chatsworth	219.32	90	292.9	4.00	stone	stone	SLOPED	good	Medium
84	1316	Beach Haven	Holyoke	400.99	180	389.0	5.00	stone	combo	SLOPED	fair	Low
85	1341	Beach Haven	Jeffries	240.67	160	345.0	5.00	combo	combo	SLOPED	good	Low
86	#N/A	Beach Haven	Leeward		0			stone	stone	SLOPED	excellent	Low
87	1041	Beach Haven	Nelson		56			wood	wood	SLOPED	good	Low
88	193	Long Beach Township	Nelson	230.05	110	335.3	5.00	stone	stone	SLOPED	good	Low
89	541	Beach Haven	Marshall	148.20	25	274.4	0.60	stone	stone	SLOPED	good	Medium
90	498	Beach Haven	Susan	158.86	30	274.7	-0.90	stone	stone	SLOPED	good	Medium
91	497	Beach Haven	webster	137.20	25	241.6	-0.20	stone	stone	SLOPED	good	Medium
92	507	Beach Haven	Rosemma	243.80	70	299.2	-0.20	stone	stone	SLOPED	good	Medium
93	780	Beach Haven	Julia	178.33	35	213.0	1.20	stone	stone	SLOPED	fair	Medium
94	1029	Beach Haven	Holgate	162.13	70	229.8		stone	stone	SLOPED	good	Medium
95	833	Long Beach Township	Caroline	99.23	60	255.1	1.50	combo	stone	SLOPED	excellent	Medium
96	744	Long Beach Township	Pershing	278.99	60	355.6	1.50	wood	stone	SLOPED	good	Low
97	715	Long Beach Township	Washington	292.67	150	386.3	5.00	stone	stone	SLOPED	good	Low
98	780	Long Beach Township	Cleveland	237.48	275	318.4	2.50	wood	combo	SLOPED	poor	Low
99	366	Long Beach Township	Cleveland-Refuge		60			stone	stone	SLOPED	fair	Low

Table 2-15 Groin Inventory Listing – 1997

2.8 EXISTING UTILITIES.

Utilities. Existing utilities that terminate, cross, or are buried along the beach or study areas are identified in the following listing. Utilities which cross the beach area include approximately six abandoned sanitary sewer outfalls varying in size from 12 in. to 24 in., one operating 48 in. sanitary sewer outfall and seven Trans-Atlantic copper or fiber optic communication cables. None of the other utilities - gas, electric, phone, cable television lines, and water - were found to cross the beach. These utilities are underground or via the utility poles. Most only extended east as far as the landward toe of the dune.

Sewage treatment for Long Beach Island is consolidated under the Ocean County Utilities Authority. Sewage is pumped off the island to be treated on the mainland via 24" and 36" diameter pipes. These two pipes lay side by side on the bottom of Barnegat Bay in the vicinity of the Manahawkin Bay Bridge (Rt. 72 causeway). After treatment, the effluent is pumped from the treatment station on the mainland back to the island via a 48" diameter pipe, which also lays on the bottom of Barnegat Bay in the vicinity of the Rt. 72 causeway. The effluent connects to a 48" outfall extending eastward one mile into the Atlantic Ocean off 5th Street in Ship Bottom. The pipes and outfalls are supported by two 10 ton concrete blocks paired on each side of each pipe or outfall in 50-75 foot intervals. Steel chains and anchors help secure the pipes and outfall, along with the concrete blocks, to the bay and ocean bottom.

There are several formerly used sanitary sewer outfalls located on Long Beach Island. Use of these outfalls ceased when the sanitary sewer system was consolidated and updated under the Ocean County Utilities Authority. The following is a list of known abandoned outfall pipes: 1) An abandoned 14" cast iron outfall beginning at Long Beach Boulevard and South 2nd Street in Surf City and extends approximately 1000 ft. under 2nd Street and into the Atlantic Ocean. The outfall was a part of the old Surf City Borough Sewage Treatment Plant. 2) An abandoned 14" cast iron outfall beginning at Long Beach Boulevard and South 3rd Street extends approximately 1000 ft. under South 3rd Street and into the Atlantic Ocean. The outfall was a part of the old Ship Bottom Borough Sewage Treatment Plant. 3) An abandoned 24" cast iron outfall extends from Long Beach Boulevard and Rhode Island Avenue (82nd Street) to approximately 1000 ft. under Rhode Island Avenue and into the Atlantic Ocean. The outfall was part of the old Long Beach Township Sewage Treatment Plant. 4) An abandoned 24" cast iron outfall extends from Long Beach Boulevard and Massachusetts Avenue (81st Street) to approximately 1000 ft. under Massachusetts Avenue and into the Atlantic Ocean. The outfall was part of the old Long Beach Township Sewage Treatment Plant. 5) An abandoned 12" cast iron outfall beginning underneath Center Street and Bay Avenue extends approximately 1000 ft. under Center Street and into the Atlantic Ocean. The outfall was a part of an old Beach Haven Sewer plant at this location. An abandoned 16" cast iron outfall beginning underneath Nelson and Bay Avenues extends approximately 1000 ft. under Nelson Avenue and into the Atlantic Ocean. The outfall was a part of the old Beach Haven Sewer plant at this location.

2.9 COASTAL PROCESSES

Basic Physical Characteristics. The basic physical characteristics of Long Beach Island are similar to those of many developed barrier islands found along the mid- and southern segments of the Atlantic Seaboard. The island's beach strand is comprised of quartz sand with median grain diameter of roughly 0.35 mm. The intratidal and swash zone, i.e., the foreshore, has a slope of about 1V to 11H and meets the beach berm at an elevation which varies from 7 to 8.5 feet above North American Vertical Datum (NAVD). The astronomical tide range at Long Beach Island is approximately 4.26 feet and mean sea level is about 0.7 feet below NAVD. The widths of the beach berm along the length of the island are highly variable over time, due to the presence of groins. The 99 groins form compartments along the entire developed ocean frontage. Accordingly, the berm' widths alternate from relatively broad to narrow at the ends of the groin compartments as dictated by alternating short-term changes in the directions of littoral transport.

The average beach berm widths along Long Beach Island are about 110 feet but may vary from as narrow as 30 feet too as broad as 140 feet or more. It is also of interest to note that a typical berm feature does not always exist. That is, on occasion, beach profile surveys reveal a continuous, upwardly sloping surface from the water line to the toe of the frontal dune situated at elevation 7 to 8.5 feet above NAVD. An exception to the island's relatively narrow beach berm is found along the northern-most 1 mile of shore located immediately south of the original Barnegat Inlet south jetty. In that area, the berm is relatively broad, having a width of about 200 feet but expanding to as much as 800 feet in the vicinity of the original jetty structure.

The island's oceanside development is fronted by a single dune line which has base widths of 150 to 500 feet, and peak elevations that generally vary from 16 to 21 feet above NAVD. An exception to these basic dune characteristics is found along the area extending about 1/2 mile south of the original Barnegat Inlet south jetty. Along that particular area, a broad series of dunes and hummocks reach elevations as high as 25 to 30 feet above NAVD. Also, there are a few very limited reaches of shore, particularly in the southern end of the developed area, where there is little or no frontal dune. Along the frontal dune, vegetative cover ranges from dense to very sparse and use of sand fences is a common practice, employed by the local authorities, to enhance dune development and to fix the position of the dune line against wind-induced migration. Pedestrian access to the beach strand, over the dune line, is generally provided at street ends. Landward of the frontal dune, the densely developed land area is flat and generally has elevations in the range of 4 to 6 feet above NAVD.

Winds, Waves, Tides, and Storm Surges. Given its north-northeast alignment, Long Beach Island has a direct exposure to normal oceanic conditions as well as storm tides and waves which are generated over a broad sector of Atlantic Ocean from north-northeast to south-southwest. These natural agents and the primary generating force of wind, to which the study area is exposed, are discussed in the following subsections of this report. The resulting effects of these natural agents on the study area′s beach and dune system, in large measure, dictate the degree of damage-potential which exists in the study area, and the type and extent of additional shore protection necessary to effectively reduce the existing damage-potential to economically efficient levels of risk.

Winds. Data on prevailing winds over the ocean areas between New York Harbor Entrance and the Entrance to Delaware Bay, as published by the U.S. Navy Hydrographic Office, have been evaluated for the 10-year period 1932-1942, see USACE/Philadelphia, 1974 [Ref. 2]. These data show that, in the 5-degree quadrangle nearest the New Jersey coast, the winds over the offshore areas are distributed with respect to duration as follows: **onshore** (northeast, east and southeast winds), 27 percent; **upshore** (south winds), 11 percent; **offshore** (southwest, west and northwest winds), 44 percent; **downshore** (north winds), 15 percent; and **calms**, 3 percent. Analysis of onshore winds recorded during the period 1923-1952 at Atlantic City, New Jersey, only 12 miles from the south end of Long Beach Island, shows that the prevailing winds are from the south and of moderate velocity of from 14 to 28 miles per hour, USACE/Philadelphia, 1990 [Ref. 1]. Winds from the northeast have the greatest average velocity of about 20 miles per hour. The wind data for this period also show that winds in excess of 28 miles per hour occur from the northeast more than twice as frequently as from any other direction.

The maximum five-minute average wind velocity at Atlantic City was recorded during the hurricane of September 1944, registering a value of 82 miles per hour from the north. Over the period 1960-1984, the fastest wind speed of 63 miles per hour was measured at the Atlantic City Marina during the passage of Hurricane Doria in August 1971. These statistics indicate that the most extreme winds occur with the relatively infrequent passage of hurricanes near the study area. However, of equal and perhaps more significance as regards effects on the shores of Island Beach, are the high winds associated with common, yearly occurrences of extratropical cyclones, i.e., northeasters.

An analysis was conducted to determine the frequency of storm winds in the general study area based on Atlantic City records for the period 1936-1958, USACE/Philadelphia, 1974 [Ref. 2]. The basic index used in that analysis was "storm-hours," defined as a one-hour period in which wind velocities equaled or exceeded 32 miles per hour and which occurred during a 24-hour period when the average wind velocity was 25 miles per hour or higher. The analysis found that the number of storm-hours during each year varied from 101 to 293 with an average of approximately 175, and that the preponderance of these storm winds were blowing in the onshore directions from the north-east to south sector of the ocean. These results suggest that the study area could experience roughly 4 to 12 full days of storm activity during any year, an inference which is supported by the record of storm occurrences affecting Island Beach in the 12-year period 1962-1973, USACE/Coastal Engineering Research Center (CERC), 1980 [Ref. 3]. In that period, 77 storm events, some of which had duration′s greater than 24 hours, affected Island Beach. Therefore, in terms of the number of storm events from 1962 through 1973, the average annual storm exposure at Island Beach was 6 to 7 storms, with the average duration in excess of 24 hours.

An analysis of the recent Wave Information Studies Hindcast "Hindcast Wave Information for the U. S. Atlantic Coast: Update 1976 - 1993 with Hurricanes" (Wave Information Study (WIS) Report 33) prepared by Brooks et al., 1995 [Ref. 33] was performed to obtain insight into average wind conditions. WIS Station 70 centered off of Barnegat Inlet was selected for the Study area. **Tables 2-16 and 2-17** provide information on monthly distribution of wind magnitude and direction. The maximum wind speed over the time period analyzed was approximately 32 m/sec (72 mph) on 13 March 1993 from a direction of 95 degrees with respect to true north. The tables indicate the predominant wind direction is from 270 degrees or blowing offshore; however, there is no way to directly infer from these tables which direction bands contain the larger wind magnitudes.

Waves. The earliest recorded wave statistics for the region are based on limited visual observations made at Barnegat Light between July and October in 1939, USACE/Philadelphia, 1974 [Ref. 2]. The results of those observations gave an average nearshore significant wave height of 2.7 feet and a maximum wave height of 13 feet, with 12 percent of the observed waves having significant heights greater than 5 feet. Significant wave heights are defined as the average height of the highest one-third of the waves observed for a specified time period. Wave periods, during the 1939 observation, ranged from 6 to 11 seconds.

Results of the first detailed studies of wave characteristics in waters off the New Jersey coast were reported in 1958, and were based on computational (hindcasting) procedures utilizing synoptic weather information, USACE/BEB, 1958 [Ref. 4]. The results of those studies gave an average significant wave height of about 2 feet, and expected annual storm wave heights of 11 to 12 feet. Average wave periods were computed at approximately 8 seconds. The highest waves were found to approach the coast most frequently from the east-northeast. The 1958 report also provided information on swells based on the analysis of shipboard observations documented by the U.S. Navy Hydrographic Office. These data showed that swells of 6 to 12 feet in height approach the coastline from the east, while swells over 12 feet in height come predominantly from the easterly and southerly quadrants of the sea.

Table 2-16. WIS Station 70 Occurrences of Wind Speed by Month for all Years (1976-1993)										
Wind Speed (m/sec)	**0.00-2.49**	**2.50-4.99**	**5.00-7.49**	**7.50-9.99**	**10.00-12.49**	**12.50-14.99**	**15.00-17.49**	**17.50-19.99**	**> 20.00**	**TOTAL**
JAN	122	905	851	1101	566	541	204	143	31	**4464**
FEB	78	877	792	1124	501	425	123	98	54	**4072**
MAR	123	1012	891	1211	547	396	149	104	31	**4464**
APR	223	1287	903	1093	435	299	63	17	.	**4320**
MAY	433	1714	1125	864	215	103	10	.	.	**4464**
JUN	494	1952	1084	657	98	31	4	.	.	**4320**
JUL	671	2341	951	435	59	7	.	.	.	**4464**
AUG	837	2276	887	385	53	17	3	5	1	**4464**
SEP	578	1904	934	693	148	55	3	1	4	**4320**
OCT	382	1435	982	1067	348	194	34	16	6	**4464**
NOV	170	1067	898	1132	537	384	74	46	12	**4320**
DEC	100	993	863	1188	586	464	138	87	45	**4464**
TOTAL	**4211**	**17763**	**11161**	**10950**	**4093**	**2916**	**805**	**517**	**184**	**52600**

Table 2-17. WIS Station 70 Occurrences of Wind Direction by Month for all Years (1976-1993)									
Direction Band	**337.50 - 22.49**	**22.50 - 67.49**	**67.50 - 112.49**	**112.50 - 157.49**	**157.50 - 202.49**	**202.50 - 247.49**	**247.50 - 292.49**	**292.50 - 337.49**	**TOTAL**
Center of Band	**(0.0)**	**(45.0)**	**(90.0)**	**(135.0)**	**(180.0)**	**(225.0)**	**(270.0)**	**(315.0)**	
JAN	541	340	285	213	383	526	820	1356	**4464**
FEB	602	397	283	255	323	544	556	1112	**4072**
MAR	716	392	346	331	556	597	543	983	**4464**
APR	532	351	306	504	561	590	591	885	**4320**
MAY	481	416	387	401	728	810	621	620	**4464**
JUN	427	288	211	289	724	1054	706	621	**4320**
JUL	435	254	252	354	581	1155	775	658	**4464**
AUG	501	445	386	310	607	1014	634	567	**4464**
SEP	587	597	463	375	468	737	560	533	**4320**
OCT	513	635	337	348	519	650	635	827	**4464**
NOV	497	363	356	296	459	652	731	966	**4320**
DEC	544	244	255	221	403	708	823	1266	**4464**
TOTAL	**6376**	**4722**	**3867**	**3897**	**6312**	**9037**	**7995**	**10394**	**52600**

General wave statistics for the study area shorelines are presented in a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, et al., 1993. The revised WIS data is also available digitally through the Coastal Engineering Data Retrieval System developed by the U.S. Army Engineer Coastal Engineering Research Center. WIS Report 30 and information in CEDRS provides revised wave data for 108 locations along the U. S. Atlantic coast, and supersedes WIS Report 2 (Corson, et al. 1981), WIS Report 6 (Corson, et al. 1982) and WIS Report 9 (Jensen 1983). The wave information for each location is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975, exclusive of hurricanes, and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Wave heights are universally higher for the revised hindcast than for the original hindcast since the values more closely correspond to maximum measured (buoy) values. A separate report (WIS Report 19) documents hindcast wave information for Atlantic Coast hurricanes during the 1976-1995 time period.

The most recent analysis of general wave statistics for the study area shoreline covers the time period of 1976 - 1993 and is presented in WIS Report 33. To better represent a realistic wave climate, tropical storms and hurricanes were included in the 1976-1993 hindcast. The update hindcast was performed using an updated version of WISWAVE 2.0, referred to as WISWAVE. Extratropical and tropical events were analyzed separately, but combined to form complete time series and annual statistics. The hindcast has recently been updated to extend through 1995; however, the methods and resulting statistics have not been documented to date.

Hindcast results are available as time series every 3-hr for the 20-yr period or as tabular summaries. WIS Reports 30 and 33 contains tables presenting the distribution of spectral wave height, peak period and peak mean direction by month for the 20-yr period; the number of occurrences by 0.5-m height and 1-sec period categories for eight different direction bands and a final table for all directions and finally summary tables of mean and maximum wave heights by month for each of the 20 years hindcast. These tables also include the peak period and peak mean wave direction associated with the maximum wave height occurrence.

The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate at Island Beach. The wave statistics pertinent to the Long Beach Island study are those derived for Station 70. The location of Station 70 is Latitude 39.75 N, Longitude 74.00 W, in a water depth of approximately 59 ft (**Figure 2-5**). Monthly mean wave heights at Station 70 for the entire 1956-1975 hindcast range from 2.3 ft in July to 4.3 ft in January. Mean wave heights for the 1976-1995 hindcast are slightly larger, ranging from 2.3 ft in July to 5.2 ft in March. The maximum wave height (H_{mo}) at Station 70 for the 1956 - 1975 hindcast is reported as 23.0 ft, with an associated peak period of 15 seconds and a peak direction of 94 deg on 7

March 1962. Maximum wave conditions for the 1976-1993 hindcast are reported as 27.6 ft, with an associated peak period of 13 seconds and a peak direction of 115 degrees on 27 September 1985. Summary Statistics for WIS Station 70 are provided in **Table 2-18** for the years 1976-1995.

The actual wave spectrum experienced at any particular time along the project shoreline may show considerable local variation. This variability is largely due to the interaction of incident waves with: tidal currents at Barnegat and Little Egg Inlets, ebb shoal morphology at the two inlets, local shoreline alignment, nearshore bathymetry, and presence of shoreline stabilization structures. Therefore, the hindcast wave statistics should be viewed as a very general representation of the wave climate of the study area offshore. Inshore of the 60 ft depth, the effects enumerated above will modify the incident waves such that significant alongshore differences may exist with respect to breaking wave height and angle relative to the shoreline. Computer programs that transform offshore waves over varying bathymetry must be used to further investigate wave conditions closer to the shoreline.

Prototype wave data has been collected at Barnegat Inlet as part of the Monitoring of Completed Coastal Projects Program. Wave data collection at Barnegat Inlet was initiated May 1994. A directional wave gage (DWG) was deployed approximately 4000 ft off the south jetty tip, located in 43 ft of water seaward of the ebb shoal **(Figure 2-5)** for one year. Preliminary analysis of the first years worth of data (May 1994 - March 1995) resulted in an average wave height (Hs_{avg}) of 2.5 ft, an average peak period of 8.9 seconds, and an average mean direction of 128 degrees. Maximum wave conditions were measured on 23 September 1994. The maximum significant wave height of 12.6 ft had a corresponding peak period of 8.5 seconds and mean direction of 104 degrees. Another event (24 December 1994) had a slightly smaller wave height of 11.4 ft with a significantly longer peak period of 14.2 seconds. A nearshore wave gage, located in approximately 17 ft of water 200 ft off of the south jetty, recorded non-directional wave data every 3 hours from May 1994 through June 1995. Analysis of the first 6 months of Insert

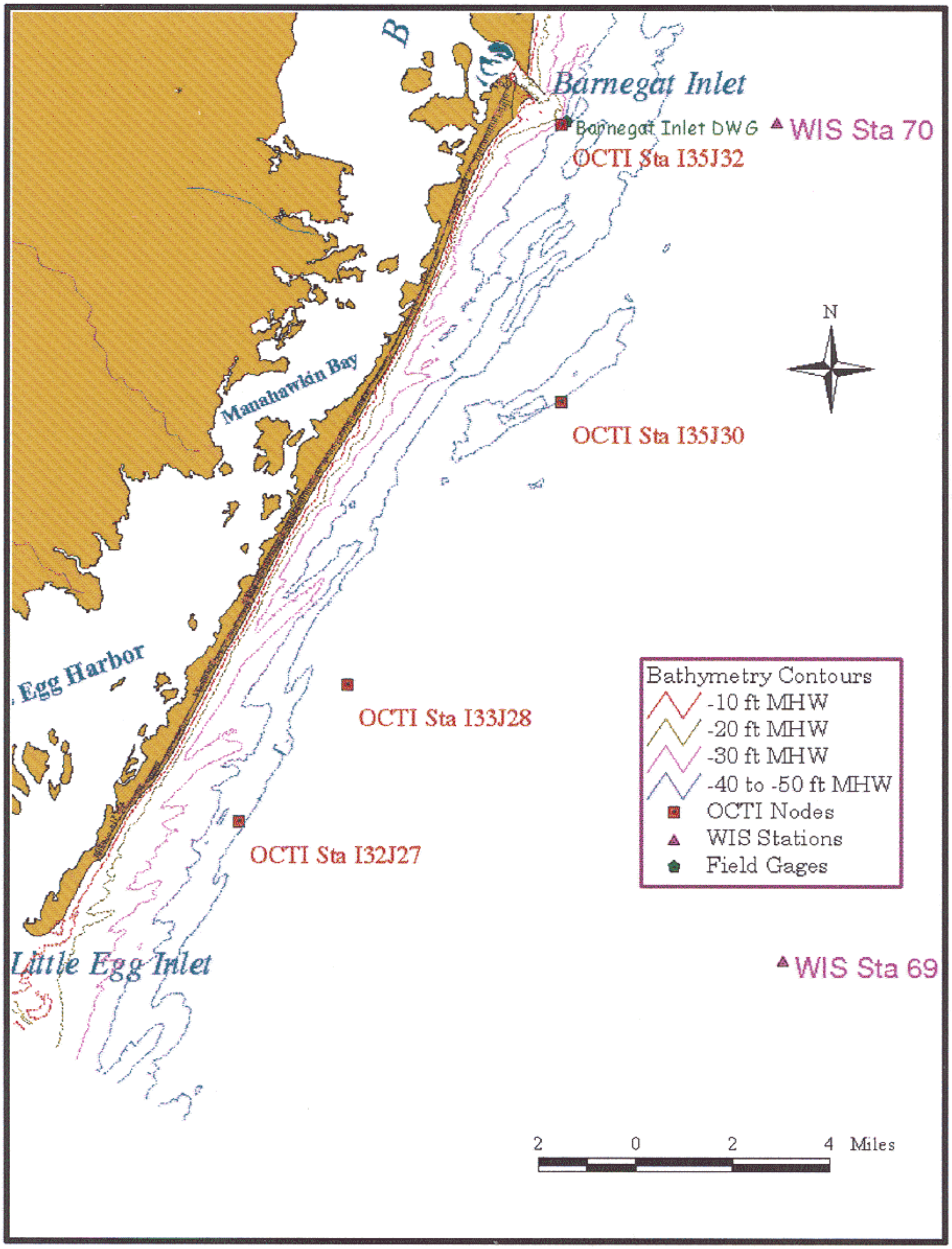


Figure 2-5. LBI Wave Hindcast Station and Field Wave Gage Locations.

Table 2-18
WIS Station 70 Summary Wave Statistics (1976-1995).

MEAN WAVE HEIGHT (IN FEET) BY MONTH AND YEAR STATION A2070 (39.75N/74.00W/59 ft)													
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**
1976	5.2	5.2	5.2	4.3	4.3	3.3	2.3	3.9	3.0	5.2	4.3	4.3	**4.3**
1977	4.9	4.3	4.9	4.3	2.6	3.0	2.3	2.3	3.0	4.9	6.2	5.6	**3.9**
1978	6.6	4.3	5.2	4.9	4.9	3.3	2.6	2.3	3.9	3.9	4.6	4.3	**4.3**
1979	6.6	6.2	6.2	4.9	4.3	2.6	2.3	2.6	4.9	3.3	4.6	5.6	**4.6**
1980	6.2	4.6	6.9	5.6	3.0	2.6	2.6	3.6	3.6	4.6	4.9	5.9	**4.6**
1981	4.6	7.9	5.2	5.2	5.2	2.6	3.3	2.6	4.9	4.3	5.2	4.3	**4.6**
1982	4.9	4.6	3.6	4.3	3.3	3.6	1.6	2.0	3.3	4.6	4.3	3.6	**3.6**
1983	4.9	5.6	5.9	4.6	3.9	2.6	2.3	2.0	3.3	5.2	4.6	6.2	**4.3**
1984	4.9	5.6	6.9	4.6	3.9	3.0	2.6	2.0	3.0	4.3	4.9	4.3	**4.3**
1985	4.6	5.2	4.6	4.3	3.6	2.6	2.3	2.3	3.6	3.0	5.9	3.9	**3.9**
1986	5.6	4.6	5.2	5.2	3.9	3.3	2.0	2.6	3.9	3.6	4.3	5.6	**4.3**
1987	5.2	4.6	5.6	6.2	3.6	2.6	2.0	2.6	3.0	3.9	4.6	3.6	**3.9**
1988	3.9	4.6	3.9	4.3	3.6	3.0	2.6	2.6	3.3	3.9	3.9	3.6	**3.6**
1989	3.9	4.3	5.6	3.9	4.3	2.6	2.3	3.6	6.9	3.9	4.9	4.3	**4.3**
1990	3.9	4.6	4.3	4.6	3.9	3.6	3.0	3.6	4.3	4.6	3.6	4.9	**3.9**
1991	4.3	3.6	4.9	3.9	2.6	2.6	2.6	3.0	3.9	4.3	4.3	4.3	**3.6**
1992	4.9	4.3	4.9	3.0	3.6	2.3	2.0	2.3	3.3	3.0	3.3	5.2	**3.6**
1993	4.9	5.2	5.2	5.9	3.3	2.6	2.3	2.6	3.3	3.9	4.9	4.9	**3.9**
1994	3.9	3.3	3.9	3.0	3.0	2.6	2.3	2.3	2.6	2.0	4.3	3.9	**3.0**
1995	4.3	3.0	3.0	2.6	2.6	3.0	2.0	3.9	3.9	3.6	4.3	3.6	**3.3**
MEAN	**4.9**	**4.9**	**5.2**	**4.6**	**3.6**	**3.0**	**2.3**	**2.6**	**3.6**	**3.9**	**4.6**	**4.6**	

LARGEST WAVE HEIGHT (IN FEET) BY MONTH AND YEAR STATION A2070 (39.75N/74.00W/59 ft)												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1976	12.1	13.8	13.1	10.5	10.5	7.2	4.9	18.7	7.9	12.1	9.5	9.5
1977	14.1	15.1	14.1	13.1	6.6	11.5	7.2	6.2	9.2	11.8	16.7	17.7
1978	19.0	14.4	14.8	17.1	13.8	9.8	8.9	6.9	8.9	10.5	12.8	11.5
1979	20.0	21.3	18.4	14.1	8.5	6.6	5.9	8.2	12.1	8.9	13.8	12.1
1980	21.3	16.1	19.7	13.8	9.2	6.2	5.2	12.1	8.2	22.6	11.8	17.1
1981	10.2	21.7	15.4	12.8	11.2	7.2	8.9	6.9	12.5	8.2	18.0	12.1
1982	14.1	15.7	9.8	12.5	6.9	8.9	4.3	6.6	9.5	19.7	12.1	9.8
1983	15.7	20.3	18.4	11.8	10.5	6.6	5.6	6.9	9.5	16.1	11.8	19.4
1984	14.1	14.4	19.4	15.7	9.2	8.2	6.9	5.9	7.5	21.0	10.2	9.2
1985	10.2	19.0	12.8	16.1	9.8	7.5	7.5	5.9	27.6	9.8	20.0	11.5
1986	12.1	14.8	16.1	15.7	11.8	9.5	4.6	12.5	9.5	9.5	11.2	24.6
1987	17.1	15.1	17.7	14.8	9.2	6.2	3.9	5.2	7.9	7.9	12.8	12.8
1988	9.2	14.4	8.5	10.8	8.9	8.2	8.2	6.9	8.9	10.2	10.8	8.9
1989	10.8	18.7	15.1	10.8	12.8	5.6	6.9	11.5	25.3	13.1	11.2	9.8
1990	9.5	11.5	13.1	9.8	11.2	8.9	6.9	10.8	9.2	13.8	7.5	11.8
1991	13.1	6.9	10.2	11.5	7.2	8.5	6.9	22.3	22.3	11.8	11.2	9.2
1992	19.0	8.5	11.2	7.9	7.5	6.6	4.9	5.9	11.5	8.9	9.5	18.4
1993	14.1	15.1	16.7	11.8	6.6	5.6	5.6	8.5	14.4	14.8	19.0	13.8
1994	12.1	9.5	17.4	6.6	11.2	8.9	5.9	5.6	10.2	7.9	13.8	15.4
1995	12.5	7.5	9.5	8.9	7.2	7.2	3.9	12.8	10.2	12.8	18.7	10.5

MEAN SPECTRAL WAVE HEIGHT (FEET)	3.9
MEAN PEAK WAVE PERIOD (SECONDS)	7.7
MOST FREQUENT 22.5 DEGREE (CENTER) DIRECTION BAND (DEGREES)	90.0
STANDARD DEVIATION OF WAVE Hmo (FEET)	2.6
STANDARD DEVIATION OF WAVE TP (SECONDS)	3.0
LARGEST WAVE Hmo (FEET)	27.6
WAVE TP ASSOCIATED WITH LARGEST WAVE Hmo (SECONDS)	13.0
PEAK DIRECTION ASSOCIATED WITH LARGEST WAVE HS (DEGREES)	115.0
DATE LARGEST Hmo OCCURRED	9/27/85 18:00

data (May 1994 - January 1995) resulted in an average significant wave height of 2.4 ft and an average peak period of 8.9 seconds. The September 1994 event showed slight attenuation of the and peak period of 9 seconds. The December 1994 event showed similar attenuation of the wave height by the ebb shoal, resulting in a 7.41 ft wave height. However, the impact of the shoal is seen by the shift in peak period (frequency) from 14.2 seconds offshore to 9.8 seconds nearshore.

Detailed studies have recently been conducted by the USACE Philadelphia District to develop combined wave/water-level frequency relationships for various open coast and estuarine areas within the district boundaries. The analysis relevant to the Long Beach Island area involved hindcasting by means of a two-dimensional wave model and statistical analyses related to 30 storms of record, for which time histories of wave characteristics were developed. The selected storm record included 15 hurricanes and 15 northeasters that generated major surges and/or waves along the study area. Several output nodes were analyzed for the Study reach with detailed analyses performed for OCTI Station I35J30 centrally located in the study reach and south of WIS Station 70 **(Figure 2-5)**. Details of the analysis will be presented later in this report in the subsection dealing with assessment of storm effects and damage parameters. Suffice it to mention at this point, that hindcasted significant wave heights for the 15 hurricanes of record varied from about 8 feet to 19 feet, with wave periods ranging from 7 to 14 seconds. In the case of the 15 major northeasters that were evaluated, significant wave heights varied from about 9 feet to 22 feet, with wave periods ranging from 10 to 17 seconds. It will be noted that in the study area, the storm waves having the greatest heights as well as the longest periods are associated with northeasters. The same relationship also obtains for the magnitudes of storm surges. The fact that northeasters represent the most intense storm conditions experienced in the study area reflects a recorded history which is absent of an event in which a hurricane has made a direct landfall at or proximate to Long Beach Island. **Figure 2-6** contains histograms that graphically summarize the distribution of wave conditions (Height, Period, and Direction) for OCTI Station I35J30. The Wave Roses shown in **Figure 2-7** further illustrate the directional distribution of wave height and period, showing the larger wave heights and periods originate from the northeast and southeast.

Tides. The tides affecting the study area are classified as semi-diurnal with two nearly equal high tides and two nearly equal low tides per day. The average tidal period is actually 12 hours and 25 minutes, such that two full tidal periods require 24 hours and 50 minutes. Thus, tide height extremes (highs and lows) appear to occur almost one hour (average is 50 minutes) later each day. The mean tide range for the Atlantic Ocean shoreline is reported as 4.29 feet at Seaside Heights in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 5.15 feet. Barnegat Inlet and the back bay areas adjacent to the study area show a large attenuation of the tide range relative to the ocean shoreline, resulting in a mean tide range of approximately 0.5 ft throughout Barnegat Bay.

No official datum relationships have been established for National Ocean Service (NOS) tide gage stations in the project area (open ocean); therefore, interpolation between the nearest NOS stations with datum relationships was required. Two primary NOS stations are nearly equidistant to the study area, with one gage located south of the area at Atlantic City, NJ and the other to the north at Sandy Hook, NJ. An additional secondary station is located in Long Branch, NJ. Interpolation between Atlantic City and Long Branch data, with consideration of Sandy Hook data, resulted in NAVD being approximately 2.9 ft above mean lower low water (MLLW) and approximately 1.5 ft below mean high water (MHW) for Barnegat Inlet (**Table 2-19**). Recent analyses have been conducted to establish datum relationships in the vicinity of Barnegat Inlet. Several tide gages were installed on the open Ocean and in Barnegat Bay for a 2-month period in the Fall of 1996. Resulting datum relationships for the Ocean gage are also presented in **Table 2-19**. The computed tidal range value of 4.26 ft. compares will with the NOS reported value of 4.29 ft. for Seaside Heights, NJ, located just north of the LBI project area.

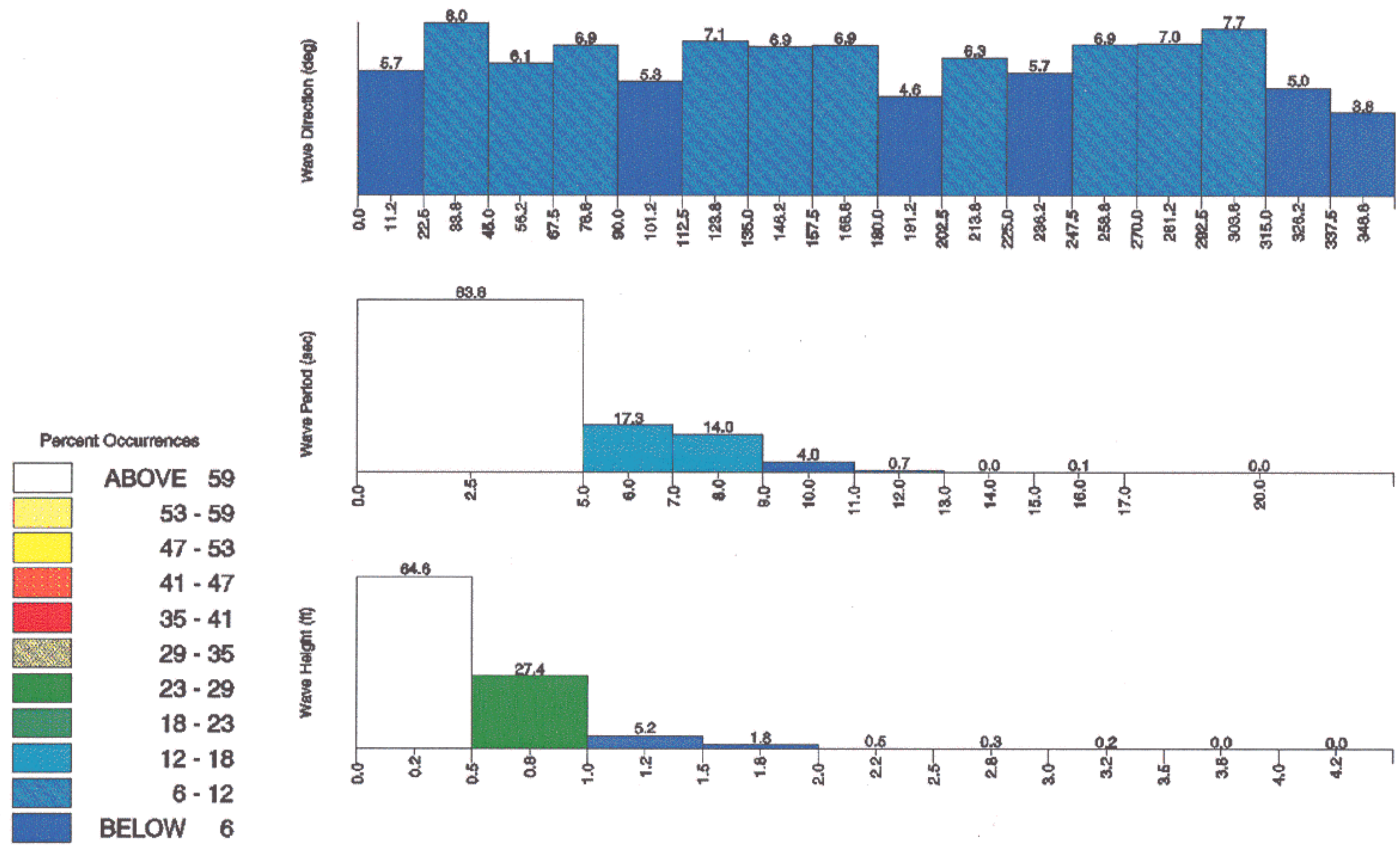


Figure 2-6 OCTI Station I35J30 Wave Histograms (**update to show revised I35J30 data**)

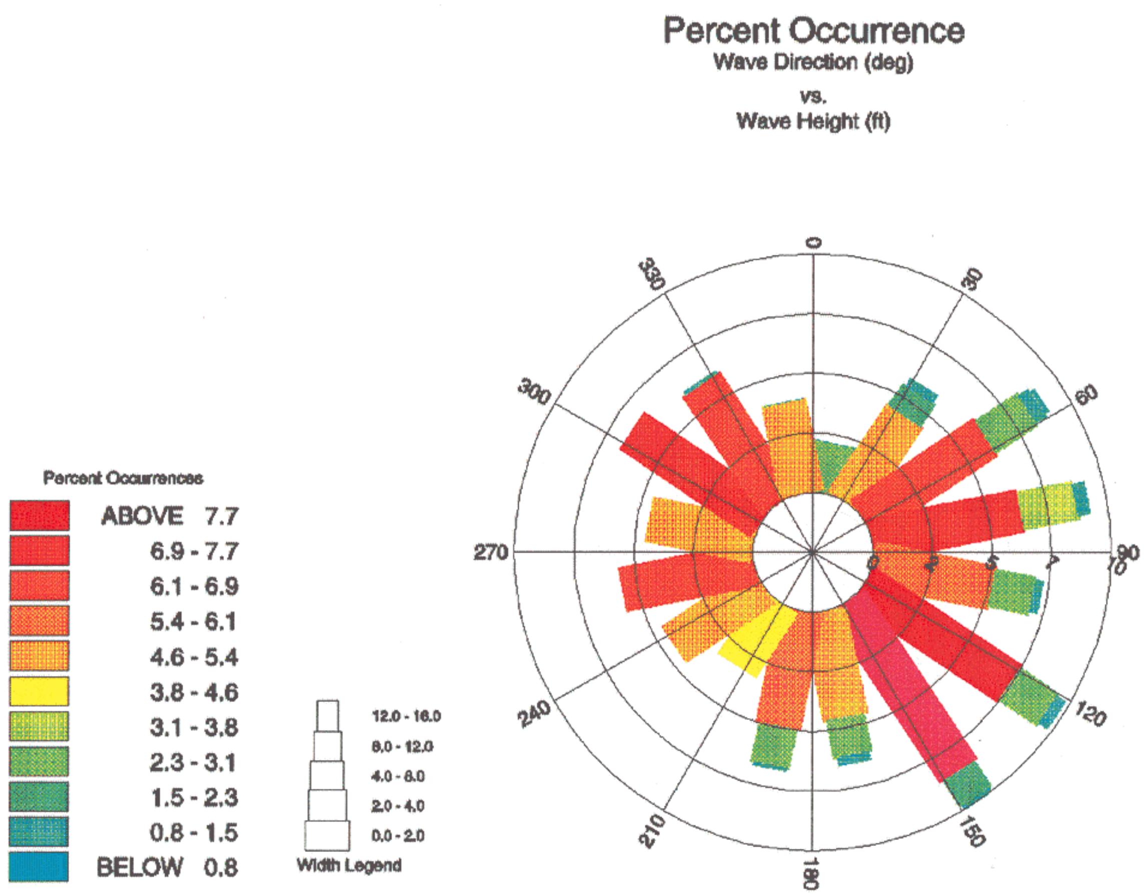


Figure 2-7 OCTI Station I35J30 Wave Roses (update to show revised I35J30 data)

Storm Surges. The study area experiences events each year in which meteorological effects generate water levels exceeding the levels of predicted astronomical tides. As noted previously in regard to wave characteristics, the USACE Philadelphia District recently completed studies to establish wave and water-level frequency relationships for the open coast and estuarine areas within the district. Time histories of storm tides have been hindcasted for the areas of interest by means of a two-dimensional storm surge model along with associated wave hindcasting. Time histories of storm-induced water levels were developed for the same 30 storms and at the same computational stations used in the companion wave analysis. As noted previously, several computation stations exist along Island Beach. The details of the surge hindcast results will be presented in a later subsection of this report, along with comparable wave information. The general results for the study area were the development of water level histories for 30 extreme events for which the combined surge and astronomical tides had peak elevations ranging from as low as 3.4 feet above NAVD to as high as 8.4 feet above NAVD. The highest computed elevation value of +8.4 feet NAVD is related to a hurricane that passed the study area on August 18, 1899. A storm tide however, with almost an equivalent peak water level value, i.e., +8.0 feet NAVD, was computed for the unusually severe northeaster that devastated the mid-Atlantic coastline between the 5th and 8th days of March 1962. Indeed, the history of extreme events that have affected Island Beach demonstrates that in terms of both wave action and surge levels, northeasters have, in the main, been the most intense type of storm affecting the study area. For example, in the case of the 15 hurricanes of record referenced above, the average of the highest significant wave heights amounted to 13.7 feet and the average of the peak water surface elevations was +4.8 feet NAVD. By comparison, the computed values for the 15 severe northeasters that were examined give the average of the highest significant wave heights as 16.9 feet, and the average of peak water surface elevations as +6.3 feet NAVD.

An evaluation of extreme water levels in Barnegat Bay was also performed to determine potential flooding along the back bay shorelines. Several tide gages located throughout Barnegat Bay, including one located at Loveladies, have been used to assess the potential impact of Barnegat Inlet′s south jetty realignment on tidal conditions throughout Barnegat Bay. Mean tidal ranges have increased slightly throughout the Bay. Additional efforts were performed as part of the Seaside Park Reconnaissance Study (1995) to establish stage frequency curves within the Bay for flood damage analysis. The resulting still water levels ranged from 1.2 ft NAVD to 6.7 ft NAVD for the 2- and 500-year recurrence intervals, respectively.

Sea Level Rise. Relative mean sea level, on statistical average, is rising at the majority of tide gage locations situated on continental coasts around the world (National Research Council (NRC), 1987; Barth and Titus, 1984). Although local levels are falling in some areas, sea level is predominantly increasing with rates ranging from 0.04 to 0.20 in/yr (NRC, 1987).

TABLE 2-19. Tidal Data and Datum Relationships for Barnegat Inlet to Little Egg Inlet Feasibility Study

	Atlantic City	**Barnegat Inlet (field study)**	**Barnegat Inlet (interpolated ocean)**	**Long Branch**	**Sandy Hook**
Tidal epoch (years data)	1960 - 1978 (1911-present)	1996 (27 Sep - 6 Nov)	N/A	1960-1978 (78-79,81-84)	1960-1978 (1910-present)
Latitude Longitude	39 deg 21 min N 74 deg 25 min W	39 deg 45 min N 74 deg 05 min W	39 deg 45 min N 74 deg 05 min W	40 deg 18 min N 73 deg 59 min W	40 deg 28 min N 74 deg 01 min W
Distance from AC	0 miles	34 miles	34 miles	70 miles	80 miles
MHHW	4.68	4.74	4.90	4.92	5.20
MHW	4.25	4.43	4.51	4.56	4.86
NAVD 88	2.97	2.94	2.94	2.86	2.90
MTL	2.20	2.37	2.34	2.38	2.53
NGVD	1.64	1.68	1.70	1.77	1.77
MLW	0.16	0.17	0.18	0.18	0.20
MLLW	0.00	0.00	0.00	0.00	0.00
Tidal Range (MHW-MLW)	4.09	4.26	4.33	4.38	4.66
Tide Tables					
Mean Range	4.09	N/A	*4.33*	4.38	4.66
Spring Range	4.95	N/A	*5.23*	5.26	5.60

* Elevation Units in ft

** NAVD 88 is 1.26 ft above NGVD based on CORPSCON Datum Conversion Program using Barnegat Inlet Coordinates

Major implications of a rise in sea level are increased shoreline erosion and coastal flooding. Other issues include the change in extent and distribution of wetlands and salinity intrusion into upper portions of estuaries and into groundwater systems. Although there is substantial local variability and statistical uncertainty, average relative sea level over the past century appears to have risen about 1 ft relative to the East Coast of the United States.

The risk of accelerated mean sea level rise as a contributing factor to long-term erosion and increased potential for coastal inundation is sufficiently documented to warrant consideration in the planning and design of coastal projects. Because of the enormous variability and uncertainty of the climatic factors that affect sea level rise, however, predicting future trends with any certainty is difficult. Many varying scenarios exist for future sea level rise. Engineer Regulation 1105-2-100 states that the potential for relative sea level change should be considered in every coastal and estuarine (as far inland as the new head of tide) feasibility study that the Corps undertakes and that the National Research Council study, Responding to Changes in Sea Level: Engineering Implications, 1987, be used until more definitive data become available. Corps of Engineer's policy calls for consideration of designs that are most appropriate for a range of possible future rates of rise. Strategies, such as beach fills which can be augmented in the future as more definitive information becomes available, should receive preference over those that would be optimal for a particular rate of rise, but unsuccessful for other possible outcomes. Potential sea level rise should be considered in every coastal study, with the degree of consideration dependent also on the quality of the historical record for the study site. Based on historical tide gage records at Atlantic City and Ventnor, NJ, sea level has been rising at an approximate average of 0.013 ft/yr (Hicks and Hickman, 1988). Over the proposed fifty year project life, it is assumed that sea level will rise by approximately 0.66 ft. This potential rise in sea level was incorporated into the ocean stage frequency analysis for the Atlantic City gage and in other project design aspects such as nourishment quantities.

Alongshore Sediment Transport. Alongshore or littoral transport can both supply and remove sand from coastal compartments. In order to determine the balance of sediment losses and gains in a system, net, rather than gross, transport rates are required. Net longshore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction.

A number of studies, beginning in the 1950's, have been conducted by the USACE which examined the magnitude and direction of alongshore sediment transport at Long Beach Island and the adjoining shores. A summary of the various results of these past Corps sediment transport estimates is presented in **Table 2-20**.

The values in **Table 2-20** indicate that gross alongshore sediment transport may vary from as low as 1/2 million to almost 2 million cubic yards per year and that, generally, there is a net southward transport which may vary from 50 to about 400 thousand cubic yards per year.

Though there is a trend in the estimates for the net alongshore transport to be in the southward direction, the estimated differences between north and south transport quantities are not extremely large with respect to the gross sediment transport values. Hence, it can be expected that reversals in alongshore sediment transport contribute significantly to both the short- and long-term behavioral patterns of the Long Beach Island shoreline. This is manifestly evident in the reversing patterns of north-side and south-side accretion at and in the vicinity of the individual groins along the length of the island. Depending on the duration of the antecedent incident wave directions and intensities, a specific pattern may exist for an extended period time or change in a matter of a day or so.

Table 2-20

PRIOR USACE ESTIMATES OF ALONGSHORE SEDIMENT TRANSPORT
(LONG BEACH ISLAND, NJ, AND VICINITY)

Location or Reach	Method	Data Source	Database	Gross Transport (cy/yr) North	Gross Transport (cy/yr) South	Net Transport (cy/yr)
Barnegat Inlet	Wave hindcast & Energy flux-method	CERC TM-18				50,000 S
	Wave hindcast & Energy flux-method	WES (1979)	1972-1975	720,000	860,000	140,000 S
			1972	1,000,000	890,000	110,000 N
			1973	540,000	700,000	160,000 S
			1974	780,000	930,000	150,000 S
			1975	560,000	930,000	370,000 S
		CERC (1967)	1838-1953	500,000	550,000	50,000 S
		CENAP (1954)	1939-1941			250,000 S
	Wave hindcast & Energy flux-method	CERC MP 89-11	1956-1975			415,000 S
Long Beach Island	Historic	Caldwell (1966)	1838-1953	500,000	550,000	50,000 S
	Profile Analysis	CERC MR 80-9	1962-1973			150,000 S
		CENAP House Doc # 94-631 Grp III	1974	250,000	300,000	50,000 S

The majority of the historic alongshore transport analyses performed in the vicinity of the project area have focussed on the adjacent inlets, with only two studies reported for the central portions of Long Beach Island. The wide variation in results as shown in **Table 2-20** coupled with the lack of data for the main reaches of Long Beach Island warranted further investigation. A longshore transport analysis was conducted for the study area using the energy flux method-with longshore energy flux and transport rate expressions taken from the Shore Protection Manual (SPM Equations 4-39 and 4-49). Recent wave hindcast data from OCTI Station I35J30 (1987-1996) were used along with average shoreline angles for several communities on Long Beach Island to briefly examine alongshore transport trends. The methodology used is very sensitive to shoreline angle and results should only be examined for general transport trends. Results of this analysis shown in **Table 2-21** determined a potential net transport to the north for all communities with an average net transport rate to the south of approximately 95,000 cu yd/yr for the entire reach. Potential net transport rates decreased from the southern part of the study south of Loveladies. The large gradient in transport between Beach Haven Borough and Holgate implies that more sediment is being removed from the Holgate area than is being supplied, resulting in a relatively highly erosive shoreline as evidenced in shoreline positions observed over the same time period. The results displayed in **Table 2-21** consist of "potential" sediment transport rates based on the computed wave energy and its angle with respect to the shoreline, assuming an unlimited supply of sediment. A calibration constant was selected to provide the most reasonable sediment transport values. Actual sediment transport rates for the site may be slightly less when considering the impact of adjacent inlets and coastal structures. Alongshore sediment transport rates were utilized in computing nourishment requirements for with-project conditions as discussed later.

A numerical model study was conducted by the U.S. Army Engineer Waterways Experiment Station's Coastal and Hydraulics Laboratory to assist NAP in evaluating the impact of potential borrow sites on the Long Beach Island shorelines. Details of the study are presented in Appendix A of Section 2. A numerical wave model was used to transform offshore waves to the nearshore zone. The incorporation of nearshore bathymetry, including potential borrow sites, provides more accurate nearshore wave conditions which control the alongshore sediment transport. The study evaluated gradients in the alongshore sediment transport values to estimate shoreline change rates and nourishment requirements for proposed with-project conditions.

TABLE 2-21. Potential Alongshore Sediment Transport Rates along Long Beach Island, NJ

Community	Bundy	Shoreline Angle (deg N)	Sediment Transport Rates (cu yd/yr) NORTH DIRECTED	SOUTH DIRECTED	NET
Barnegat Light	1	39.91	-105,000	175,000	70,000
Loveladies 1	2	26.41	-95,000	200,000	105,000
Loveladies 2	3	21.40	-95,000	210,000	115,000
Harvey Cedars 1	4	21.23	-95,000	210,000	115,000
Harvey Cedars 2	5	26.26	-95,000	200,000	105,000
North Beach	6	29.48	-95,000	190,000	95,000
Surf City	7	31.24	-95,000	185,000	90,000
Ship Bottom	8	31.33	-95,000	185,000	90,000
Brant Beach	9	29.43	-95,000	190,000	95,000
BH Crest to BH Park	10	27.79	-95,000	190,000	95,000
Haven Beach to BH Ga	11	28.64	-95,000	190,000	95,000
Spray Bch to BH boro 1	12	26.96	-95,000	190,000	95,000
BH Boro	13	33.97	-105,000	185,000	80,000
BH Boro 2	14	42.20	-113,000	175,000	62,000
BH Boro, Holgate	15	29.28	-95,000	190,000	95,000
AVERAGE CONDITIONS		**29.70**	**-97,533**	**191,000**	**93,467**

Sed Tran Values Computed using OCTI gage I35J30 with shoreline angles determined from Dec 1997 shoreline.

Bathymetry. An analysis of available offshore and nearshore bathymetric data was conducted to identify important geomorphic features that may impact nearshore wave transformation and resulting sediment transport patterns. A search of the NOS bathymetric database for the study area resulted in limited data available, with the most recent survey being performed in 1954. Near complete coverage of the project area (including Barnegat Bay) exist for the 1930's time period. The only other time period NOS surveyed the area was in 1954. The 1954 NOS survey shown in **Figure 2-8** was conducted in the vicinity of Little Egg and Beach Haven Inlets to document the change in conditions from the 1930's survey due to the opening and closing of Beach Haven Inlet.

Recent beach profile data were overlaid on the NOS bathymetry in an effort to confirm the overall bathymetric features represented by the NOS data set were accurate. Discrepancies along the finger shoals located adjacent to both Harvey Cedars and Brant Beach warranted further investigation. It should be noted such features significantly impact nearshore wave transformation and resulting storm-induced damage and alongshore sediment transport rates. Detailed surveys were conducted in the Fall of 1996 to resolve the nearshore features. The resulting bathymetry (**Figure 2-9**) indicated the features were similar to those observed in the 1930's NOS survey. The overall features had been translated slightly landward with moderate reductions in elevation.

Additional surveys were conducted to characterize the potential borrow sites located in the Study area (see **Figure 2-1**). The resulting survey data combined with vibracore measurements allowed for quantification of quality sediment that can be used in nourishment operations.

Routine surveys have been conducted in the vicinity of Barnegat Inlet since completion of the south jetty as part of the Barnegat Inlet MCCP Study. Surveys of the ebb shoal, flood shoal, and channel conditions aided in evaluating impacts of the construction on sediment bypassing, channel shoaling, and overall ebb and flood shoal feature changes. The survey data were incorporated into numerical bathymetric grids used for simulating wave and current conditions in the vicinity of Barnegat Inlet. **Figure 2-10** display the ebb shoal, flood shoal, and channel conditions for October 1997.

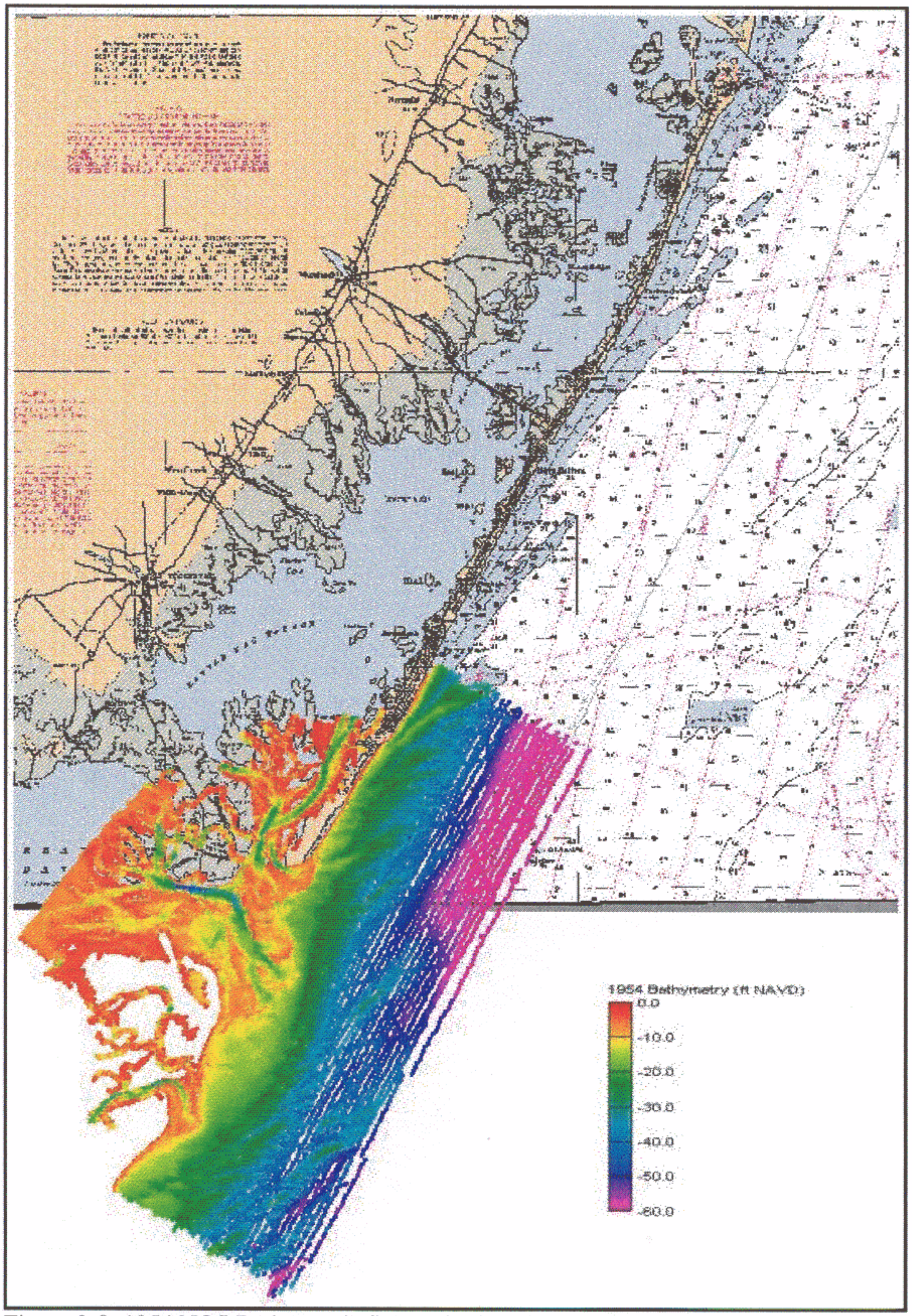


Figure 2-8 1954 NOS Bathymetric Survey in the Vicinity of Little Egg and Beach Haven Inlets, NJ.

79

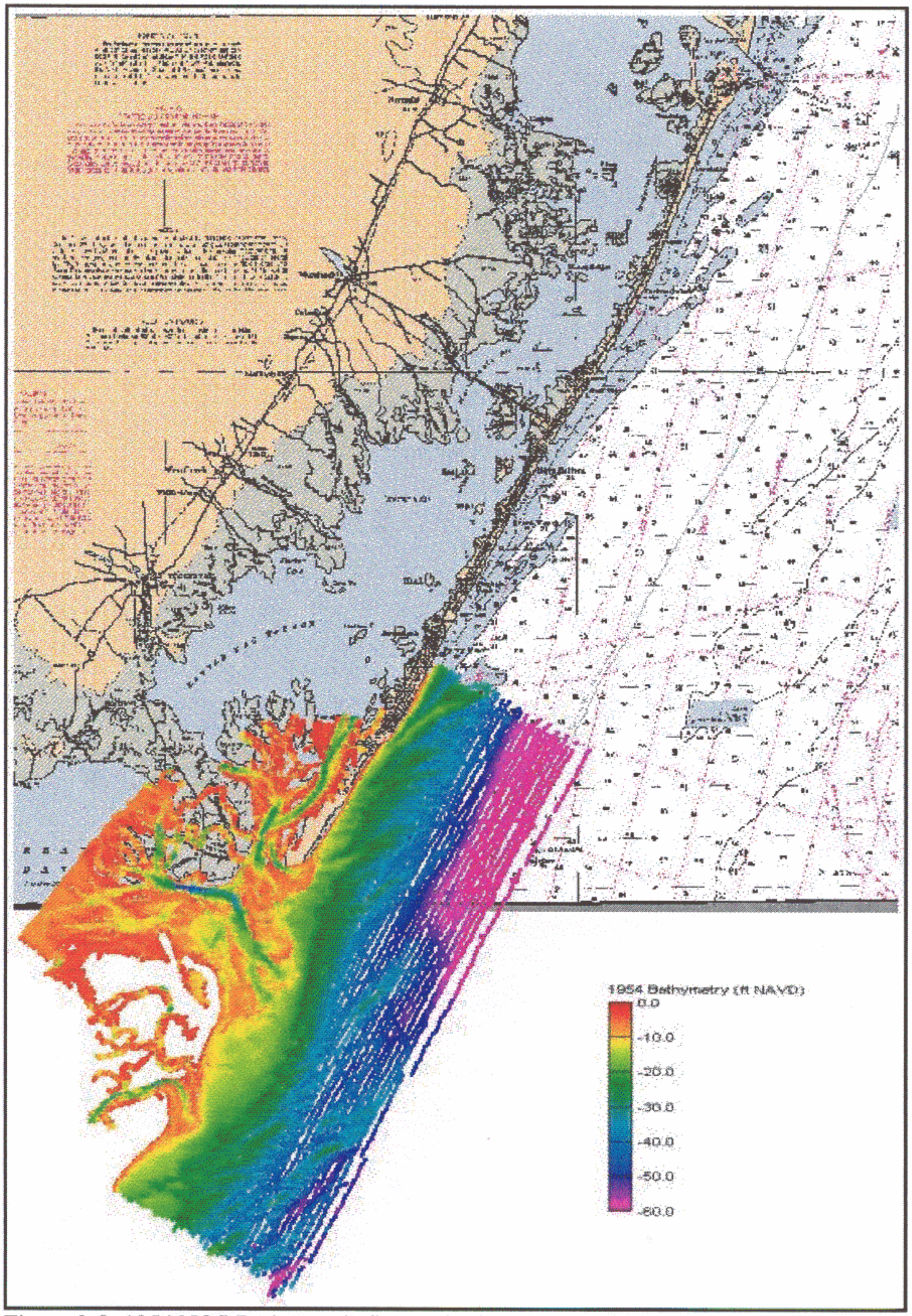


Figure 2-8 1954 NOS Bathymetric Survey in the Vicinity of Little Egg and Beach Haven Inlets, NJ.

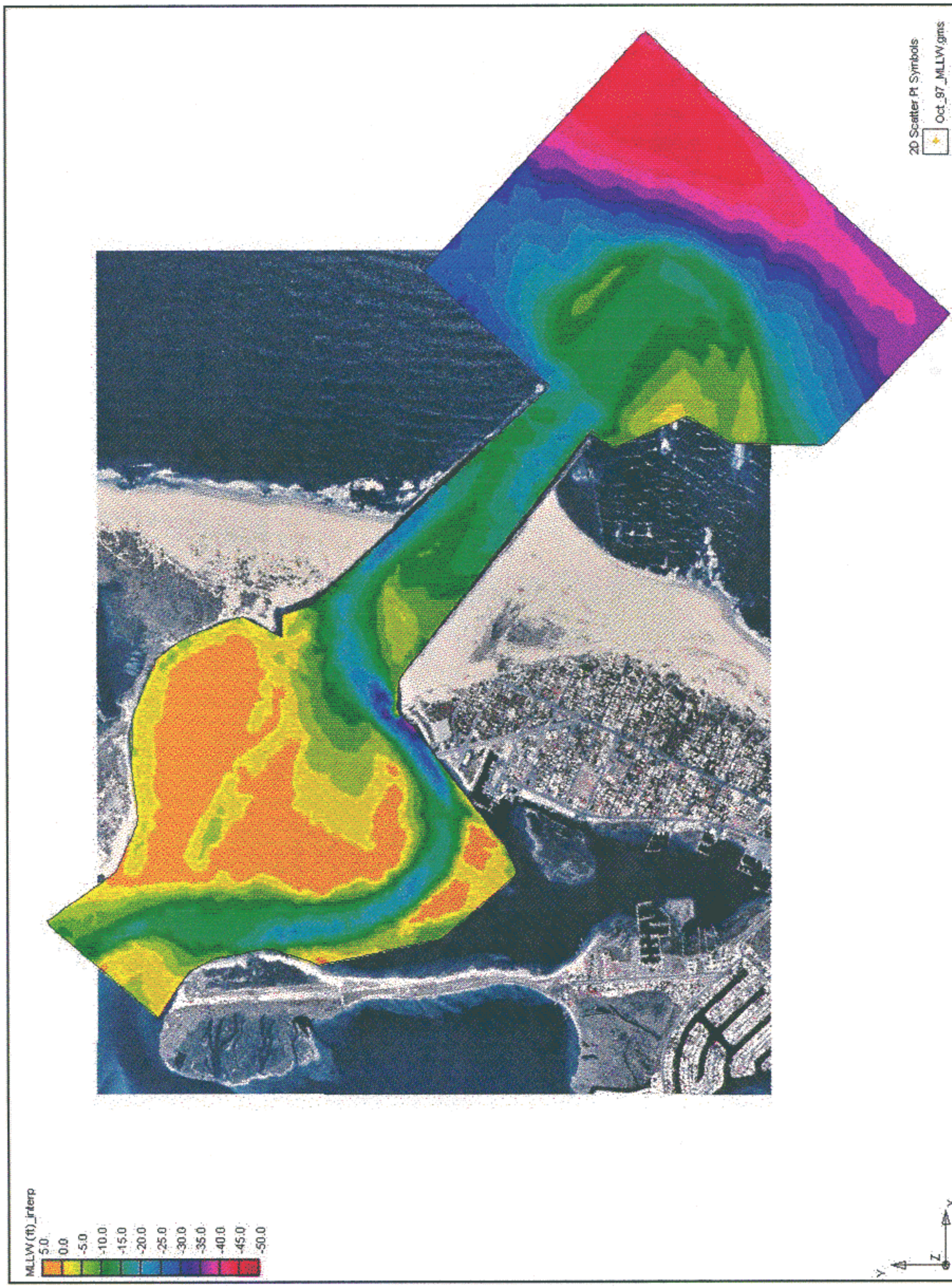


Figure 2-10. Barnegat Inlet Ebb Shoal, Flood Shoal, and Channel Conditions (October 1997).

A numerical grid was developed for modeling nearshore wave transformations throughout the Study area. A compilation of survey data from various sources described above was converted to a common vertical datum and gridded on a scale fine enough to resolve all significant features which may impact wave transformations into the nearshore. The STWAVE grid (**Figure 2-11**) was extended beyond the bordering inlets to account for potential refraction around the ebb shoal complexes.

Beach Profile Characteristics. An analysis of recent and historic beach profile data was performed to identify the temporal and spatial variability in beach profile characteristics throughout the study area. The main profile characteristics of interest included: Dune Crest Elevation, Berm Elevation, Berm Width, MHW Location, Volume of Material above MHW, and Foreshore Slope. Results of the analysis were used to development representative profile conditions described further in *Section 4.1.6 Development of Input Data for Beach Profile Modeling*. Additional analyses were performed using the temporal changes in MHW position and volumetric change rates for each profile to assess long-term shoreline change rates and estimated nourishment requirements as described further in *Section 2.10.4 Examination of Beach Profile Data*. Several sources of beach profile data were assembled and analyzed. A wide array of survey techniques was utilized in the collection of the various sources of data. Onshore portions of the surveys were typically surveyed using the standard land surveying techniques. Nearshore and offshore portions of the surveys utilized fathometers and sea sleds. All data sources were adjusted to a common datum, NAVD 1988, and analyzed. **Table 2-22** summarizes the various profile data available throughout the communities along the Study area. **Figure 2-12** displays the locations of the LRP and MCCP profiles along LBI. The stationing scheme presented begins at Barnegat Inlet and extends to Little Egg Inlet. Further discussion is presented in *Section 2.10.3 Historic Shoreline Change Analysis.* Specifically, the beach profile data sources are:

1. Line Reference Points. Onshore and offshore profile surveys referred to as *Line Reference Point* (LRP) *Surveys* after the nomenclature used on the survey control sheets to designate the profile reference points, conducted by the USACE, Philadelphia District, were initiated in 1955 and subsequently repeated in 1963, 1965, and 1984. Twenty-two (22) profiles were originally collected for the 1955 survey. The number of profiles decreased for the 1984 survey. The numbering sequence for the LRP profiles increases from north to south, and the vertical datums were MLW for the 1965 surveys and NGVD for the 1984 surveys. Several of the LRP profiles were recently re-surveyed by Offshore and Coastal Technologies Inc. - East Coast (OCTI-E) as described below.

2. CERC Profiles. A total of thirty-two (32) profiles were established and repeatedly surveyed, on LBI, as part of a broader field research program, Beach Evaluation Program (BEP), conducted by the USACE Coastal Engineering Research Center (CERC) in the period 1962 to 1973. The BEP was initiated after the Great East Coast Storm of March 1962 to observe variations on typical beaches in response to waves and tides of specific intensity and duration. **Figure 2-13** displays the CERC profile locations. Analysis of the CERC profile data focused on assessing the variability in the shape of the beach profile. Although the measured profile characteristics were not useful in developing representative profile conditions for the Feasibility

Study, the understanding of the potential variability in profile characteristics through time would greatly benefit future risk and uncertainty analyses.

3. NJDEP Surveys. Onshore and nearshore profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were collected annually, beginning in 1986. Fourteen (14) profiles have been collected within the study area as part of a general NJDEP program of monitoring the state′s beaches. These profiles, referred herein as NJDEP profiles, are numbered in the states' designation system: NJDEP Profile Nos. 245, 145, 144, 143, 142, 241, 141, 140, 139, 138, 137, 136, 135, and 234. New Jersey profile surveys available for this investigation are the annual surveys from 1986 to 1994 and semi-annual surveys from 1995 to present. The numbering sequence for the New Jersey profiles increases from south to north, and the vertical datum is NGVD. The beach profiles are collected using typical land based surveying techniques with the offshore limits of the surveys extending to wading depth. **Table 2-23** presents the locations of NJDEP beach profiles located in the study area along with average beach profile characteristics. The profiles were analyzed to assess the variability in profile characteristics at each profile and along the entire study area. The overall individual profile characteristics have been relatively stable over the monitoring period. Dune elevations have deviated approximately 1 ft with a mean elevation of + 18.6 ft NAVD. Berm dimensions as well show small changes, with the berm widths deviating 25 to 50 ft with a mean of 190-ft width, as measured from the centerline of the dune. The dune and berm systems at Barnegat Inlet significantly bias average conditions.

4. Barnegat Inlet MCCP Surveys. A total of forty-two (42) profiles have been annually surveyed as part of the Barnegat Inlet Monitoring of Completed Coastal Projects (MCCP) Study since 1993. Beach profiles were established Eighteen (18) profiles were established north of Barnegat Inlet into Island Beach State Park and twenty-four (24) profiles were established south of Barnegat Inlet to Harvey Cedars (see Volume 2 Engineering Technical Appendix **Figure 2.9.6-3**). Analysis of the survey data was performed to assess the impacts of the recent south jetty construction on adjacent shoreline stability. The analysis primarily focused on estimating volumetric change rates and variations in the MHW shoreline position as discussed in detail in the following section on historical shoreline analyses.

5. OCTI-E Surveys. Recent onshore and offshore profile data were collected by OCTI-E for the Philadelphia District July 1996 to document existing conditions. Forty-two (42) profiles were collected within the communities to be studied in detail. OCTI-E utilized a sea sled beach profiling system, which provides a highly accurate depiction of the entire profile from the upper beach to beyond the theoretical closure depth. The locations of the profiles were selected to correspond to locations previously surveyed, allowing comparative analyses. Twenty-two (22) of the profiles re-occupied former LRP survey locations, with the remaining twenty (20) profiles located approximately midway between adjacent LRP profile locations. The twenty "sub-profiles" only extended seaward to wading depth and are denoted with the "-1" extension hereafter.

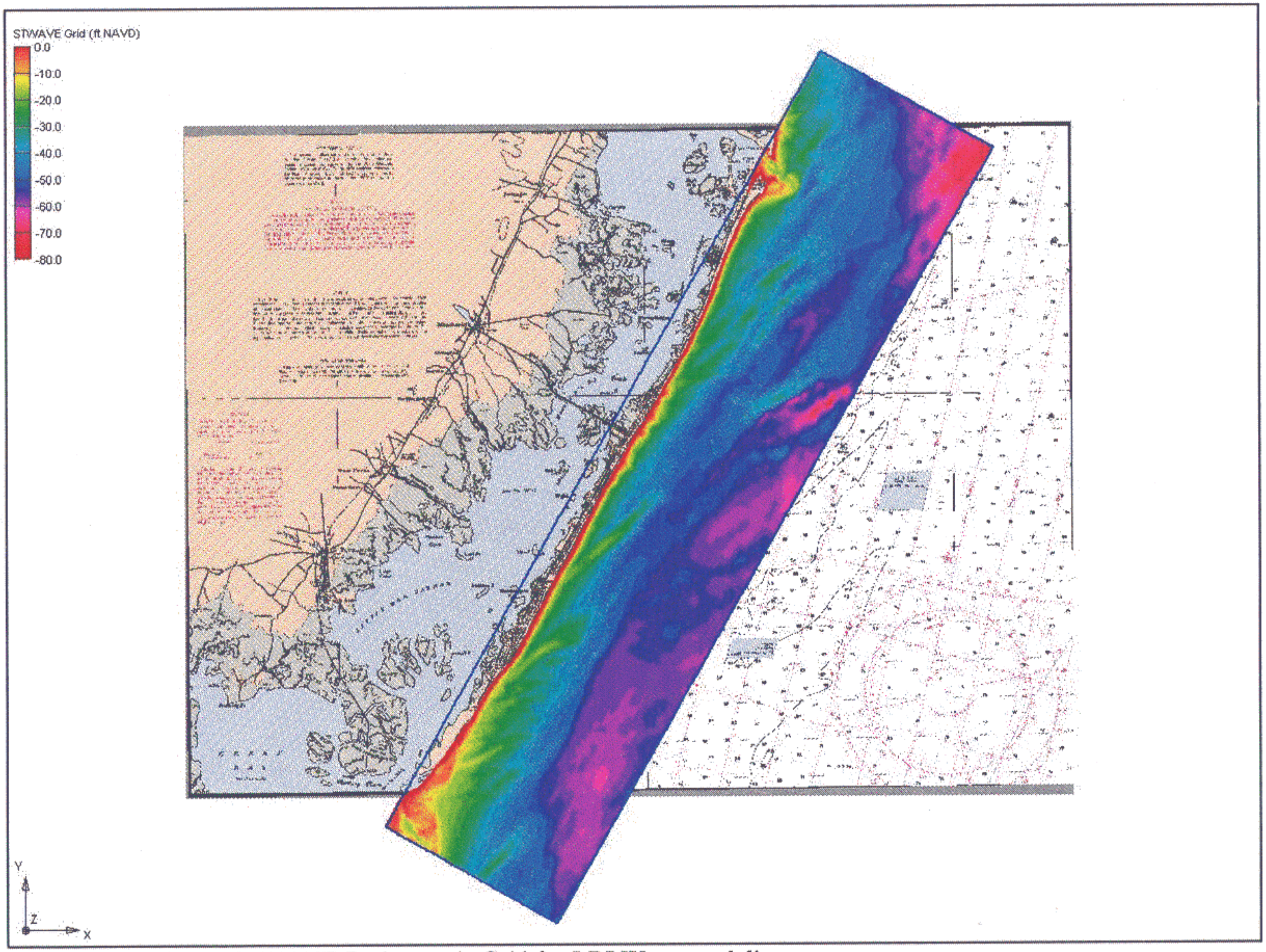


Figure 2-11. STWAVE Bathymetric Grid for LBI Wave modeling.

84

TABLE 2-22. BEACH PROFILE LOCATIONS ALONG LONG BEACH ISLAND, NJ.
REFERENCE LINE STATIONING IN RELATION TO COMMUNITIES AND PROFILES
BARNEGAT INLET TO LITTLE EGG INLET FEASIBILITY STUDY

Name of Communities	Stationing (Ft X 1000)	Profiles	Station (ft)
Barnegat Light Borough	0 to 9.6	CERC-3 / LRP 54 / NJDEP-245	2,725
		CERC-4 / LRP-55 / NJDEP-145	7,625
Long Beach Township (LBT)			
* Loveladies Community	9.6 to 20.6	CERC-5 / LRP-56	13,025
		CERC-6 / LRP-57 / NJDEP-144	16,725
		CERC-7	19,885
Harvey Cedars Borough	20.6 to 31.2	NJDEP-143	23,685
		CERC-8 / LRP-59	25,285
		CERC-9	27,285
		CERC-10 / LRP-60	29,885
		NJDEP-142	30,105
Long Beach Township (LBT)			
* North Beach	31.2 to 37.7	CERC-11 / LRP-61	33,505
Surf City Borough	37.7 to 45.5	CERC-12 / LRP-62 / NJDEP-241	38,505
Ship Bottom Borough	45.5 to 52.2	NJDEP-141	45,705
		CERC-13 / LRP-64	46,765
		CERC-14 / LRP-65 / NJDEP-140	51,865
Long Beach Township (LBT)			
* Brant Beach Community	52.2 to 61.9	LRP-66	55,365
		LRP-67	58,165
* Beach Haven Crest Community	61.9 to 63.5	CERC-15 / NJDEP-139	61,965
		LRP-68	62,165
* Brighton Beach Community	63.5 to 65.1		
* Peahala Park Community	65.1 to 66.7		
* Beach Haven Park Community	66.7 to 69.0	LRP-69	66,465
* Haven Beach Community	69.0 to 70.7		
* Beach Haven Terrace Communit	70.7 to 73.8	CERC-16 / NJDEP-138	70,565
		LRP-70	70,795
* Beach Haven Garden Communit	73.8 to 75.5	LRP-71	74,595
* Spray Beach Community	75.5 to 77.2		
* North Beach Haven Community	77.2 to 79.2		
Beach Haven Borough	79.2 to 89.1	CERC-17 / LRP-72 / NJDEP-137	79,355
		NJDEP-136	84,155
		CERC-18 / LRP-73	85,455
Long Beach Township (LBT)			
* South Beach Haven Community	89.1 to 91.3	NJDEP-135	92,355
* Holgate Community	91.3 to 93.1	CERC-19 / LRP-74	89,755
* Beach Haven Inlet Community	93.1 to 96.0	CERC-20	92,855
		LRP-75	94,705
* Holgate Wildlife Refuge		NJDEP-234	95,600

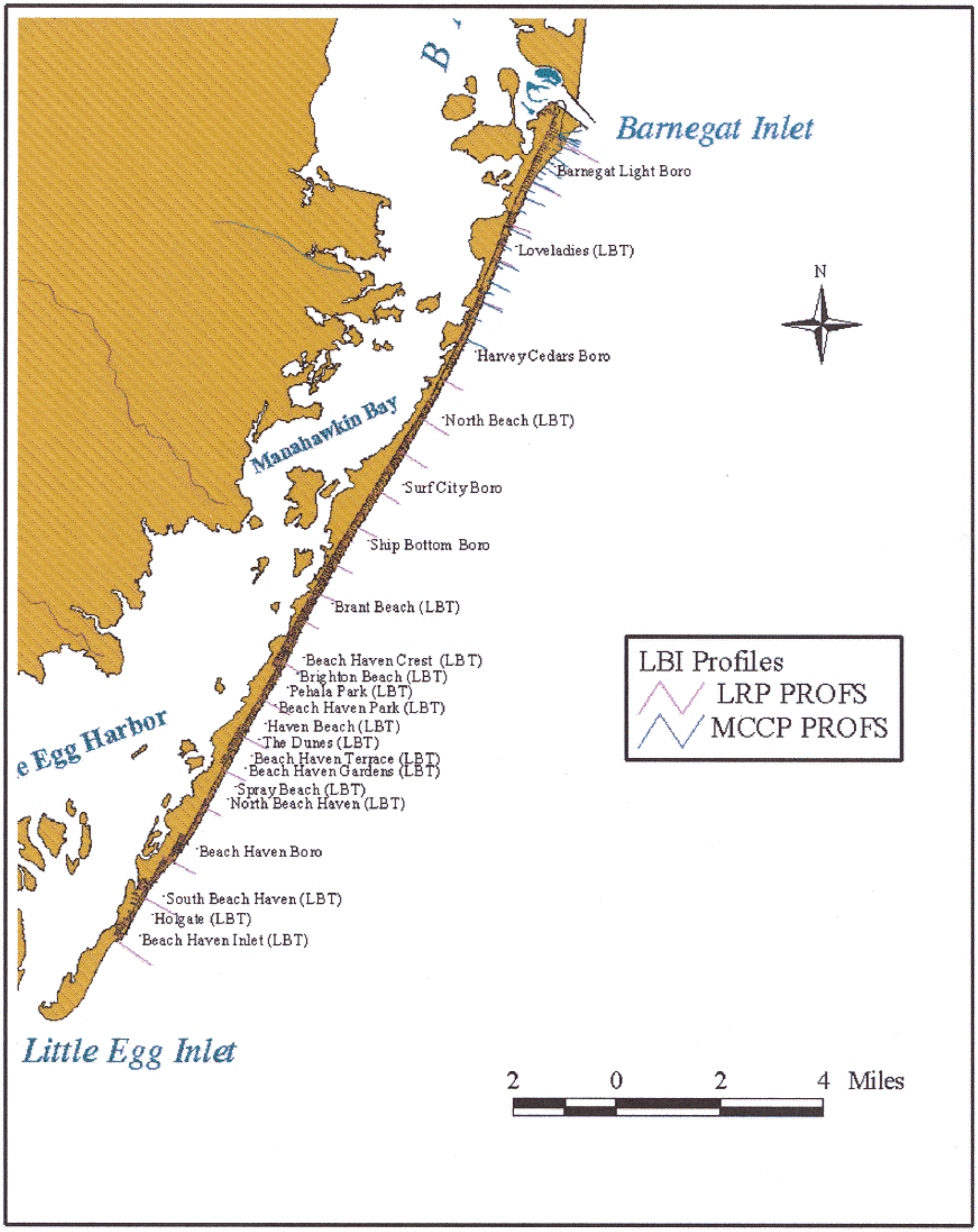


Figure 2-12. LRP and MCCP Profile Locations along LBI, NJ.

86

TABLE 2-23. NJDEP Average Beach Profile Characteristics (1986 - 1997).						
			Average Profile Characteristics			
Profile Type	Community	Alonghsore Coords wrt GENESIS grid	Dune El (ft NAVD)	Berm Width (ft, from cl)	Berm El (ft NAVD)	Vol above MHW (yd^3/ft)
NJDPE 245	Barnegat Light Borough	2,725	23.71	984	7.87	451.6
NJDPE 145	Barnegat Light Borough	7,625	19.60	180	7.35	135.9
NJDPE 144	Loveladies (LBT)	16,725	17.78	92	8.80	69.9
NJDPE 143	Harvey Cedars Borough	23,685	17.43	97	7.16	77.4
NJDPE 142	Harvey Cedars Borough	30,105	16.48	119	7.95	97.0
NJDPE 241	Surf City Borough	38,505	22.94	150	10.37	151.7
NJDPE 141	Ship Bottom Borough	45,705	19.92	136	9.18	97.7
NJDPE 140	Ship Bottom Borough	51,865	21.36	124	8.75	120.1
NJDPE 139	Beach Haven Crest (LBT)	61,965	17.90	104	8.33	65.9
NJDPE 138	Beach Haven Terrace (LBT)	70,565	19.33	113	7.66	98.1
NJDPE 137	Beach Haven Borough	79,355	16.52	133	7.70	92.8
NJDPE 136	Beach Haven Borough	84,155	15.28	122	7.33	62.5
NJDPE 135	South Beach Haven (LBT)	92,355	17.43	107	7.65	101.0
NJDPE 234	Holgate (LBT)	95,600	14.71	143	6.52	70.5
AVERAGE CONDITIONS			**18.60**	**186**	**8.04**	**120.9**

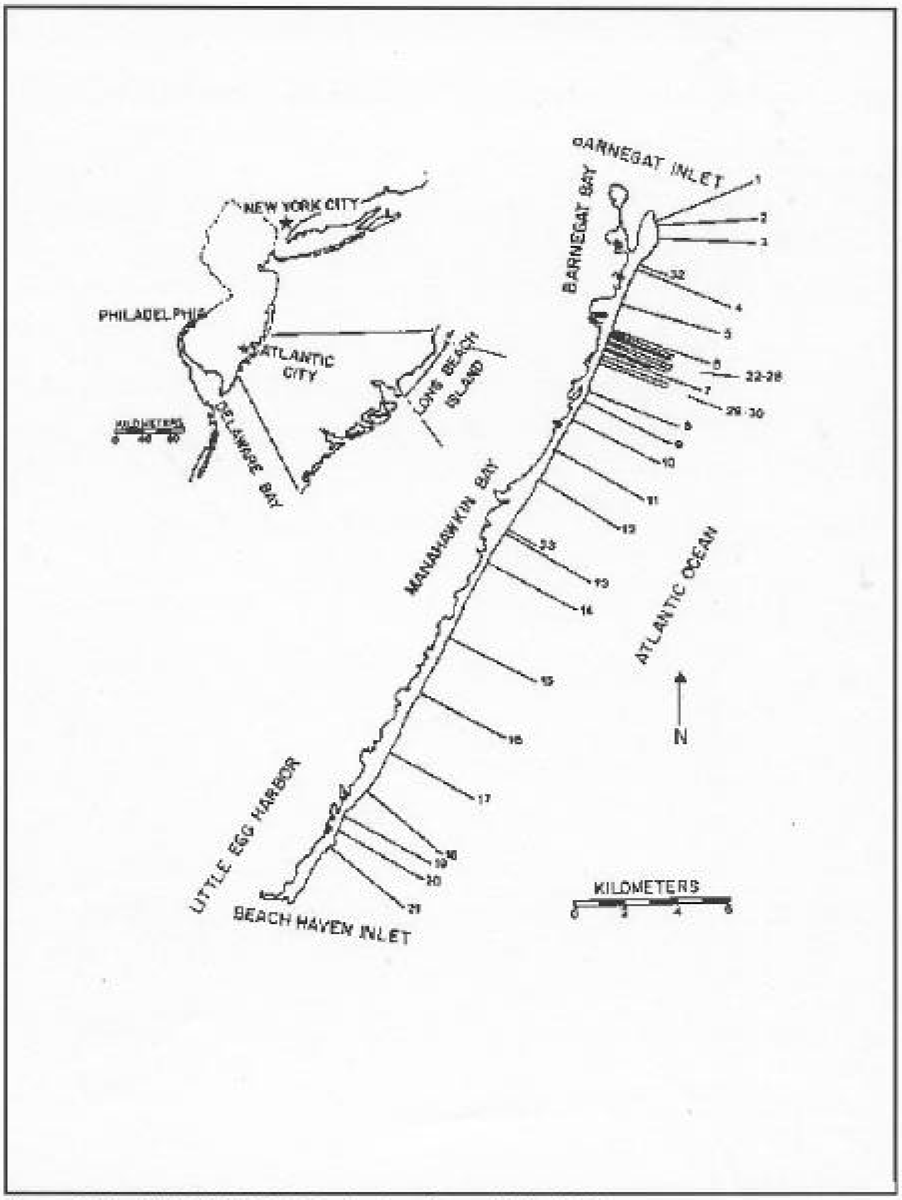


Figure 2-13. CERC MP-80-9 Profile Locations (1962-1973).

88

Table 2-24 presents the locations of OCTI-E beach profiles located in the study area along with beach profile characteristics. The profiles were analyzed and used to assess existing conditions. The existing conditions compared well to the NJDEP average profile characteristics. Select profiles were assembled and used as input for numerical modeling of storm-induced damages as discussed in *Section 4.1.6 Development of Input Data for Storm Erosion Modeling*. (See Section 2 in Volume 2)

2.10 SUMMARY OF HISTORICAL SHORELINE CONDITIONS

Historical Shoreline Analysis. Analysis of historic shoreline positions constitutes a logical basis for estimating future shoreline locations, assuming there would be no new and large-scale systematic interventions to control future shoreline positions. It is assumed that the "without-project" condition prevails over the time period in which the future position of the shoreline is to be estimated. The investigation focused on those portions of the available data that reflect the current shore regime. Current shoreline is dictated by the nearshore hydrodynamics, the existing shore protection structures along most of the island′s length, and the navigation improvements at the north end of the study area, i.e., the Barnegat Inlet dual jetty system.

Though emphasis is placed on defining the existing shore regime, the entire recorded history of ocean-shoreline positions at Long Beach Island, beginning in 1836, was examined. This extended to formulating a basic portrayal of the sequential changes in shoreline movement rates as conditions evolved from an essentially pristine state, to the existing condition, which includes significant artificial influences on the shore processes along the study area. Tracing the evolutionary changes in shoreline positions was of interest as it would provide the basis to: (a) develop the past and pre-intervention patterns of shore movements in the interest of defining cause and effect relationships induced by subsequent progressive anthropogenic influences on shore processes; (b) determine if and where conditions prior to human influence apparently followed the same patterns evident in the present shore regime, and how such patterns may influence future shore positions; and (c) evaluate if the present shore regime is more or less in a state of dynamic equilibrium or in a state of change with a particular trend, i.e., accretion or erosion. This investigation provided the opportunity to provide a very detailed analysis of historic shoreline movements which can readily be expanded as new shoreline position maps are added to the UASCE and NJDEP States' GIS database.

Prior Studies, Reports, and Projects for Manasquan to Barnegat Inlet. Reports pertinent to Long Beach Island were compiled and reviewed for this historic shoreline change evaluation. This information was used to develop a quantitative understanding of historic behavior of the study area shorelines. Shoreline change rates can vary significantly depending on the methodology used and time period analyzed. The reports reviewed include:

1. House Document No. 208, "Shore of New Jersey - Barnegat Inlet to Cape May Canal, Beach Erosion Control Study, " 1959;

2. House Document No. 94-631, "New Jersey Coastal Inlets and Beaches - Barnegat Inlet to Longport ," 1976;

3. USACE, Philadelphia District., New Jersey Shore Protection Study - Report of Limited Reconnaissance Study, Philadelphia, Pennsylvania, September 1990;

4. USACE, CERC MP-80-9, Beach Changes at Long Beach Island, New Jersey, 1962-1973, 1980;

5. Farrell, S. C., Speer, B., Hafner, S., Lepp, T., and Ebersold, S.E. 1998. "New Jersey Beach Profile Network, Analysis of the Shoreline Changes in New Jersey Coastal Reaches One through Fifteen, Raritan Bay to Delaware Bay," prepared for New Jersey Department of Environmental Protection, Coastal Research Center, Stockton State College, Pomona, NJ.

6. Farrell, S. C. et al. A number of profile lines are monitored annually by Stockton State College for the State of NJ as part of the NJ Beach Profile Network. A series of reports by Farrell, et al. (1991, 1993, 1994, 1995, 1997) analyzes this data for annual volumetric and morphologic changes.

7. Farrell, S.C., Inglin, D., Venanzi, P., and Leatherman, S. 1989. "A Summary Document for the Use and Interpretation of the Historical Shoreline Change Maps for the State of New Jersey," prepared for New Jersey Department of Environmental Protection, Coastal Research Center, Stockton State College, Pomona, NJ.

8. Barnegat Inlet to Little Egg Inlet Reconnaissance Study, "U.S. Army Engineer District, Philadelphia, March 1995."

Historic Shoreline Change Analysis. Digital shoreline change maps prepared for the State of New Jersey Historical Shoreline Map Series (Farrell et al. 1989) were reviewed to evaluate general shoreline trends. These maps include MHW shorelines from 1836-42, 1855, 1866-68, 1871-75, 1879-85, 1899, 1932-36, 1943, 1951-53, 1971, 1977, and 1986. Added to the analysis were interpreted MHW shoreline positions from recently digitize aerials for the years 1991, 1993, and 1997. Additionally a 1996 MHW shoreline obtained from digital photogrammetry was incorporated into the analysis. As part of the coastal structure inventory effort, the groins along LBI were remotely surveyed and mapped in July 1996 using the Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS). The SHOALS survey also provided mapping of the MHW contour. Comparison of the SHOALS contour to the MHW contour derived from the photogrammetry yielded minor differences. The photogrammetry contour was utilized as the 1996 shoreline in the analysis.

All shoreline position data were initially converted to the NJ State Plane NAD 83 horizontal coordinate system, if necessary. As part of this feasibility study, a detailed quantitative analysis was done to compute shoreline change rates from these maps. Several of the shorelines were missing, incomplete, or invalid for this area, therefore shoreline change rates were computed for the following periods: 1899, 1934, 1952, 1971, 1977, 1986, 1991, 1993, 1996, and 1997.

The shoreline change analysis involved rotating and translating each digital shoreline to a user-defined coordinate system. The coordinate system will hereafter be referred to as the GENESIS coordinate system. The origin of the coordinate system is located adjacent to Barnegat Inlet (603,000 N, 338,900 E) with a rotation angle of 119.5 degree with respect to north (**Figure 2-14**). The alongshore coordinates ranged from 0 at Barnegat Inlet to 95,870 ft at the terminal groin located north of the Holgate Wildlife Refuge. Plotting the shorelines in the GENESIS coordinate system using a distorted scale (**Figure 2-15**) displays the deviation in shoreline orientation as well the overall historic shoreline changes throughout the Island.

The digital shorelines were segmented into discrete compartments alongshore that were spaced 1,000 ft. apart except in areas where groin compartments were used (**Figure 2-16**). In the vicinity of Barnegat Inlet, compartment boundaries were selected to correspond to limits represented by MCCP profile conditions for comparative purposes. **Figures for BUNDY's 1, 4, 9, and 14 (Figures 2-17 through 2-20)** display the compartment boundaries and recent shoreline positions. (**See Volume 2, Engineering Technical Appendix, Figures 2.10.3-4 to 2.10.3-18** for all BUNDY's.)

A mean shoreline position was computed within each compartment by integrating the shoreline with respect to the coordinate system over the length of the compartment and dividing by the length of the compartment. A least squares fit of the mean shoreline positions versus date data was performed for each compartment to determine a shoreline change rate. **Figure 2.10.3** in the Engineering Appendix displays the digitized shorelines in GENESIS coordinates (compartment 48 through 50) located in Brant Beach), the computed mean shorelines for each time period, and the resulting shoreline change rates computed for select time periods. **Figure 2-20A** displays the computed mean shoreline positions for all compartments throughout LBI. Shoreline change rates were computed for sequential historic time periods and then relative to 1997 as displayed in **Figures 2-20B and 2-20C**, respectively.

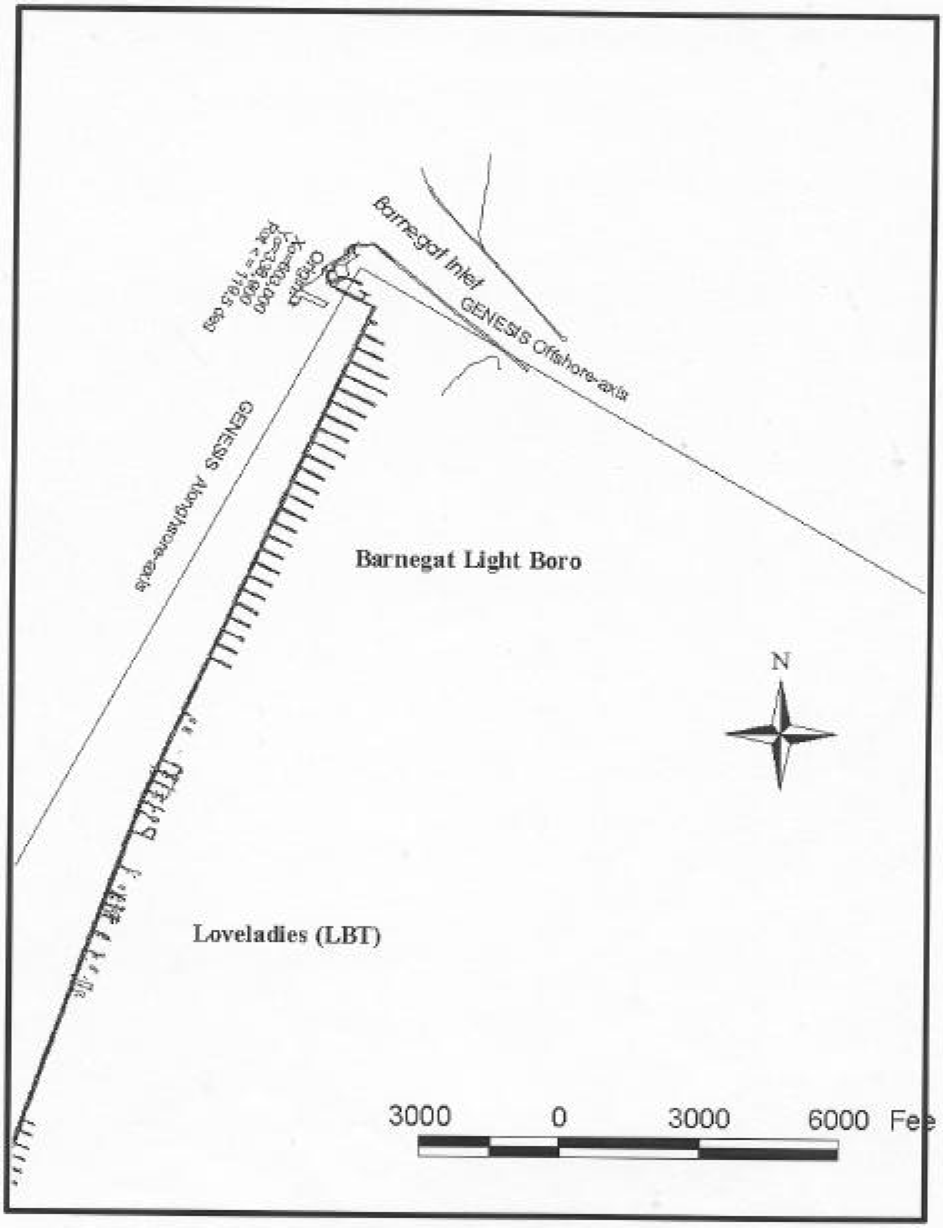


Figure 2-14 GENESIS Coordinate System for Shoreline Change Analyses.

TABLE 2-24. OCTI-E July 1996 LBI Beach Profile Characteristics.					
Profile #	Community	PROFILE CHARACTERISTICS			
		Dune El (ft NAVD)	Avg Berm El (ft NAVD)	Berm Width (ft from cl Dune)	Vol above Berm (cu yd /ft)
LRP 54	LBT, Loveladies				111.50
LRP 55	LBT, Loveladies	20.10	7.30	205.00	51.73
LRP 55-1	LBT, Loveladies	21.60	7.90	124.00	62.58
LRP 56	LBT, Loveladies	20.50	8.40	67.00	52.59
LRP 56-1	LBT, Loveladies	18.50	7.90	115.00	40.37
LRP 57	LBT, Loveladies	20.70	8.10	98.00	33.12
LRP 57-1	LBT, Loveladies	18.90	8.30	110.00	25.19
LRP 58	Harvey Cedars Boro	15.60			24.41
LRP 58-1	Harvey Cedars Boro	17.20	7.90	136.00	27.10
LRP 59	Harvey Cedars Boro	16.50	7.90	91.00	16.89
LRP 59-1	Harvey Cedars Boro	14.60	7.80	78.00	19.15
LRP 60	LBT, North Beach	16.30	6.70	144.00	23.41
LRP 60-1	LBT, North Beach	13.00	7.60	114.00	8.77
LRP 61	LBT, North Beach	18.60	7.50	134.00	34.28
LRP 61-1	LBT, North Beach	17.00	7.30	126.00	26.51
LRP 62	Surf City Boro	22.40	9.00	127.00	61.70
LRP 62-1	Surf City Boro	21.00	8.40	106.00	35.52
LRP 63	Surf City Boro	21.90	8.00	90.00	39.81
LRP 63-1	Ship Bottom Boro	21.40	8.10	122.00	38.17
LRP 64	Ship Bottom Boro	21.60	8.10	136.00	51.40
LRP 64-1	Ship Bottom Boro	21.00	7.90	151.00	33.64
LRP 65	LBT, Brant Beach	22.20			51.90
LRP 65-1	LBT, Brant Beach	17.20	8.40	68.00	11.37
LRP 66	LBT, Brant Beach	15.40	7.50	83.00	21.31
LRP 66-1	LBT, Brant Beach	17.80	7.70	56.00	11.03
LRP 67	LBT, Brant Beach	18.70	9.30	68.00	22.10
LRP 67-1	LBT, Beach Haven Crest	18.90	7.60	99.00	26.97
LRP 68	LBT, Brighton Beach	18.90	7.60	114.00	26.94
LRP 68-1	LBT, Peahala Park	19.90	7.80	168.00	35.99
LRP 69	LBT, Beach Haven Park	21.10	7.60	120.00	30.63
LRP 69-1	LBT, Haven Beach	17.10	7.20	108.00	13.91
LRP 70	LBT, Beach Haven Terrace	15.90	6.30	143.00	32.88
LRP 70-1	LBT, Beach Haven Gardens	18.20	7.10	150.00	14.53
LRP 71	LBT, Spray Beach	22.70	7.90	118.00	47.78
LRP 71-1	LBT, North Beach Haven	18.20	7.40	103.00	24.70
LRP 72	Beach Haven Boro	20.80	7.90	120.00	45.84
LRP 72-1	Beach Haven Boro	18.40	7.10	104.00	37.21
LRP 73A	Beach Haven Boro	17.20	7.10	177.00	45.93
LRP 73-1	Beach Haven Boro	11.90	7.20	58.00	9.10
LRP 74	Beach Haven Boro	20.10	6.70	137.00	47.91
LRP 74-1	LBT, Holgate	19.60	8.60	99.00	40.99
LRP 75	Wildlife Refuge				
AVERAGE CONDITIONS		**18.72**	**7.74**	**114.92**	**34.56**

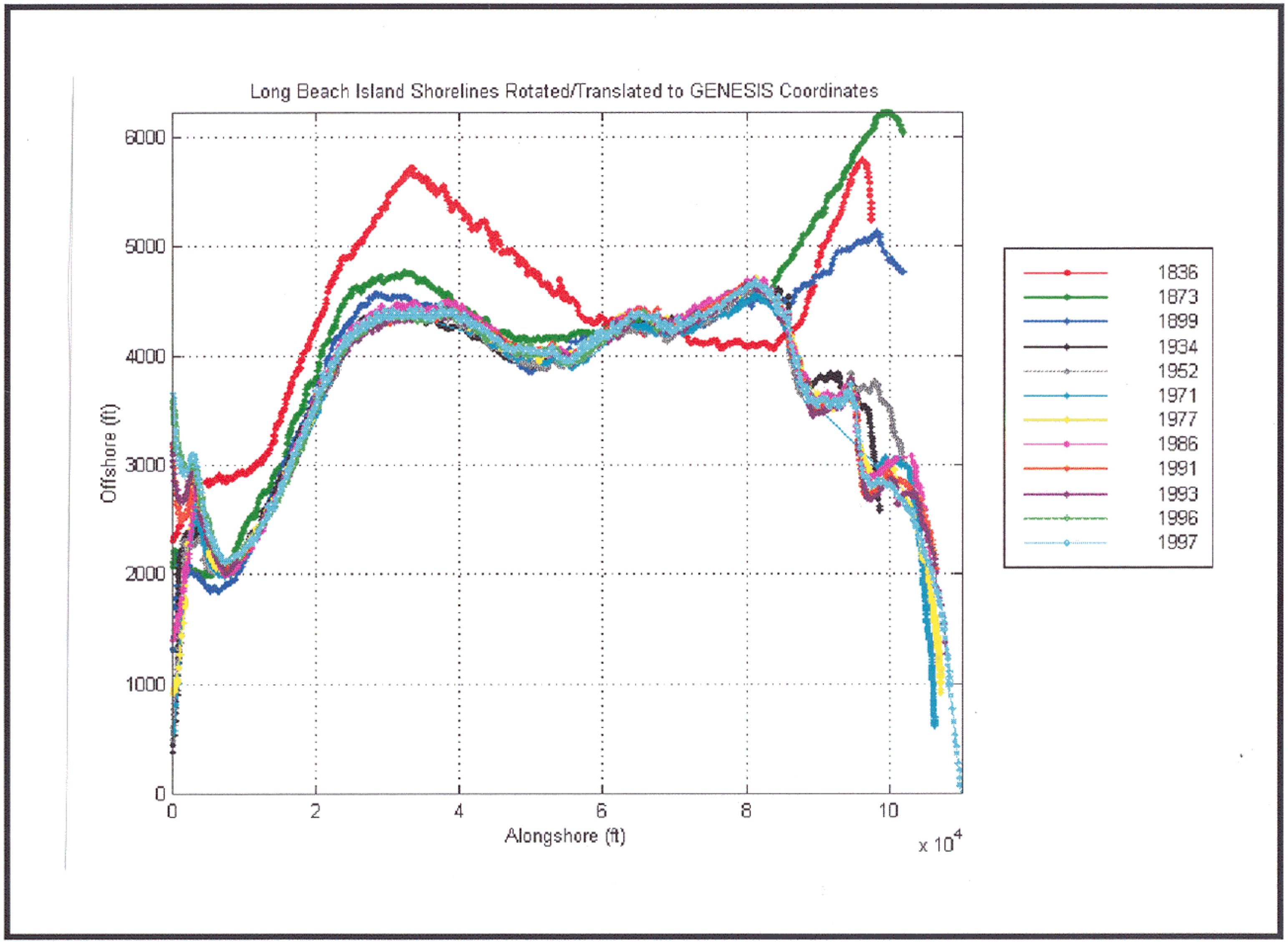


FIGURE 2-15 Long Beach Island Shorelines in GENESIS Coordinate System

94

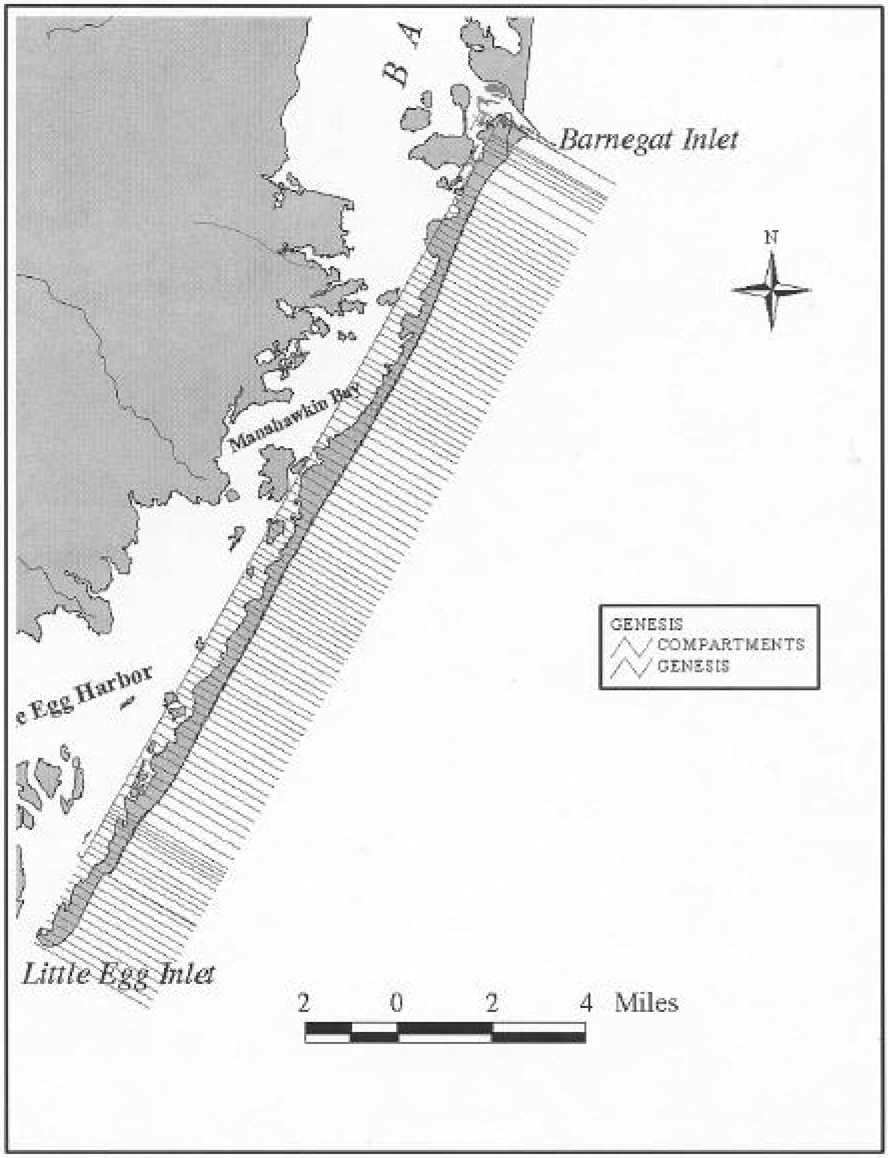


Figure 2-16. Shoreline Change Analysis Compartment Boundaries.
Note: Compartments are Perpendicular to Shoreline (Genesis Boundaries).

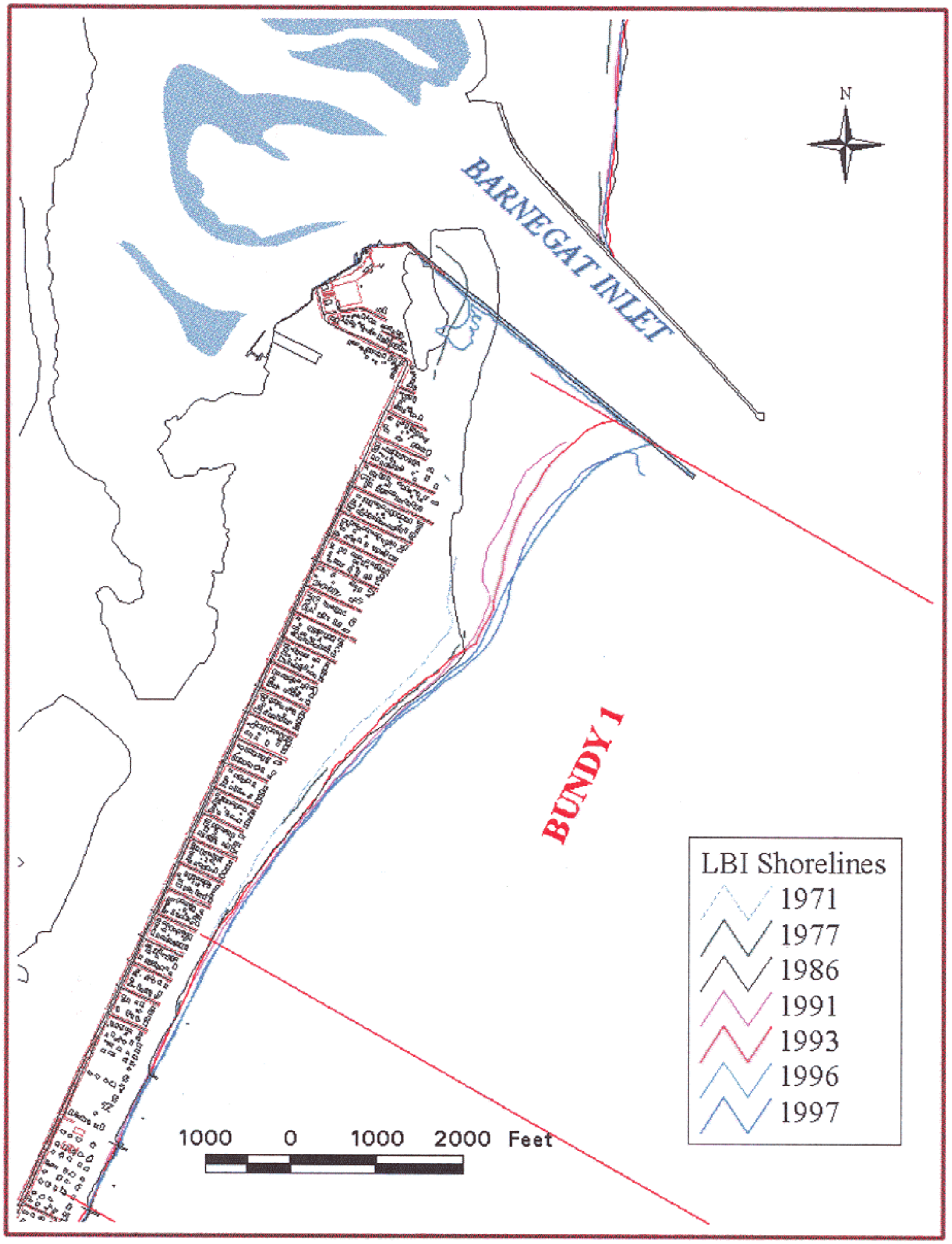


Figure 2-17. Recent Shoreline Conditions for BUNDY 1.

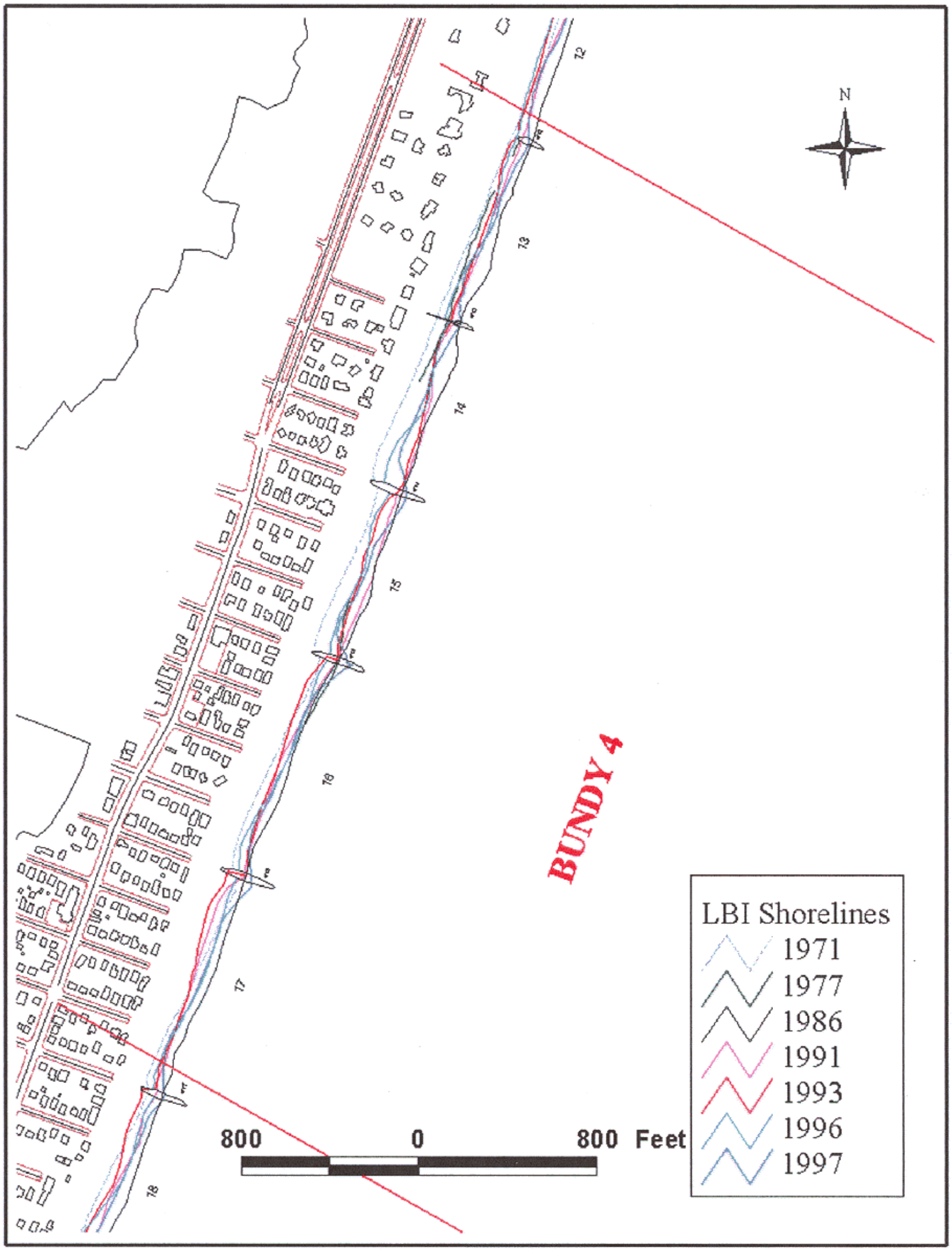


Figure 2-18. Recent Shoreline Conditions for BUNDY 4.

97

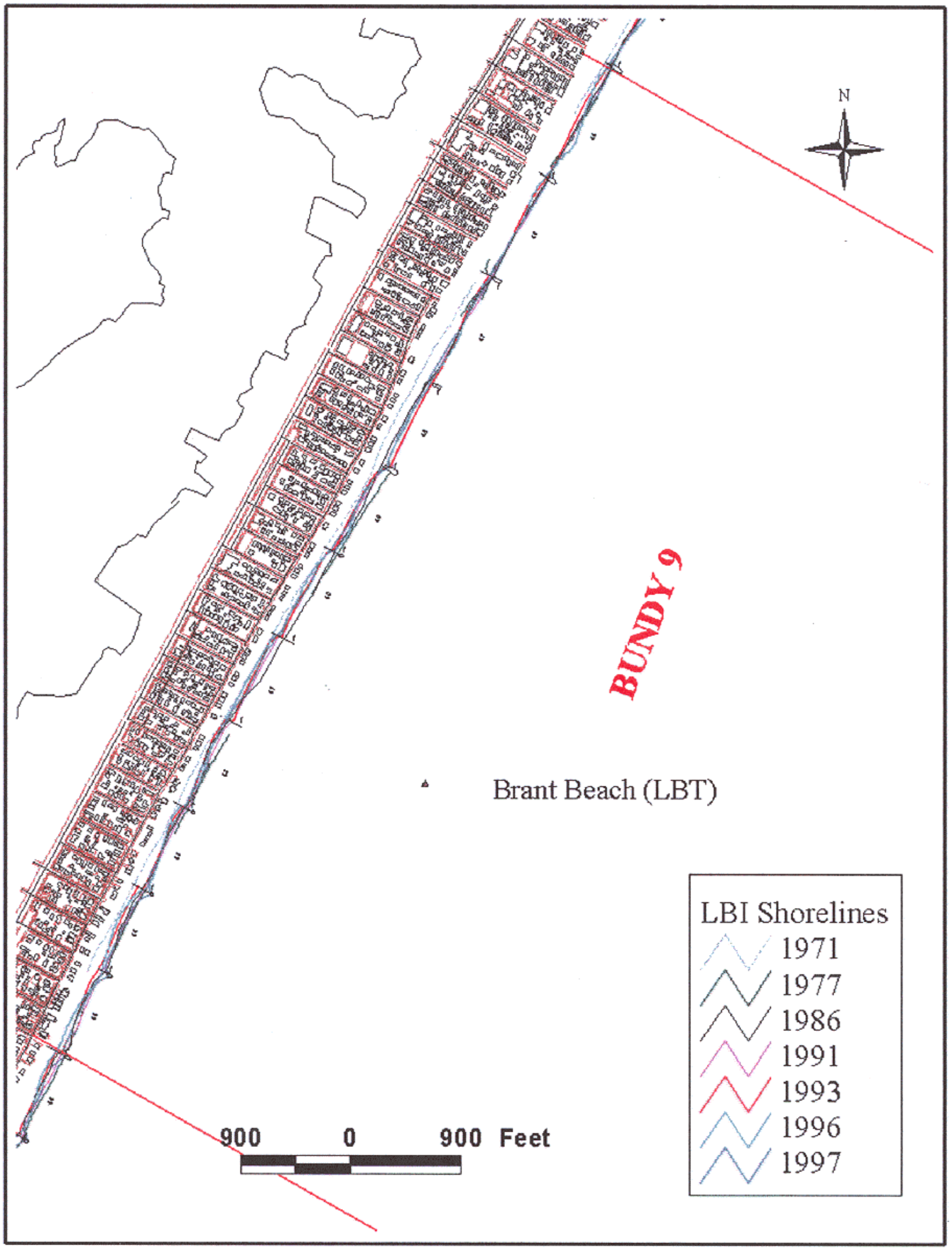


Figure 2-19. Recent Shoreline Conditions for BUNDY 9.

98

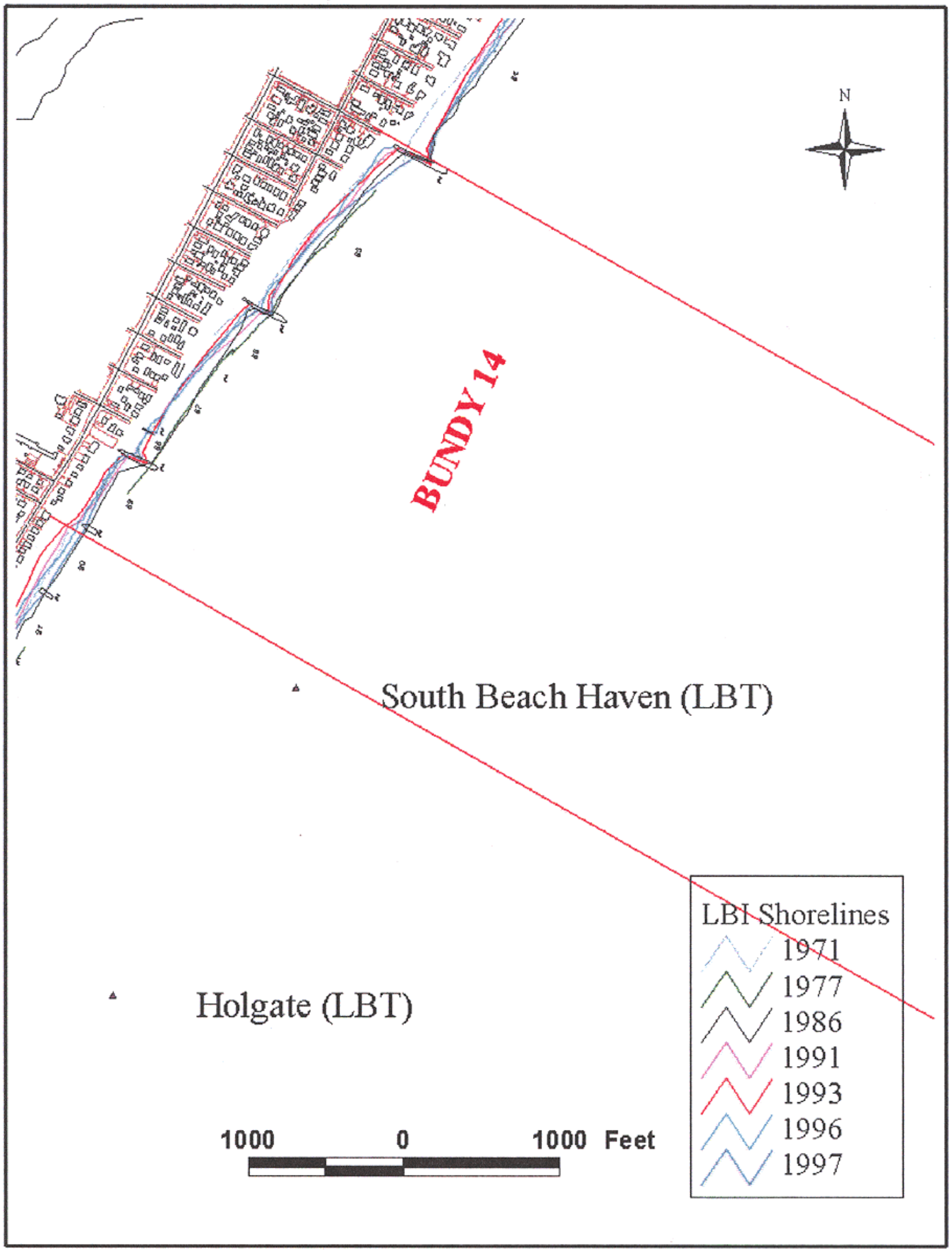


Figure 2-20. Recent Shoreline Conditions for BUNDY 14.

Examination of Beach Profile Data. Beach profile surveys along Long Beach Island have been conducted by various agencies since 1836. The data most relevant to this study are listed below in **Table 2-25**:

TABLE 2-25.
Summary of Beach Profile Data Collection Efforts along LBI, NJ.

AGENCY	DATA SET	DATES SURVEYED
USACE, Philadelphia District	Line Reference Point Surveys (LRP)	1965, 1984, 1996
USACE, Coastal Engineering Research Center (CERC).	CERC Surveys	1962-1973
NJDEP, Coastal Research Center at Stockton State College	New Jersey Beach Profile Network (NJBPN)	1986 to Present
USACE, Coastal and Hydraulics Laboratory (CHL)	Barnegat Inlet MCCP Surveys	1993 to Present

Each of these data provides information relevant to the evaluation of previous shoreline behavior and assessment of the continued evolution of the island′s shoreline positions. The CERC survey data set is, by far, the most detailed in terms of the number of profiles, the associated number of repeat surveys, and the continuity of record which covers a continuous period of about 13 years, following the storm of March 1962. Therefore, the CERC data provide an extended view of shore behavior, and due to the relatively frequent repetition of the surveys, give valuable insights regarding short-term beach responses. The primary limitation of the CERC data set is that it does not provide information seaward of the intratidal zone. On the other hand, the LRP data set provides information on the offshore as well as onshore portions of the active beach profiles, but is extremely limited in regard to the number of comparable sequential surveys. The NJDEP and MCCP profile surveys constitute the latest set of recorded data and accordingly, are the most representative of the databases in regard to the present characteristics and behavior of Long Beach Island′s beach and dune system. The MCCP profiles; however, are limited to the vicinity of Barnegat Inlet.

Analysis of the NJDEP profile data indicate volumetric changes in the profile only through the nearshore zone. The profiles do not extend beyond the surf zone where significant movement of littoral material occurs. Thus, storage of material removed from the nearshore during a significant event may not be accounted for. The lack of established survey controls for the NJDEP surveys prevented direct comparison of recent shoreline positions against historic shoreline positions determined through shoreline change mapping. However, the data identify relative changes in the shoreline position and account for losses and gains to the berm/dune system.

Qualitative changes over time for each profile are summarized by Farrell et. al (1998) as described above. Additional analyses were performed on the temporal changes in MHW positions for each profile to provide more quantitative shoreline change information. The MHW position, distance along profile corresponding to an elevation of approximately +1.5 ft NAVD, was determined for each profile. Analysis of the positions over time for each profile provides insight into the variability in shoreline positions and estimation of trends in shoreline movement. The MHW positions were plotted for each profile versus the date surveyed and a least squares fit was performed to estimate a shoreline change rate over the corresponding time period. **Figure 2-21** displays the shoreline positions at profile NJDEP 143 in Harvey Cedars. The figure shows the gross changes in the shoreline position on the order of 70 ft with an accretional trend of 0.7 feet per year**. Table 2-26** displays the results of the shoreline change rate analysis on the NJDEP profiles

Profile data collected as part of the MCCP program were used to compute shoreline change rates and volumetric change rates in the vicinity of Barnegat Inlet. Changes in the MHW contour position were analyzed for each profile to compute a shoreline change rate as shown in **Figure 2-22**. The shoreline change rates for the time period analyzed compare favorably to shoreline change rates computed using the shoreline positions shown previously. Additionally, volumetric changes across the entire profile over time were computed. Volumetric changes for representative reaches (compartments) were then computed using average-area-end method. A volumetric change rate was also computed using shoreline change rates (from shoreline positions) using the active profile (average berm elevation to depth-of-closure) assumption. Comparison of the two methods resulted in small refinements in the assumed depth-of-closure to provide equal volumetric change rates. Therefore, shoreline position data can be used with confidence to estimate historic volumetric changes and to predict future with-project nourishment requirements.

Summary of Historical Shoreline Conditions. Analysis of the overall study area indicates a relatively stable shoreline, with brief periods of erosion which are followed by a quick recovery. The bulk of the analysis was performed using the Leathermann Shoreline Change Maps (and recent additions) to document long-term conditions from 1839-1997. More recent conditions were analyzed using the NJDEP profile data from 1986 to present with detailed analyses conducted in the Barnegat Inlet vicinity using the MCCP profile data.

TABLE 2-26. SHORELINE CHANGE ANALYSIS RESULTS FOR NJDEP PROFILES LOCATED on Long Beach Island, NJ.

NJDEP Profile	SURVEY DATE and SHORELINE POSITION													
									Nov-94	*Apr-95*	*Oct-95*	*Jun-96*	*Nov-96*	*May-97*
OC245									1350.13	1398.49	1386.13	1315.02	1326.89	1339.91
	Nov-86	*Oct-87*	*Nov-88*	*Nov-89*	*33190*	*Nov-91*	*Nov-92*	*Oct-93*	*Oct-94*	*Apr-95*	*Oct-95*	*Jun-96*	*May-97*	*Nov-97*
OC145	351.59	389.61	395.70	373.30	384.07	387.78	415.13	397.42	416.96	412.99	443.47	435.01	472.31	456.41
	Nov-86	*Oct-87*	*Nov-88*	*Nov-89*	*33190*	*Nov-91*	*Nov-92*	*Oct-93*	*Sep-94*	*May-95*	*Dec-95*	*May-96*	*Nov-96*	*May-97*
OC144	209.30	204.33	205.45	200.34	211.76	208.29	209.28	200.63	218.81	205.88	200.17	179.83	202.62	211.29
	Nov-86	*Oct-87*	*Nov-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Sep-94*	*May-95*	*Dec-95*	*May-96*	*Nov-96*	*May-97*
OC143	186.06	193.28	173.21	162.34	177.77	177.79	188.23	177.96	169.45	232.47	191.41	170.52	181.83	179.91
	Nov-86	*Oct-87*	*Nov-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Sep-94*	*May-95*	*Nov-95*	*May-96*	*Nov-96*	*May-97*
OC142	400.20	422.76	405.75	440.63	427.41	441.82	419.49	428.27	430.12	450.95	448.24	450.73	457.47	443.11
									Oct-94	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC241									357.25	370.16	364.15	323.56	339.54	322.03
	Nov-86	*Oct-87*	*Nov-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC141	267.56	274.08	256.62	None	249.03	261.12	215.44	255.73	241.64	249.68	268.64	234.78	266.77	225.63
	Nov-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC140	353.96	342.47	301.08	320.74	311.49	314.24	338.38	319.27	235.04	322.45	344.63	309.25	323.72	302.28
	Nov-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC139	198.37	176.27	224.97	193.02	199.77	159.50	190.82	182.89	210.26	171.49	192.33	180.93	191.71	205.24
	Nov-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC138	297.67	260.72	255.91	281.86	280.45	261.27	259.55	281.15	270.26	271.40	279.15	255.21	252.24	239.08
	Dec-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC137	297.06	283.68	307.64	276.48	277.19	289.47	279.55	285.40	262.72	265.52	291.50	245.51	289.54	259.59
	Dec-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC136	256.37	247.07	233.78	203.94	226.24	203.47	176.78	219.40	208.36	191.95	185.30	186.77	213.21	211.73
	Oct-86	*Oct-87*	*Dec-88*	*Nov-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC135	311.35	307.25	373.99	355.81	357.58	312.97	351.39	353.01	346.63	357.35	367.19	340.08	352.05	384.33
									Nov-94	*Apr-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*
OC234									348.45	305.89	379.91	255.76	425.70	327.77

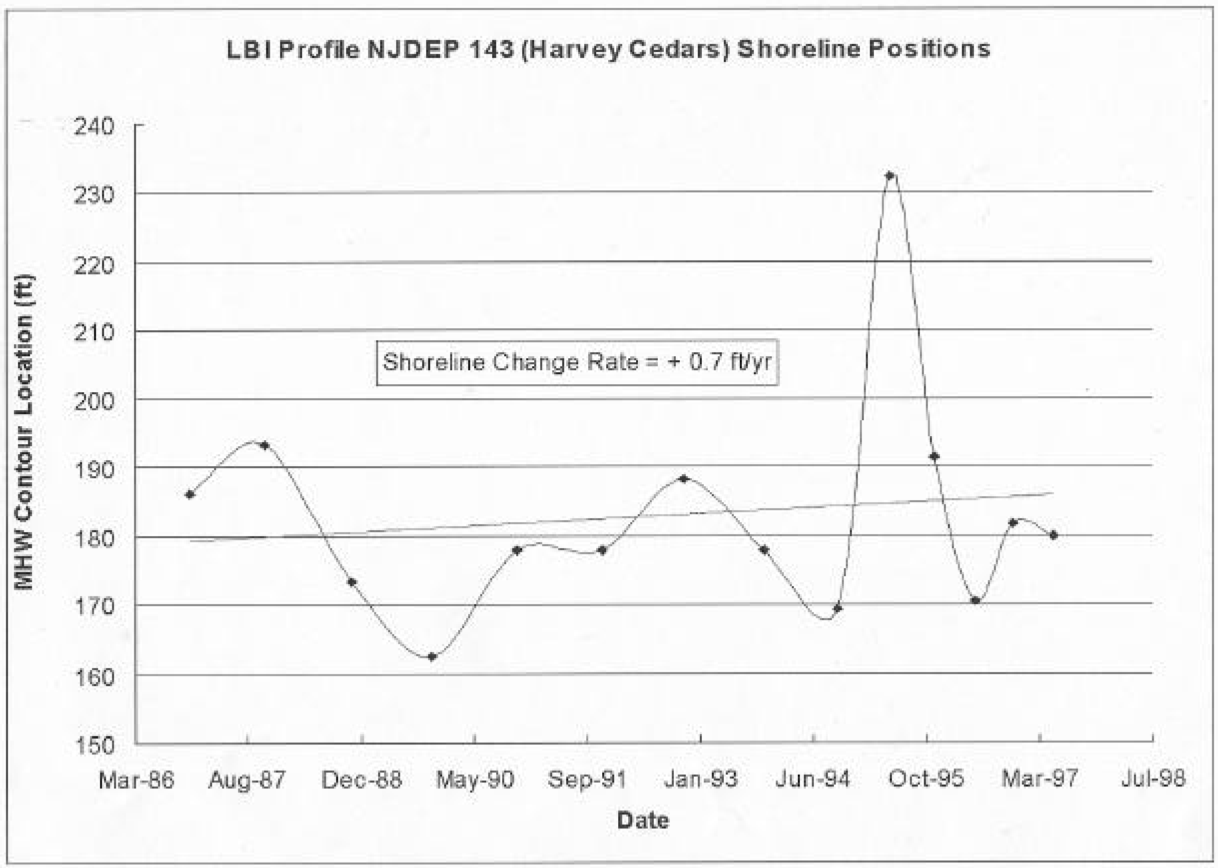
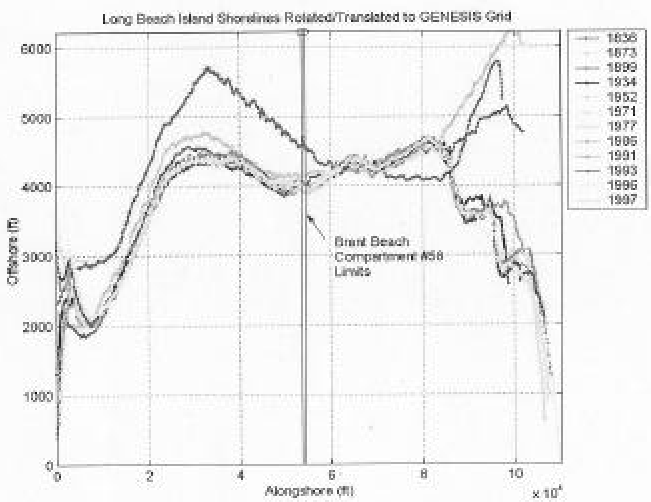
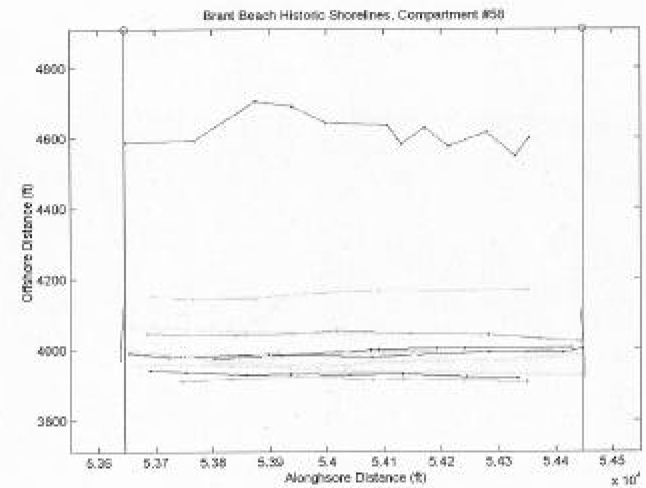
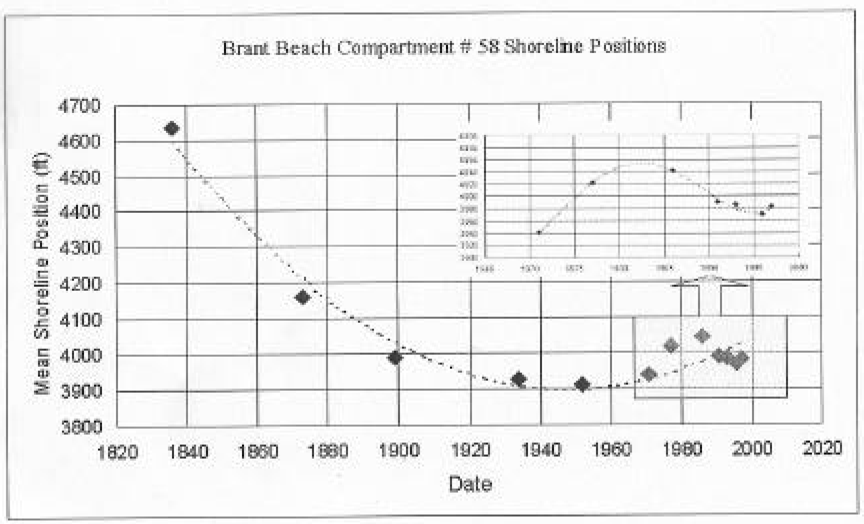


FIGURE 2-21 LBI Profile NJDEP 143 (Harvey Cedars) Shoreline Positions

103







Shoreline Change Rates via Linear Regression

Epoch	Shoreline Change Rate (ft/yr)
1971-1997	0.26
1986-1997	-6.32
1991-1997	-2.51
1996-1997	12.60

Figure 2-22 Shoreline Change Analysis Results for Compartment 58 located in Brant Beach.

104

2.11 PROBLEM IDENTIFICATION.

Problems which exist in the Barnegat Inlet to Little Egg Inlet study area have been identified during site visits, public and interagency coordination, review of historical records and aerial photographs, and beach and offshore surveys.

The principal water resource problems identified along the Barnegat Inlet to Little Egg Inlet study area are: 1) beach or shoreline erosion due to long term shore coastal processed and coastal storms, 2) storm damage vulnerability associated with wave attach and inundation, exacerbated by long tem erosion, and 3) Ecosystem losses associated with long term erosion. These problems not only threaten residences and natural habitat of the study area but also affect the local economy as businesses are disrupted and utilities are damaged.

2.12 LONG TERM EROSION.

Long term erosion. Long term erosion within the study area has narrowed beaches and dunes and left the area more vulnerable to storm damage. Progressive and constant erosion is evident in certain areas throughout the entire length of Long Beach Island. The following paragraphs describe communities, from north to south, most affected by long term erosion.

Prior to 1987, Barnegat Light was greatly affected by the migration of the navigation channel at Barnegat Inlet, and the bypassing of sand around the inlet from Island Beach State Park. The two mechanisms produced an unpredictable and widely fluctuating shoreline in Barnegat Light since the existence of Barnegat Inlet. The construction of the inlet jetties in 1939-40 minimized this fluctuation in most areas except the shore of Barnegat Light north of the south jetty. With the construction of the new south jetty at Barnegat Inlet beginning in 1987 and ending in 1991, Barnegat Light now has a very wide, stabilized beach combined with the pre-existing wide and high dune system to protect the majority of their community. Refer back to Figure 1-2 and 1-2A. It is expected that Barnegat Light will maintain this significant level of protection in the future.

Loveladies is a section of Long Beach Township located 1.9 miles south of Barnegat Inlet and borders Barnegat Light. This 2.1-mile portion of Long Beach Township has been subject to long term erosion and has most recently received a State sponsored beachfill of 183,000 cubic yards in 1992. Previously, Loveladies received a portion of the approximately 1,000,000 cubic yards placed in 1978 in the Loveladies - Harvey Cedars area.

Recent investigations suggest that Loveladies is positioned within a local diverging nodal zone of littoral transport created by the presence of Barnegat Inlet. Sand placed in 1978 in Harvey Cedars and Loveladies was monitored and found to move north towards Barnegat Light while net transport for the majority of Long Beach Island is to the south. This effect appears to be the result of a local reversal in the littoral drift caused by the influence of Barnegat Inlet. This phenomenon is not unique to Barnegat Inlet and is commonly created by the presence of a tidal inlet in a barrier island environment. The reversal of littoral drift is created by: 1) the effects of the wave driven longshore currents induced by wave refraction around and sheltering behind the outer ebb shoal complex and 2) the influence of tidal currents on the near shore flow.

The effect of being positioned in a divergent nodal zone is that the longshore transport of sand moves in two opposite directions, in this case both north and south, and thus away from the nodal zone leaving the area starved for sand. This type of migrating nodal zone can shift up or down the coast depending on wave climate and changes to the adjacent inlet and its associated ebb shoal complex. In this case, the nodal zone appears not to be continuously located at Loveladies, and at times the area does receive sand from adjacent shorelines.

Recent heightened erosion occurring during the spring and summer of 1994 along the New Jersey coast due to atypical weather patterns has drastically affected Loveladies as well as other areas of Long Beach Island.

During the spring and summer beaches usually build back after the winter season through onshore migration of the winter sandbars. However, in the spring and summer of 1994, large scale beach erosion occurred in Loveladies and other areas of the New Jersey coast. The erosion was associated with a persistent weather pattern that created an abundance of unusually strong southwest winds over the period from late April to late July. This weather pattern is not conducive to producing waves of significant height and proper direction to move sand shoreward. In fact, the southwest winds create a strong longshore drift and the corresponding offshore flowing "rip" currents on the south side of the groins on LBI. The erosion that has occurred is caused, at least in part, by the resulting currents produced by the southwest winds.

While many areas were affected along the New Jersey coast, Loveladies and Brant Beach Long Beach Township have been the worst affected. In many locations the dune has been eroded to within a few feet of homes and to the point of exposing the foundation piles on a few. (See **Figures 2-23 through 2-40** at the end of section 2.14**)** This condition has left the area in a very vulnerable state for the following winter.

Efforts to slow the erosion included intervention from the Corps of Engineers. Dredge material from Barnegat Inlet was deposited offshore in the surf zone via the Corps' split hull hopper dredge CURRITUCK. The placement of the dredge material was coincident with dredging of Barnegat Inlet as part of the ongoing Operation and Maintenance program and is consistent with the Barnegat Inlet General Design Memorandum. During a 10 day period in August 1994, 12,000 cubic yards of material was deposited in the nearshore zone between the groins in the worst affected area in Loveladies. The material was placed within one groin cell and visually monitored to determine if it moved onshore. Preliminary reports show that at least some material, identified by its grayish tint, moved onto the beach.

During upcoming dredging cycles the Philadelphia District plans to again deposit dredge material from Barnegat Inlet off of Loveladies when conditions permit. However, the volume of material that may be deposited offshore is not considered to be sufficient to offset the present rate of erosion in the Loveladies area.

Harvey Cedars is the next community south of Loveladies and is approximately 2 miles long and has dealt with erosion for many years. Historically, narrow beaches and dunes made Harvey Cedars one of the hardest hit areas on the New Jersey shore in the storm of 1962. Since then, State and local efforts to maintain a beach and dune system have been continuous. The borough of Harvey Cedars provides extensive maintenance of the dunes several times each year in an effort to establish a stable dune system. In recent years Harvey Cedars dunes have been completely removed during storm events, prompting emergency intervention from the County and State to provide emergency dunes.

In 1978 approximately 1, 000,000 cubic yards of material dredged from Barnegat Inlet was placed on the beaches of Harvey Cedars and Loveladies by the Corps of Engineers in response to the February 1978 Nor'easter. A recent State and local project in 1994 through 1995 trucked in 495,000 cubic yards of sand to Harvey Cedars. Records of fills placed in Harvey Cedars and elsewhere on Long Beach Island can be found in Section 1 and in Table 2-26.

Other communities on Long Beach Island have been less affected by persistent long-term erosion but are not immune from its effects. Downdrift and updrift adjacent areas still may impact areas with relatively stable shorelines (low erosion rates). Since all communities are linked on this one barrier island, towns adjacent to those areas most affected by long term erosion feel the consequences of being located downdrift of an area with a sand deficit during various times of the year. For instance, during the summer when the primary littoral drift is to the north, the towns south of Loveladies and Harvey Cedars are not adversely affected, but in winter, when littoral drift is primarily to the south, nearby communities become downdrift of areas that have a sand deficit.

Simply because some areas have relatively stable beaches or show low background erosion rates, this does not preclude the need to fully address options for shore protection. The town of Surf City is an example of an area that experiences relatively low, damages, as its current beach profile is sufficient to reduce damages effectively. Yet Surf City has an erosion rate of -3.0-feet per year. Over the next 10 to 15 years storm damages have the potential to increase markedly.

Immediately south of Surf City is the town of Ship Bottom. In contrast Ship Bottom has a relatively stable shoreline. One possible reason is the down drift sand it receives from Ship Bottoms erosion. Additionally, groins may be more effectively trapping sand in Ship Bottom while Surf City's groins function less efficiently.

The existing groin field along Long Beach Island was put in place to minimize the impacts and processes of long term erosion. However, field observations suggest that in a few areas of LBI the length and height of some groins can have negative impacts by inhibiting the bypassing of sand at critical times when the beaches are narrow and low. The result is an exaggerated erosion zone immediately adjacent to the groin and starving downdrift areas for sand. This condition is especially noticeable in Beach Haven at the Holyoke Avenue Groin.

2.13 STORM DAMAGE

Storm damage. Storms are the primary source of economic damages along the Atlantic coast of New Jersey. Storm damage includes storm-induced erosion and inundation. Major storms have occurred in September 1944, March 1962, February 1978, March 1984, September 1985, October 1991, January 1992, and December 1992.

An accurate assessment of storm damages is difficult to develop for coastal storms. Along the study area, records of historical storm damages are poor except for the 1962 northeaster, which is the storm of record for the study area. This storm damaged infrastructure, utilities, public and private property and, 1,234 structures totaling $19,000,000 in damages. The February 1978 storm prompted reactivation of a Federal project under Public Law 84-99 and resulted in the pumping of approximately 1,000,000 cubic yards of sand onto the beaches of Loveladies and Harvey Cedars. Recent storms in March 1984, October 1991, January 1992 and December 1992 have also caused significant damages and shown the potential for extensive damage to the study area from larger storm events. The December 1992 storm produced the second highest water levels recorded at Atlantic City, New Jersey tide gage resulting in structural damage to homes and businesses and extensive beach erosion and dune loss. Damages to private property are difficult to establish however, this storm produced FEMA qualified damage to public facilities totaling $1,800,000.

The sections of Long Beach Island consistently affected the most by storm induced erosion are Harvey Cedars, Brant Beach, and Beach Haven. Other communities on LBI have also been affected by storm induced erosion, the intensity of which has varied. During the 1962 storm virtually every part of Long Beach Island had its beach and dunes nearly leveled.

During the March storm of 1962 breaching of the island by the sea occurred at five locations, four of which were in the vicinity of Harvey Cedars. The dune ridge was completely flattened and many structures were destroyed or swept into Barnegat Bay. Following this storm the Corps of Engineers constructed emergency sand dunes and a beach berm in the vicinity of Loveladies, Harvey Cedars, and North Beach.

TABLE 2-27
Existing Storm Damage Data

DATE	DAMAGES	NOTES
3/62	$19,000,000 (1962 $)	infrastructure, utilities, public and private property and 1,234 struct
2/78	unknown	1,000,000 cubic yards sand pumped onshore under reactivation of Public Law 84-99 at Loveladies and Harvey Cedars.
3/84	N/A	damage to beaches, some infrastructure,
10/91	$300 to $500K	Heavy widespread erosion along coast. Contributed to extent of dar in 1992 storms.
12/92	$1,800,000 (1992 $)	FEMA qualified damages to public facilities- unknown private pro damages

The December 1992 storm produced overwashes from the oceanfront in Harvey Cedars, Brant Beach and Beach Haven. (**Figures 2-23 through 2-40** at the end of section 2.14, represent various locations along LBI impacted by storms.) The largest of the overwashes was again in Harvey Cedars. The dune was completely leveled in the southern section of town for a length of several blocks. Homes were partially undermined, ground floors, decks and stairs were damaged. Waves and water swept through the streets into the bay, blocking main streets and damaging utilities. Ocean County constructed an emergency dike from upland sources of sand and clay. Narrower breaches of the dune occurred in Brant Beach and Beach Haven. At these locations houses were partially damaged and large amounts of sand blocked streets. There were several other areas that narrowly escaped the ocean breaking through the dune.

Although Long Beach Island is also susceptible to inundation from back bay flooding, to date back bay flood water levels typically have not risen high enough to affect the majority of structures east of Long Beach Boulevard. However, in communities that have experienced inundation from the ocean side, water and waves coming from the ocean have damaged structures that were otherwise above the flood stage of the static bay waters.

Ecosystem Damages to the Holgate PeninsulaEcosystem Damages to the Holgate PeninsulaEcosystem Damages to the Holgate Peninsula

Complex hydrologic and littoral changes in the latter half of this century have resulted in several acute problems in the Holgate area. The most significant problem is the anticipated breach in the vicinity of the wash-over fan. If a new inlet were to form in this area, the location may be much further north than the previous historical formation of Beach Haven Inlet. The result may include the complete loss of 2.5 miles of coastal wetlands, sandy beach and scrub shrub habitats to erosion and the establishment of a new inlet channel. This could possibly leave adjacent developed land more vulnerable to storm damage and long term erosion processes. Breaching of a similar area at Stone Harbor Point, New Jersey, 44 miles down the coast, resulted in the complete loss of approximately 7000 feet of coastal scrub and wetland habitat south of the terminal groin. The loss of land behind the terminal groin, resulted in a substantial widening of Hereford Inlet. A similar scenario is likely to occur with a breach in the Holgate area. Homes and land adjacent to the refuge in the community of Holgate may subsequently become more vulnerable to storm damage and beach erosion.

Breaching of the Holgate spit has occurred in the past with a subsequent re-growth of the area. However, there are some concerns regarding the changes that have occurred since the development of Long Beach Island. The existence of groins, which have helped protect beaches, dunes and homes in the developed portion of Long Beach Island, may also be contributing to the erosion of the Holgate peninsula. Also, it is believed that the downdrift effects of the groin field are significant enough to limit sand transport past, and around, the Lincoln Avenue groin. This may limit or inhibit the reformation of the Holgate peninsula and hence, the existence of the natural habitat. In addition to the ecological impacts, this would also leave the community of Holgate much more vulnerable to erosion and wave attack from the south. Currently the US Fish & Wildlife Policy is to allow natural processes to govern the future of the Holgate wildlife refuge.

Corps Involvement in the LBI Study Area. The Corp's Policy Guidance Letter No. 24 states that fish & wildlife restoration activities may be recommended only if justified and a Civil Works project has contributed to the degradation. In addition, a past cooperative venture between the Department of the Interior and the Department of the Army agreed to further the goals set forth by the U.S. Fish & Wildlife Service in the North American Waterfowl Management Plan of May 14, 1986. This plan is concerned with the conservation, development and management of habitat for waterfowl and associated wetland species on Army Civil Works Projects. Any environmental restoration initiatives conducted by the Corps at these locations would therefore contribute to the goals of the North American Waterfowl Management Plan.

Congress authorized and adopted a beach erosion control project at Long Beach Island, Ocean County, New Jersey by enactment of Section 101 of the Land Acquisition Policy Act of 1960, Public Law 86-645. House Document No. 208, 86th Congress, contained provisions for widening critically eroded beaches, periodically nourishing the beaches between the South Jetty at Barnegat Inlet and Beach Haven Inlet, and constructing four timber groins in Long Beach Township. On 14 September 1961, the State of New Jersey entered into an agreement with the Federal Government, under Contract No. DA36-109-CIVENG-62-16, for the initiation, prosecution, and reimbursement for completing the Shore Protection Projects cited in House Document No. 208, 86th Congress under the general supervision of the Chief of Engineers. In accordance with the provisions of the agreement, the State of New Jersey was reimbursed in July 1963 $40,665 for the Federal share of work accomplished up to that date. The non-Federal costs for the described work totaled $88,086. Enactment of Section 103 of the Rivers and Harbor Act of 1962, Public Law 87-874, modified the cost sharing provisions by increasing the Federal share to 46.2% for work not substantially completed by October 1962. The Water Resources Development Act of 1976, Public Law 94-631 modified the existing project and authorized Phase I AE&D. These modifications as presented in House Document 631, 94th Congress primarily increased the berm width by 25 feet and also provided for additional groin construction. Section 605 of the Water Resources Development Act of 1986 reauthorized this project.

In 1957, as part of the non-Federal interest's groin construction program, four groins of timber and stone were constructed along the northern section of Holgate. These groins were damaged during the severe March 1962 Coastal Storm and the repairs were completed in 1967. Under the Accelerated Public Works Program, four additional timber and stone groins were constructed along the central portion of the Holgate shoreline. Based on extensive review of designs at the time by the Philadelphia District, the eight groins appeared to satisfy the authorized need of groins equally spaced in the central and northern sections of Holgate.

Following the severe coastal storm of March 1962, the Corps of Engineers, under emergency contracting assistance in accordance with Public Law 81-875, constructed sand dunes and a beach berm. The project dimensions for Long Beach Island included the vicinity of Loveladies through Harvey Cedars to North Beach for a distance of 19,000 feet and at a cost of $765,000. In addition, the Office of Emergency Planning, under the authority of Public Law 81-875, reimbursed state and local interests over $3 million for shore protection work. The work consisted of the construction of sand dunes and beach berm, installation of protective dune fence and planting of dune grass along the remainder of Long Beach Island, all under the general supervision of the Corps of Engineers. Following Hurricane BELLE in August 1976, FDAA reimbursed state and local governments approximately $500,000 for work consisting of the installation of dune fence and dune stabilization that was performed.

As a result of erosion damages sustained to the Long Beach Island Beach Erosion Control Project during the 5-7 February 1978 Coastal Storm, restoration by the Federal Government was authorized under the provisions of Public Law 84-99, in the amount of $2,765,000.

2.14 PRIOR ATTEMPTS TO LIMIT DAMAGES.

Prior Attempts to Limit Damages. Various measures have been employed by local , State and Federal government agencies to limit damages within the Barnegat Inlet to Little Egg Inlet study area. Most have been successful to some degree. However, as we have seen from recent storms such as the October 1991 “Halloween storm” and the December 1992, the sum of these measures has not been enough to prevent significant damages resulting from storms and long term erosion. A brief description of the various methods and measures presently employed to reduce damages follows:

a. **Groin Construction**. Groins have been constructed by various agencies since around the 1920’s. Early groins were few in numbers and widely dispersed throughout LBI. After the March 1962 storm an effort was made to stabilize segments of the LBI shoreline by building groins, adding to the few that currently existed. After 1964, an effort was made to complete the previously interspersed groin field from Barnegat Light to Holgate. By 1969 all groins were completed with an average spacing of 900 feet to produce a groin field approximately 18 miles long with a total of 112 groins. Of the 112 groins, 101 front the developed portion of the island between the Barnegat Inlet old south jetty and the Lincoln Avenue groin. Groins were constructed of timber, stone or both and vary in length, width and profile from community to community. Preliminary analysis suggests that the groin field has helped reduce the overall rate of long term erosion. However, those areas mentioned previously such as Harvey Cedars and Brant Beach have remained very vulnerable and are still experiencing some degree of long-term erosion. **Figures 2-41 through 2-52** depict the various groins along LBI.

b. **Building Codes**. Stricter standards for new construction has resulted in more buildings elevated above the 100 year flood level, deeper penetration of pile foundations, and overall more structurally sound buildings. Evidence from the December 1992 storm suggest that this is one of the reasons that damages similar to the 1962 storm did not occur even though population and density of structures has increased tremendously and both storms were of similar magnitude. However the majority of structures behind the first row of ocean front homes, built before improved building codes were in effect, remain at slightly above grade and not on pile foundations. That leaves many structures still vulnerable to storms, particularly storms of greater magnitude than the 1962 and 1992 storms.

c. **Dune Maintenance and Construction**. All the communities of Long Beach Island practice some form of dune maintenance and construction (reconstruction). Following the 1962 storm beaches and dunes that were leveled by the storm were rebuilt. Since then sand fence and dune grass have been continually replaced and planted on an annual basis. This has resulted in some areas of significant dunes. However, in areas most subject to severe storm erosion, dunes have required continual replacement or modification by beach scraping or bulldozing sand from the beach face or small scale trucked in beach fill. While this has helped in the short term after a storm has hit, it has been minimally effective at reestablishing significant and stable dunes, especially in recent years where severe storms have hit with a much higher frequency. Pushed up sand is not compact and therefore more subject to the erosive forces of wind and water than well established dunes with compact sand and deep rooted dune grass. The limited amount of sand available from Long Beach Island's narrow beach face, particularly after a storm, or, the small quantities brought in by truck are not enough to provide adequate dune protection for the long term.

d. **Beachfills**. Since 1954 the State of New Jersey and the Federal Government have been providing money and manpower for beachfill efforts on Long Beach Island. Beachfills have been in response to storm erosion and long term erosion. Total volume of beachfill since 1954 is estimated at 6,000,000 cubic yards. Limited funding and manpower at the state and local level typically results in beachfill only after damage has occurred, the situation has become critical, and a significant amount of lobbying by the local communities. This method of "repair after the fact" is not as efficient at preventing damages as a program of scheduled nourishment and maintenance of a design profile.

e. **Better Warnings for Beach Erosion and Inundation**. Local community officials and property owners have become better informed during storms through experience and information available from the National Weather Service and NOAA weather radio. Storm forecasting, water level predictions, and warnings of times of high beach erosion have aided communities in minimizing damages by preparing for storms. We know from experience that storm warnings and forecasts can be one of the most effective means of preventing loss of life and damage to items which can be moved or elevated such as automobiles and house contents. This solution is most effective for minimizing damages from large-scale storms such as hurricanes that are usually tracked for relatively long periods and allow for ample warning time. However, extratropical storms and Northeasters, the most devastating storms of this region, can sometimes develop very quickly and unpredictably off the mid-Atlantic and New England coastlines, allowing little time for prediction and warning. This scenario occurred twice during this study in late summer of 1994 where two unpredicted small scale Northeasters developed directly off the coast of New Jersey.

FIGURE 2-23 Barnegat Inlet Dec 14, 1992

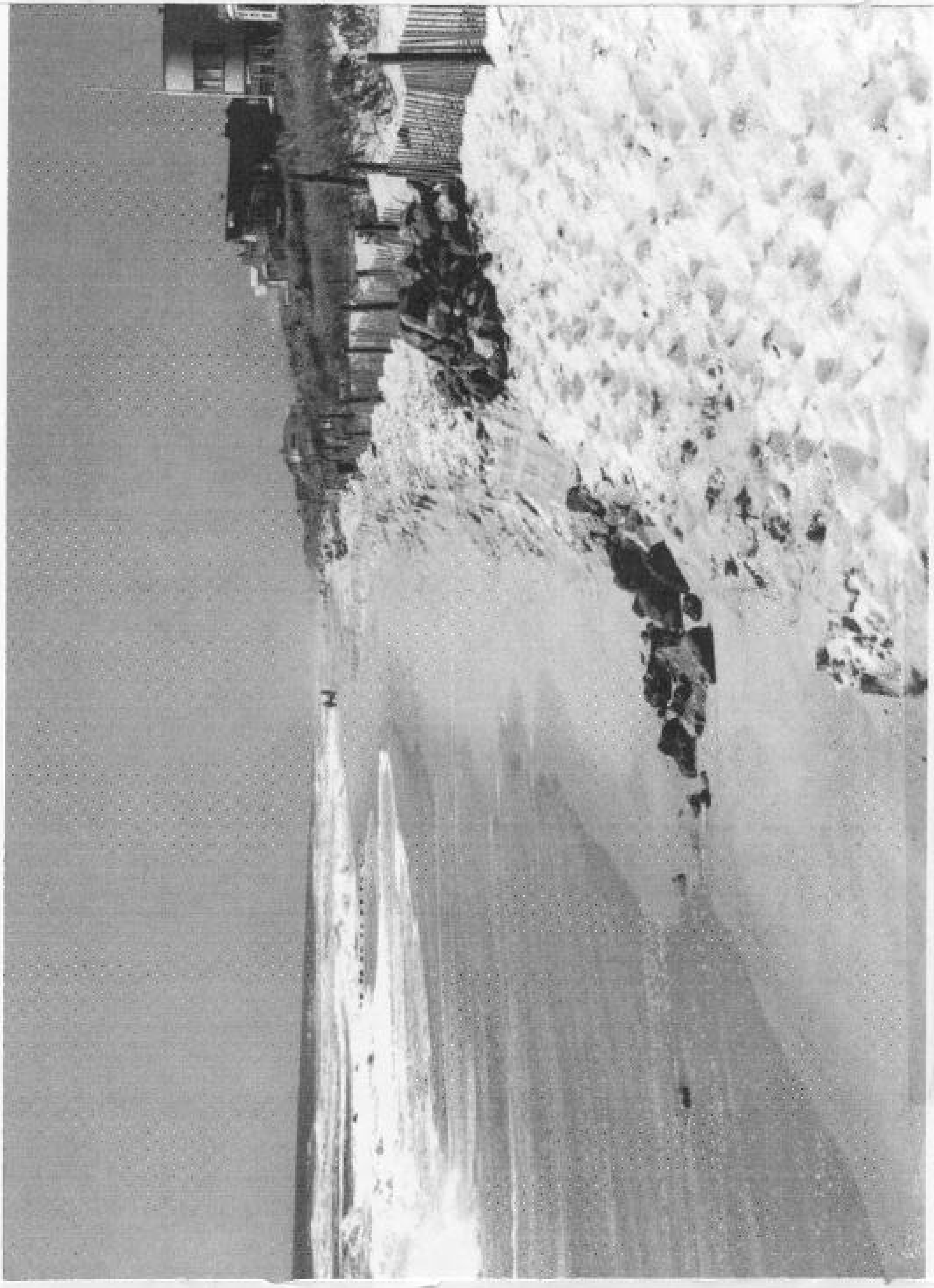


FIGURE 2-24 Barnegat Light at 30th Street Aug 24, 1994

115

FIGURE 2-25 Loveladies, Long Beach Township, New Jersey Feb 6, 1998

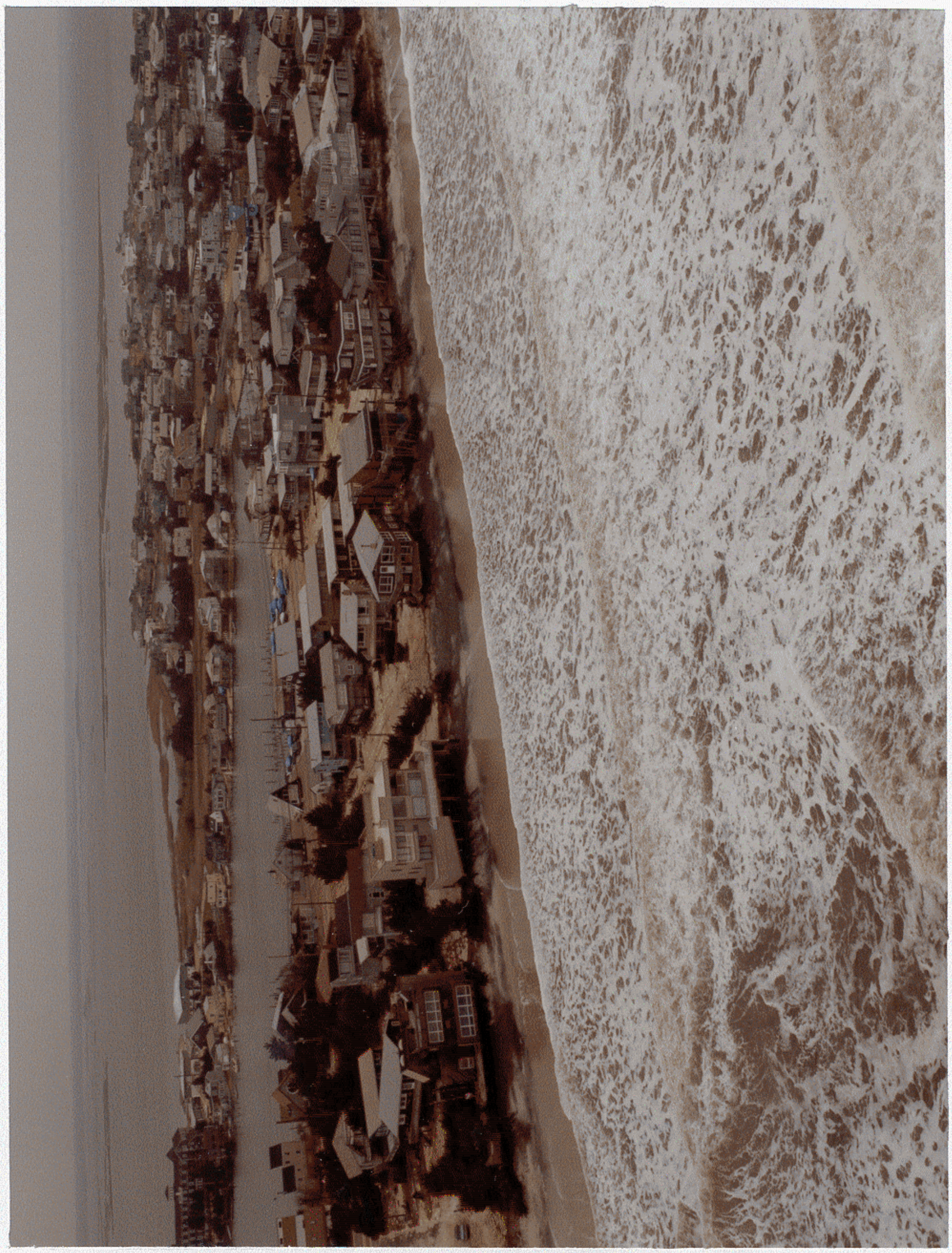


FIGURE 2-26 Harvey Cedars, New Jersey Dec 1992

117

FIGURE 2-27 Problem Erosion Harvey Cedars Dec 14, 1992

118

FIGURE 2-28 85th Street at Harvey Cedars Jan 6, 1996

119

FIGURE 2-29 Harvey Cedars, New Jersey Dec 14, 1992

120

FIGURE 2-30 North Beach, Long Beach Township, New Jersey Dec 14, 1992

121

FIGURE 2-31 Surf City, New Jersey Dec 14, 1992

122

Scary Wind Creates New Cliffhangers

BRINKMANSHIP: Winds up to a hurricane force of 75 mph turned waves into shovels last Thursday leaving the beach at 48th Street in Brant Beach resembling the south rim of the Grand Canyon. Long Beach Township is having trouble finding places to put sand fences to try help stop further erosion.

Tim Moersh

FIGURE 2-32 Brant Beach, Long Beach Township, New Jersey Summer 1997

FIGURE 2-33 Brant Beach Loss of Dunes Dec 14, 1992

124

FIGURE 2-34 Brant Beach, Typical Local Response after Jan 6, 1999 Blizzard

FIGURE 2-35 Brant Beach, Long Beach Township Jan 6, 1996

126

FIGURE 2-36 Holyoke Avenue Groin, Beach Haven Township Jan 6, 1996

FIGURE 2-37 Beach Haven, New Jersey Feb 6, 1998

FIGURE 2-38 Beach Haven, New Jersey Feb 6, 1998

FIGURE 2-39 Holgate, Long Beach Township, New Jersey

FIGURE 2-40 Holgate Unit, Edwin Forsythe Wildlife Refuge Aug 30, 1995

131

FIGURE 2-41 Groin 6 combo wood and stone at Riviera Ave., (Loveladies) Long Beach Township

FIGURE 2-42 Groin 9, Low Permeability Timber Groin at Panorama So., (Loveladies) Long Beach Township

FIGURE 2-43 Groin 14 - Functional Stone Groin at 85th Street Harvey Cedars

FIGURE 2-44 Typical Groin Configuration for LBI, Groin 38 at North 3rd Street Surf City

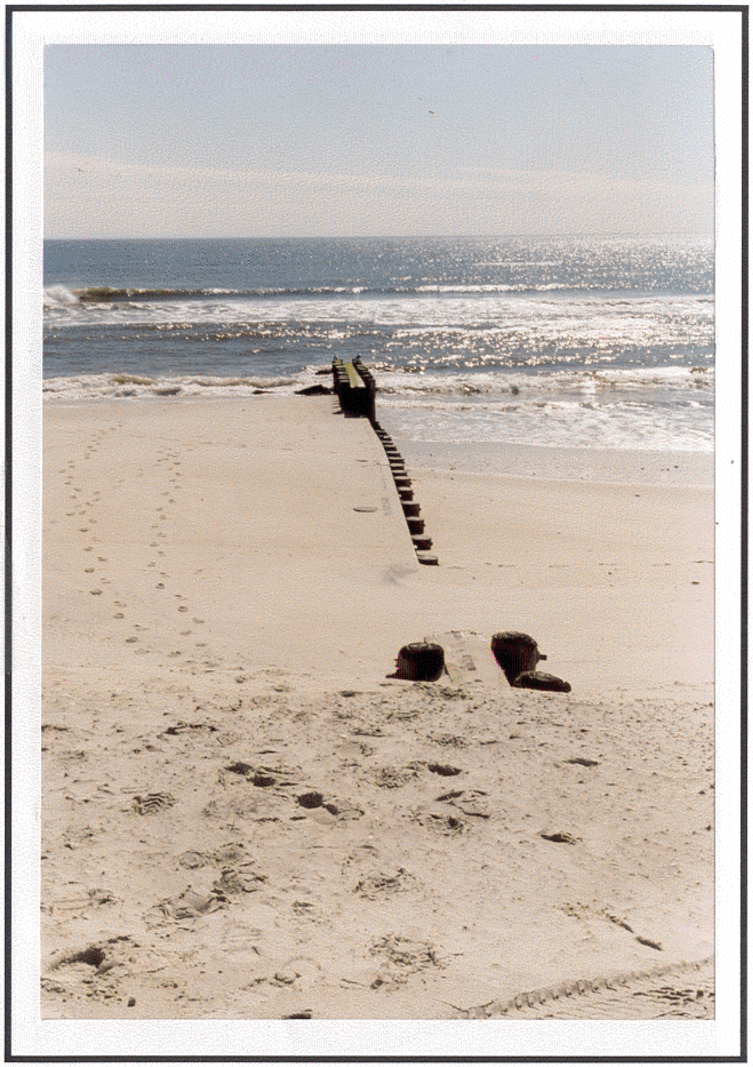


FIGURE 2-45 Effects of Notched Groin at 79th Street, Long Beach Township

FIGURE 2-46 Example of Ineffective Notched Groin at 51st street, Brant Beach

FIGURE 2-47 Combination Stone End and Low Profile Timber Groin at North Beach, Long Beach Township

FIGURE 2-48 Higher Elevation all Stone Groin at 30th Street, Brant Beach, Long Beach Township

FIGURE 2-49 54th Street at Brant Beach
Potential Groin for notching

FIGURE 2-50 Effects of Groin Notching at 79th Street, Long Beach Township

FIGURE 2-51 Marshall Street, Groin 89 in Holgate, Long Beach Township

FIGURE 2-52 Seaward view of Marshall Street Groin

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3.0 WITHOUT PROJECT

3.1 HYDRAULIC ANALYSIS.

Storm erosion, Inundation and Wave Attack Analyses. Storm erosion, inundation and wave attack analyses were conducted for the communities north of Holgate Wildlife Refuge to determine the potential for erosion caused by waves and elevated water levels that accompany storms. Storm-induced erosion and coastal flooding is first evaluated for the without project condition, which is a projection of existing conditions in the base year. Similar analyses will then be conducted using selected alternatives for the with project conditions.

Factors Influencing Storm Effects. A brief summary of the mechanisms that result in erosion and inundation from coastal storms is provided in this section. Wind, storm track, and precipitation are the primary meteorological factors affecting the damage potential of coastal storms. The major causes of damage and loss of life are storm surge, storm duration, and wave action.

Under storm conditions, there is typically a net increase in the ocean water level which is superimposed on the normal astronomic tide height fluctuations. The increase in water level caused by the storm is referred to as "storm surge." The effect of storm surge on the coast depends on the interaction between the normal astronomic tide and storm-produced water level rise. For example, if the time of normal high tide coincides with the maximum surge, the overall effect will be greater. If the surge occurs at low or falling tide, the impact will likely be lessened. The term "stage" as applied in this analysis pertains to the total water elevation, including both tide and storm surge components, relative to a reference datum (NAVD88, used herein). The term "surge" is defined as the difference between the observed stage and the stage that is predicted to occur due to normal tidal forces, and is thus a good indicator of the magnitude of storm intensity. Slowly moving "northeasters" may continue to build a surge that lasts through several high tides. Such a condition occurred during the devastating March 1962 storm that lasted for five high tides.

In addition to storm surge, a rise in water level in the near shore can occur due to wave setup. Although short period surface waves are responsible for minimal mass transport in the direction of wave propagation in open water, they cause significant transport near shore upon breaking. Water propelled landward due to breaking waves occurs rather rapidly, but water returned seaward under the influence of gravity is slower. This difference in transport rates in the onshore and offshore direction results in a pileup of water near shore known as wave setup. Wave setup was computed and included in this storm analysis.

There is typically also an increase in absolute wave height and wave steepness (the ratio of wave height to wavelength). When these factors combine under storm conditions, the higher, steeper waves and elevated ocean stage cause a seaward transport of material from the beach face. Net movement of material is from the foreshore seaward toward the surf zone. This offshore transport creates a wider, flatter nearshore zone over which the incident waves break and dissipate energy.

Lastly, coastal structures can be exposed to the direct impact of waves and high velocity runup in addition to still water flooding. This phenomenon will be considered the wave attack for the purpose of this analysis. Reducing wave attack with a proposed project such as a beach fill would reduce the severity of coastal storm damage and also improve the utility of bulkheads and seawalls during the storm.

Wave zones are the regions in which at least a 3-ft wave or a velocity flow that overtops the profile crests by 3-ft can be expected to exist. These zones are the areas in which greater structural damages are expected to occur. The remaining zones are susceptible to flooding by overtopping and waves less than the minimum of 3-ft. Total water level information for the study area was compiled, and the values used as input to the economic model that ultimately computes damages associated with all three, storm related damage mechanisms.

Modeling Storm-induced Erosion. Storm erosion analyses require either a long period of record over which important storm parameters as well as resultant storm erosion are quantified, or a model which is capable of realistically simulating erosion effects of a particular set of storm parameters acting on a given beach configuration. There are very few locations for which the necessary period of prototype information is available to perform an empirical analysis of storm-induced erosion. This is primarily due to the difficulty of directly measuring many important beach geometry and storm parameters, before, during, and immediately after a storm. Thus, a systematic evaluation of erosion under a range of possible starting conditions requires that a numerical model approach be adopted for the study area.

The USACE has developed, released and adopted the numerical storm-erosion model SBEACH (Storm induced BEAch CHange) for use in field offices (Rosati, et al., 1993). SBEACH is available via a user interface for the personal computer or through the Coastal Modeling System (CMS) (Cialone et al., 1992). Comprehensive descriptions of development, testing, and application of the model are contained in Reports 1 and 2 of the SBEACH series (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990)

Overview of SBEACH Methodology. SBEACH Version 3.2 (Windows version) was used in this analysis. SBEACH is a geomorphic-based two-dimensional model that simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels (Rosati, et al. 1993). SBEACH has significant capabilities that make it useful for quantitative and qualitative investigation of short-term, beach profile response to storms. However, since SBEACH is based on cross-shore processes, there are shortcomings when used in areas having significant longshore transport.

Input parameters include varying water levels as produced by storm surge and tide, varying wave heights and periods, and grain size in the fine-to-medium sand range. The initial beach profile can be input as either an idealized dune and berm configuration or as a surveyed total profile configuration. SBEACH allows for variable cross-shore grid spacing, simulated water-level setup due to wind, advanced procedures for calculating the wave breaking index and breaker decay, and provides an estimation of dune overwash. Shoreward boundary conditions that may be specified include a vertical structure (that can fail due to either excessive scour or instability caused by wave action/water elevation) or a beach with a dune. Output results from SBEACH include calculated profiles, cross-shore parameters, and log and a report file.

SBEACH Calibration. Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by an actual storm. Due to the empirical foundation of the SBEACH model and the natural variability that occurs along a beach under storm attack, proper use of the model requires calibration and verification using data from beach profiles surveyed before and after exposure to the effects of a particular storm. The calibration procedure involves iterative adjustments of controlling simulation parameters until agreement is obtained between measured and simulated profiles. In this investigation, model calibration and verification were based on original SBEACH calibration/verification efforts conducted by CERC at Point Pleasant Beach, see USACE/CERC, 1990. The Point Pleasant Beach profile used in calibration has similar characteristics in terms of nearshore, berm, and dune features to profiles found throughout Long Beach Island. The conditions selected for calibration were associated with a northeaster that occurred over the period 27 to 29 March 1984 during which the peak water level reached +6.2 feet NGVD, and maximum wave heights of 21.6 feet were recorded in a water depth of 50 feet off of Manasquan Inlet. The selected pre-storm profile surveys were taken on 26 and 27 March. Post-storm profiles were taken on 2 April. Examination of the post-storm profile shows considerable deposition on top of the dune. The eroded portion of the profile was contaminated with some recovery that occurred between post-storm and the survey. The calibration adjustment runs for this area were brought to a conclusion on reaching conditions that generally followed the pattern of the post-storm profile survey.

All in all, the calibration and verification of the SBEACH model produced acceptable but not outstanding results. Admittedly, the process lacked complete data with respect to overall onshore/offshore surveys of pre- and post-storm profiles, and measured water levels at Island Beach. Additionally, it should be appreciated that actual profile responses along the shores of the study area are probably significantly influenced by alongshore processes and the related effects of the adjacent jetties and groin field. Since the SBEACH model cannot simulate the alongshore component of sediment transport and groin/sediment-transport interaction, it is highly probable that, even with ideal data sets, extremely close correspondence between simulated and measured results is not achievable in the case of Long Beach Island.

Development of Input Data for Storm Erosion Modeling. Transects were selected representing the "average" shoreline, structure, backshore configuration, and upland development conditions for various reaches in the study area. For each reach, storm erosion and inundation were computed and reported relative to a designated baseline. Input data was developed for each cell as follows.

Profile Data. The principal physical characterization of each cell is provided by the cross-sectional configuration of its beach and dune system. In this investigation, the July 1996 most recent survey profiles were selected to represent the onshore and nearshore areas under the “without” (W/O) project base year condition. Each profile extended from the dunes to a sufficient distance seaward beyond the depth of closure. The original survey information was sufficient to perform beach/dune response modeling; however, economic damage assessment requires evaluation of damage potential landward of the first row of development. Therefore, the profiles were artificially extended in a landward direction until the profile reached the Bay. These extensions were based on general characteristics of the island's topography as determined by field investigations, USGS topographic sheets, 1996 digital orthophotogrammetric data, and recent structure inventory surveys. Cross sections of representative beach profile lines can be seen in **Figures 3-1 to 3-3.** The profile line names correspond to the cells that they represent. The cell limits were previously described in **Table 3-5** and are graphically depicted in **Figure 3-5**.

Potential "future" damages were also evaluated for cells where long term erosion may result in profile conditions significantly different from those simulated in the "base year." Sufficient long-term erosion warranted modification of profiles for cells 3 to 15 (Loveladies to Holgate), with the ends of the Island being historically stable. Long-term erosion was incorporated by translating the profile landward a distance equal to the long-term erosion rate adopted for each cell, times the number of years projected into the future. It was assumed the locals would maintain existing dune conditions, as has been demonstrated historically. Therefore, no modifications were made to the profile above the berm. **Figure 3-6** shows both the base year and future (year 15) conditions for BUNDY 9 located in Brant Beach with a long-term erosion rate of -2 ft/yr.

Model Parameters. Various model parameters required to run SBEACH are input into the reach and storm configuration files. The reach configuration parameters include grid data, profile characteristics, beach data (including grain size), sediment transport parameters, and seawall or bulkhead data. The storm configuration file includes information on wave angle, height and period, water elevation, wind speed and angle and other storm information.

Water Elevation. The water level is the most important or first-order forcing parameter controlling storm-induced beach profile change, normally exerting greater control over profile change during storms than either waves or wind. Water level consists of contributions from the tide, storm surge, wave- and wind-induced setup, and wave runup; the latter three are computed within SBEACH. Input data in this case is tide and storm surge data. The combined time series of tide and surge is referred to as the hydrograph of total water level. The shape of the hydrograph is characterized by its duration (time when erosive wave conditions and higher than normal water elevation occur) and by its peak elevation.

Water level input data files for representative 5-, 10-, 20-, 50-, 100-, 200-, and 500-yr events were developed for the study area as part of the wave hindcast conducted by OCTI. The Gumbel distribution (Fisher-Tippett Type I) was used.

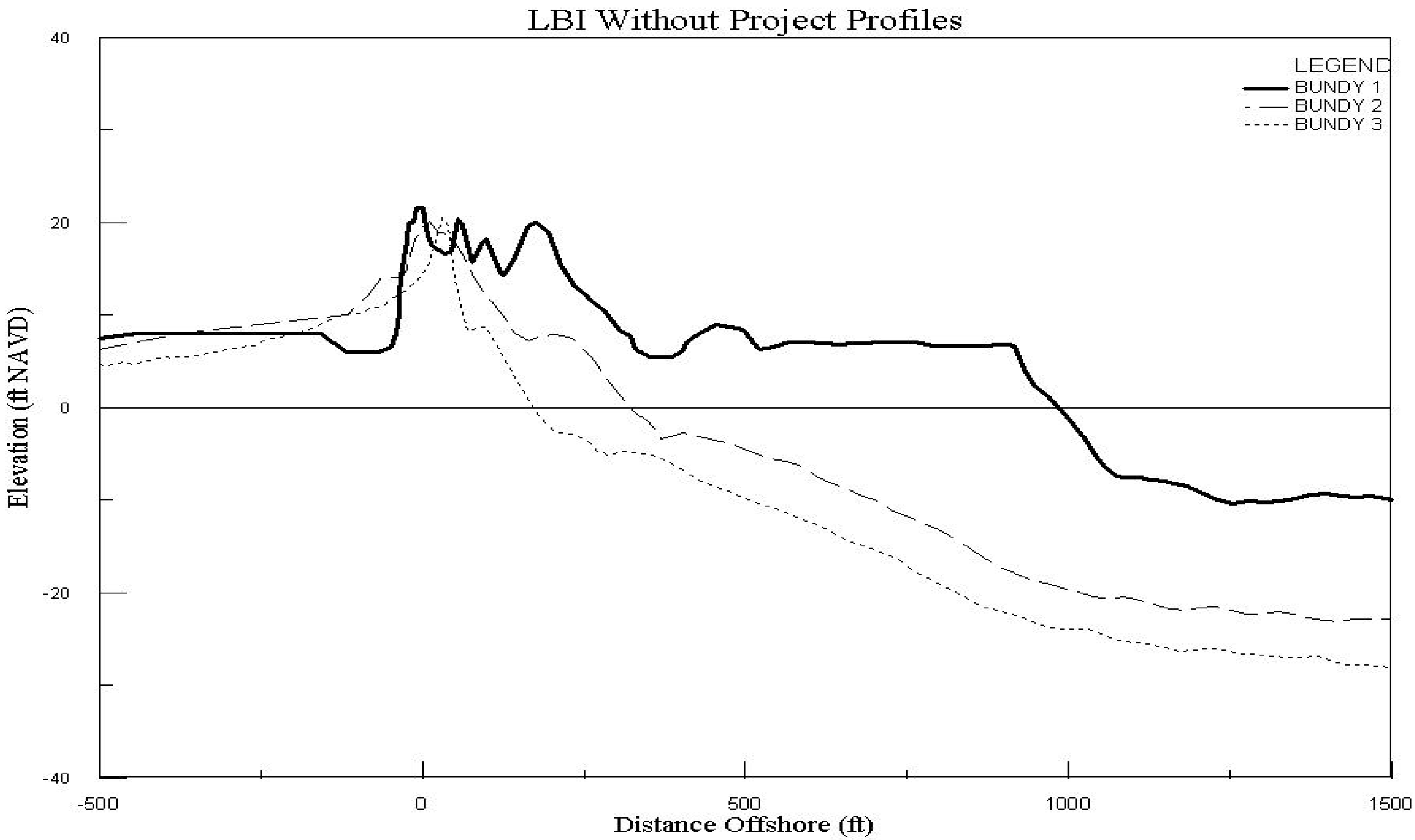


Figure 3-1 Representative Beach Profiles for BUNDYs 1-3 (Base Year).

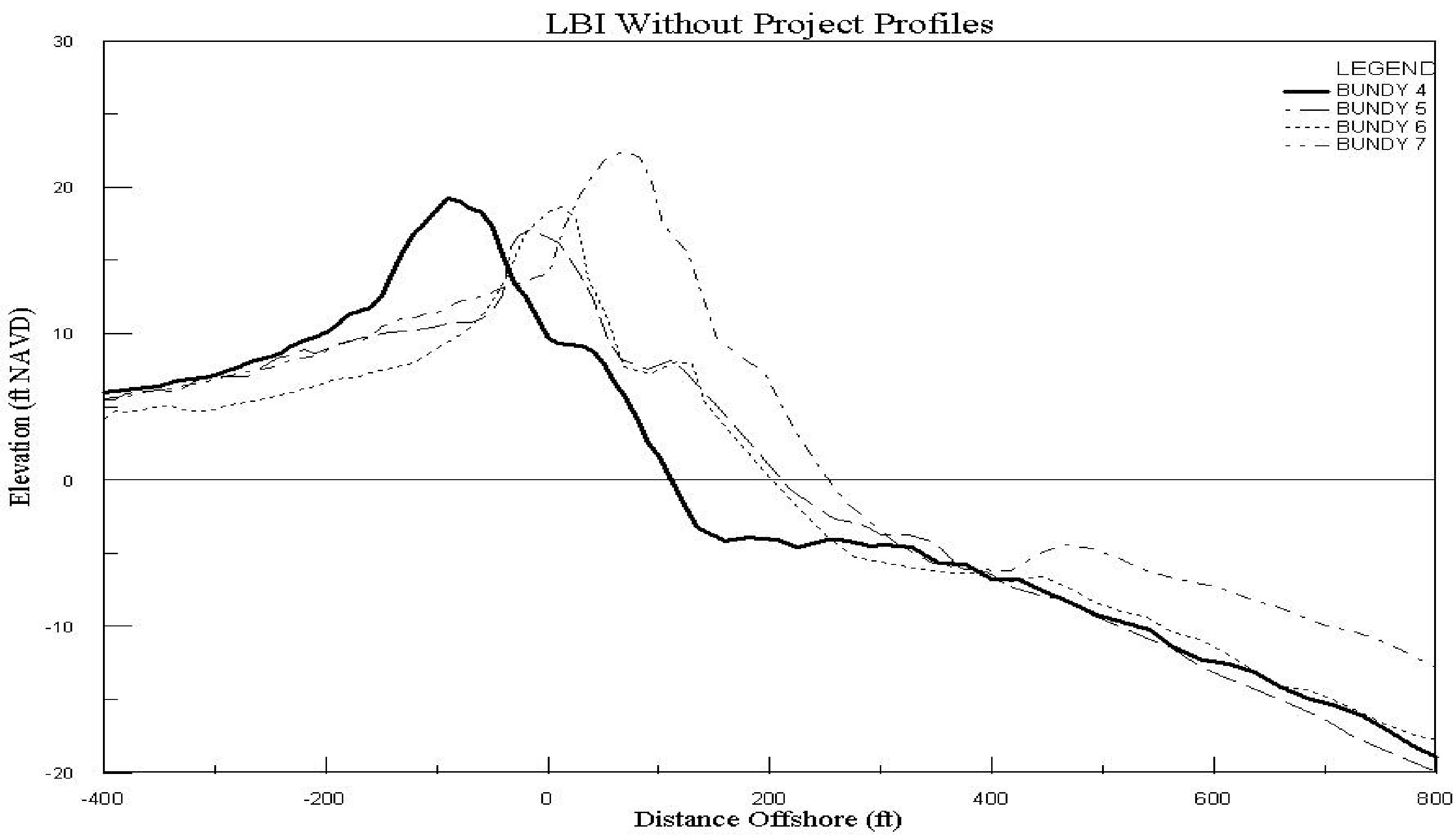


Figure 3-2. Representative Beach Profiles for BUNDYs 4-7 (Base Year).

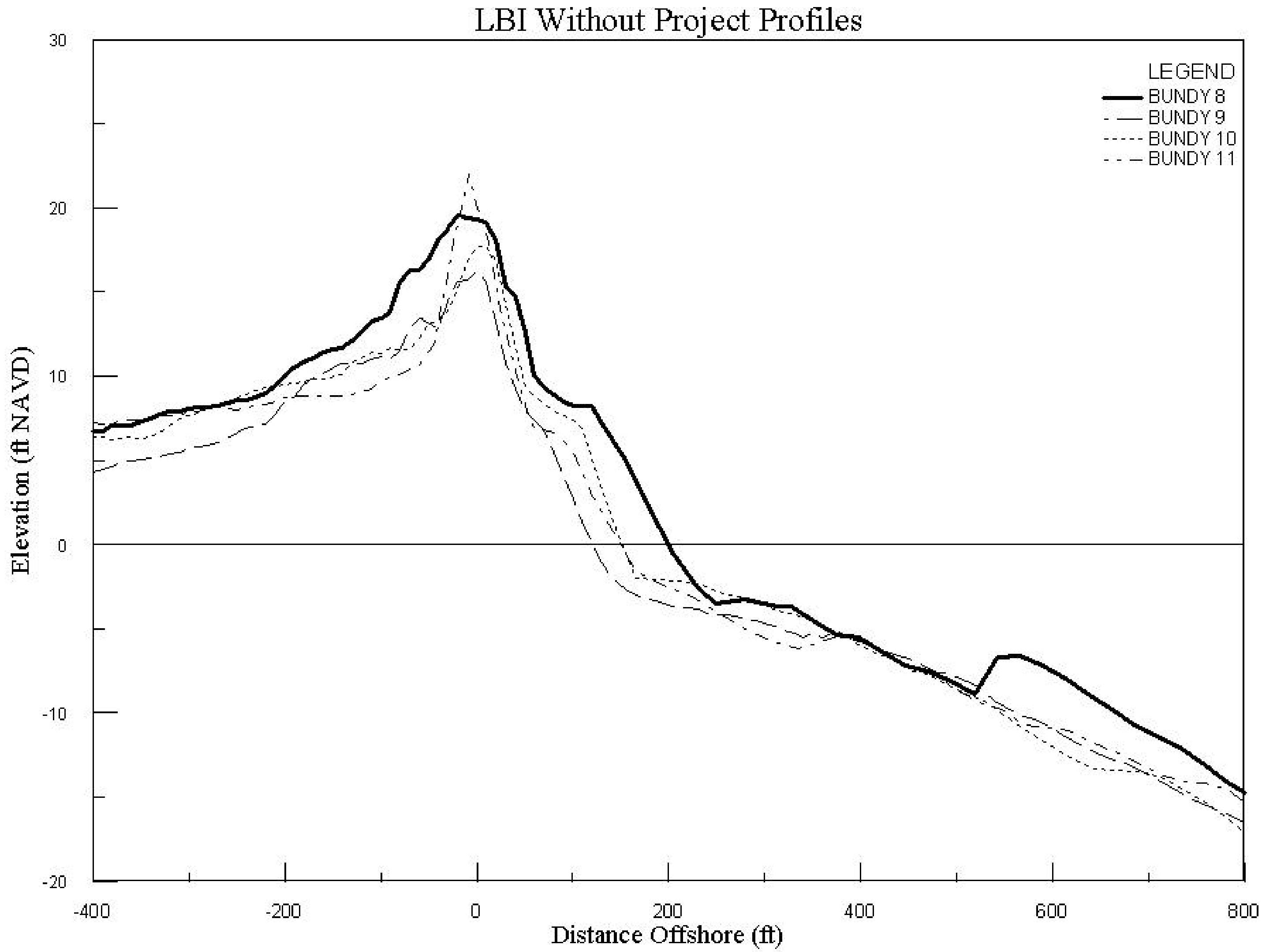


Figure 3-3. Representative Beach Profiles for BUNDYs 8-11 (Base Year).

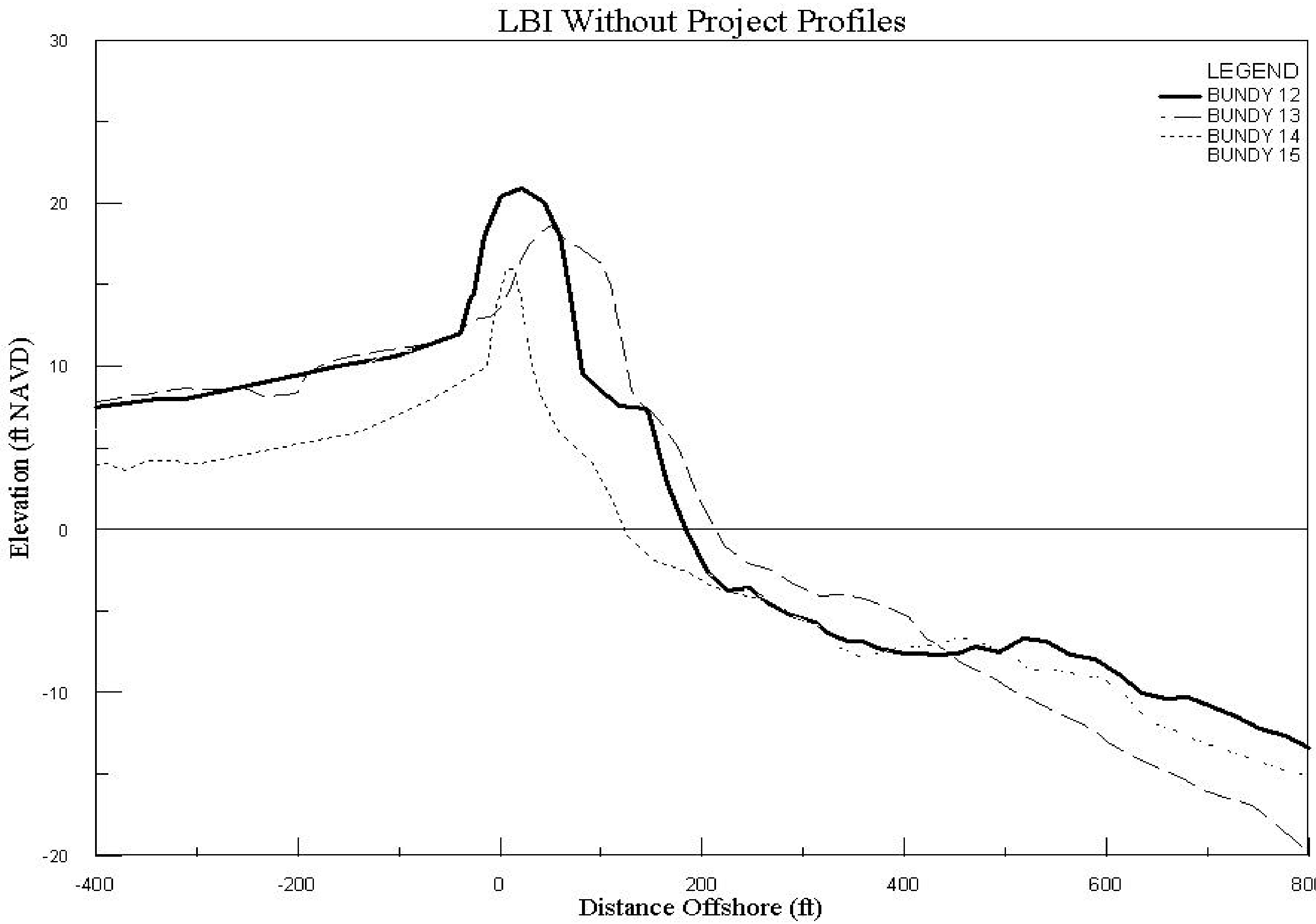
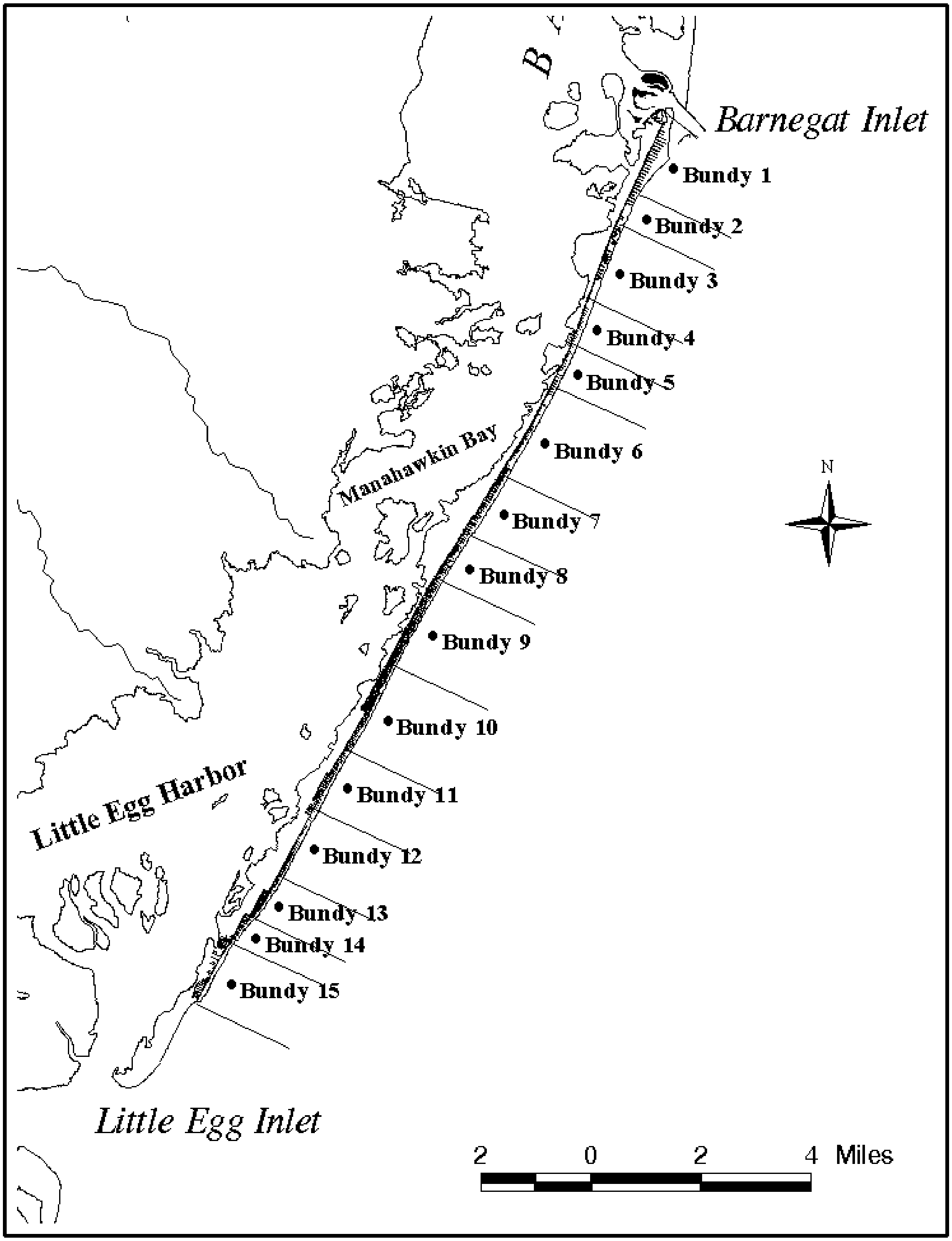


Figure 3-4. Representative Beach Profiles for BUNDYs 12-15 (Base Year).

Figure 3-5. BUNDY Limits.



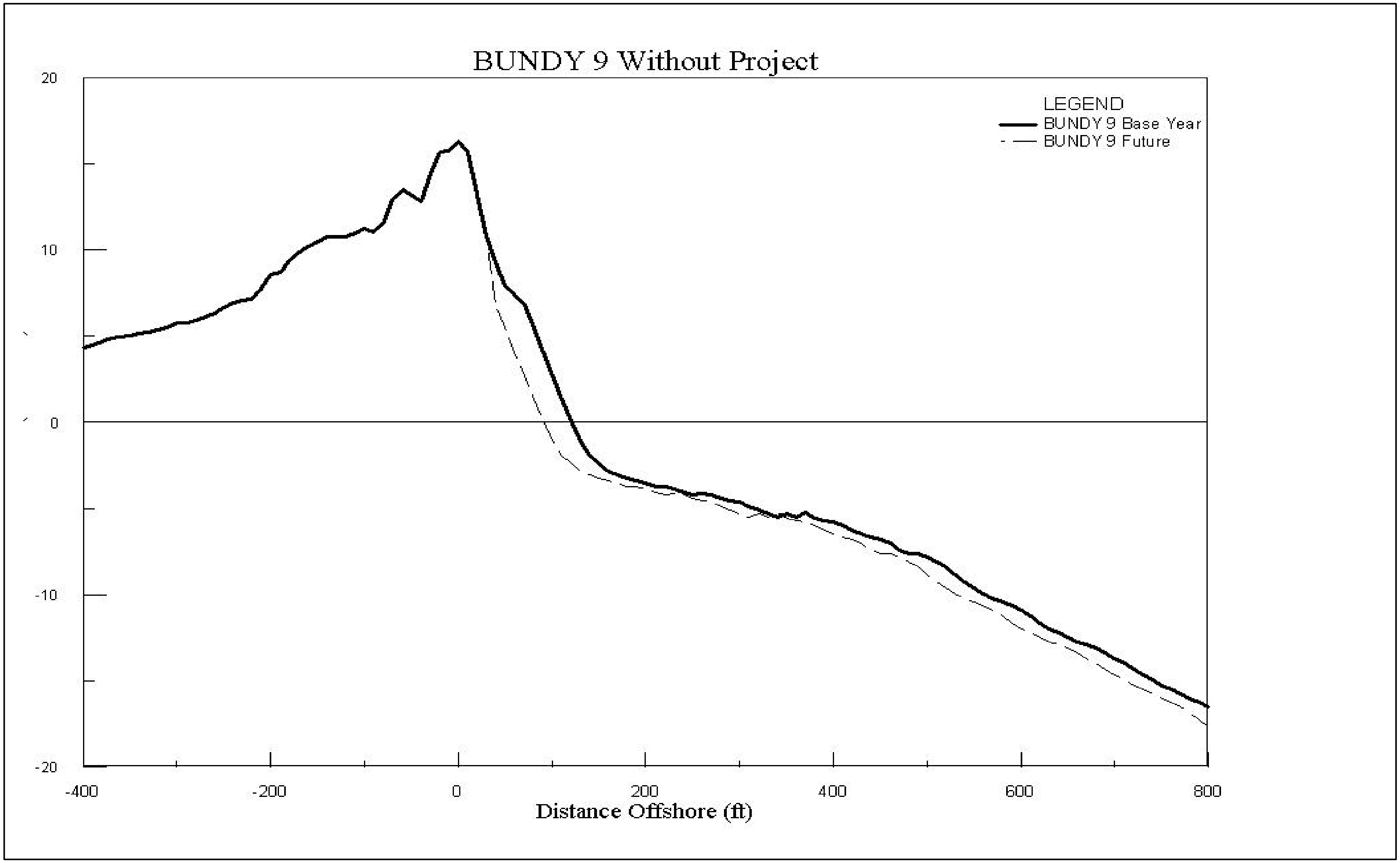


Figure 3-6. BUNDY 9 Without Project Profile Conditions for "Base Year" and "Future" Conditions.

Wave Height, Period, and Angle. Elevated water levels accompanying storms allow waves to attack portions of the profile that are out of equilibrium with wave action because the area of the beach is not normally inundated. Wave height and period are combined in an empirical equation within SBEACH to determine if the beach will erode or accrete for a time step. In beach erosion modeling, a storm is defined neither by the water level nor by the wave height or period alone, but by the combination of these parameters that produces offshore transport.

The SBEACH Version 3.2 allows for the input of random wave data, that is, waves with variable height, period, and direction or angle. Storm wave data for the seven representative events used in this analysis were generated in the OCTI wave hindcast described previously in the Physical Processes Section. Storm wave heights, as well as water levels, were developed by rescaling hindcasted actual storm time series. **Figures 3-7 to 3-14** display the storm conditions for the 2- to 500-yr events developed for SBEACH.

Storm Parameters. A variety of data sources were used to characterize the storms used in this analysis. The twenty highest ocean stages recorded at the Atlantic City tide gage between 1912 and 1997 were listed in a previous section on water levels. For each stage, additional information on the storm type causing the water surface elevation and if possible the actual storm surge hydrograph were obtained. Of the 20 highest events, 12 are northeasters and 8 are hurricanes. The duration of hurricanes along the New Jersey shore is generally less than 24 hours, while the average duration of northeasters is on the order of 40 hours, and in some cases (e.g., 5-7 March 1962) considerably longer. Though actual storm surge hydrographs are not available for all storm events, it was assumed that all hurricanes exhibit similar characteristics to one another. Northeasters demonstrate similar features; however, durations may vary significantly from storm to storm.

Storm Erosion Simulations. The SBEACH model was applied to predict storm-induced erosion for all cells within the study area. All representative storm events were run against the pre-storm profiles for both the base year and "future" conditions shown in **Figures 3-1 to 3-3.** Model output for each simulation includes a post-storm profile plot and plots showing volume change and maximum wave and water level conditions. Simulation results from each particular combination of profile geometry and storm characteristics yield predicted profile retreat at three selected elevation contours. In this analysis, profile retreat for a given storm event was measured landward from the proposed project baseline to the location of the top of the erosion scarp on the beach face. Typical plots of input pre-storm profiles and the resultant post-storm (50-yr event) profiles based on SBEACH predicted retreat are provided in **Figure 3-15** for BUNDY 9 located in Brant Beach.

Analysis of Erosion Model Results. Two approaches can be taken to estimate storm-induced beach erosion: the "design-storm" and the "storm-ensemble" approach. For the storm-ensemble approach, erosion rates are calculated from a large number of historical storms and then ranked statistically to yield an erosion-frequency curve. In the design-storm approach, the modeled storm is either a hypothetical or historical event that produces a specific storm surge hydrograph and wave condition of the desired frequency. The design-storm approach was used in the storm erosion and inundation analyses for this study area. Volumetric erosion into the community per unit length of shoreline can subsequently be computed from the pre- and post-storm profiles.

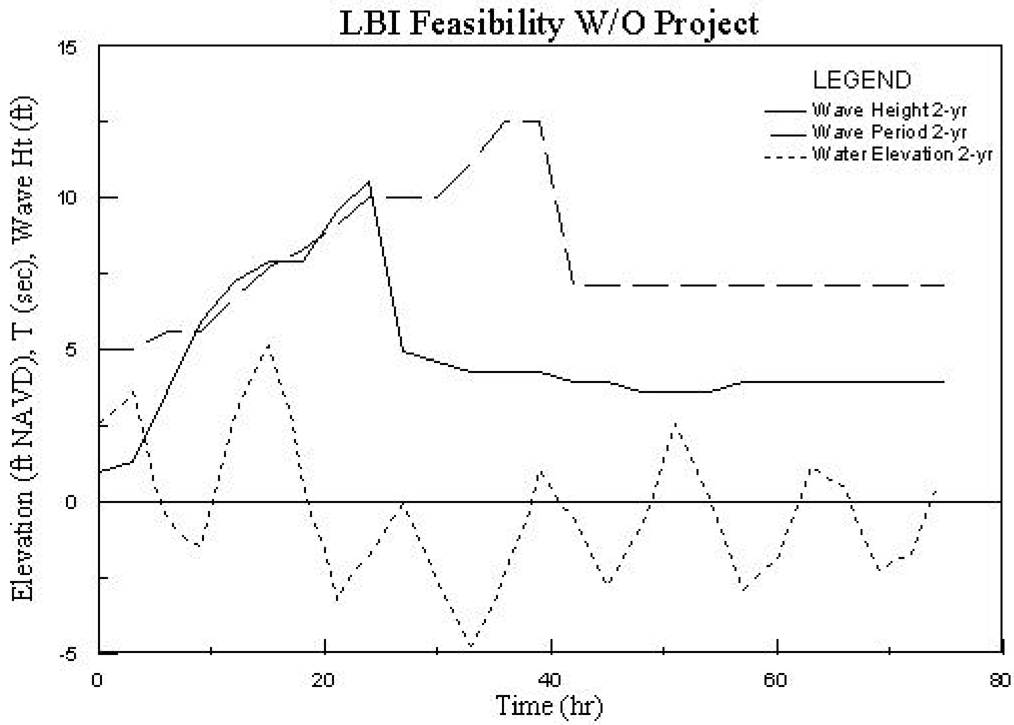


Figure 3-7 "2-yr" Storm Conditions used in Storm Damage Analysis

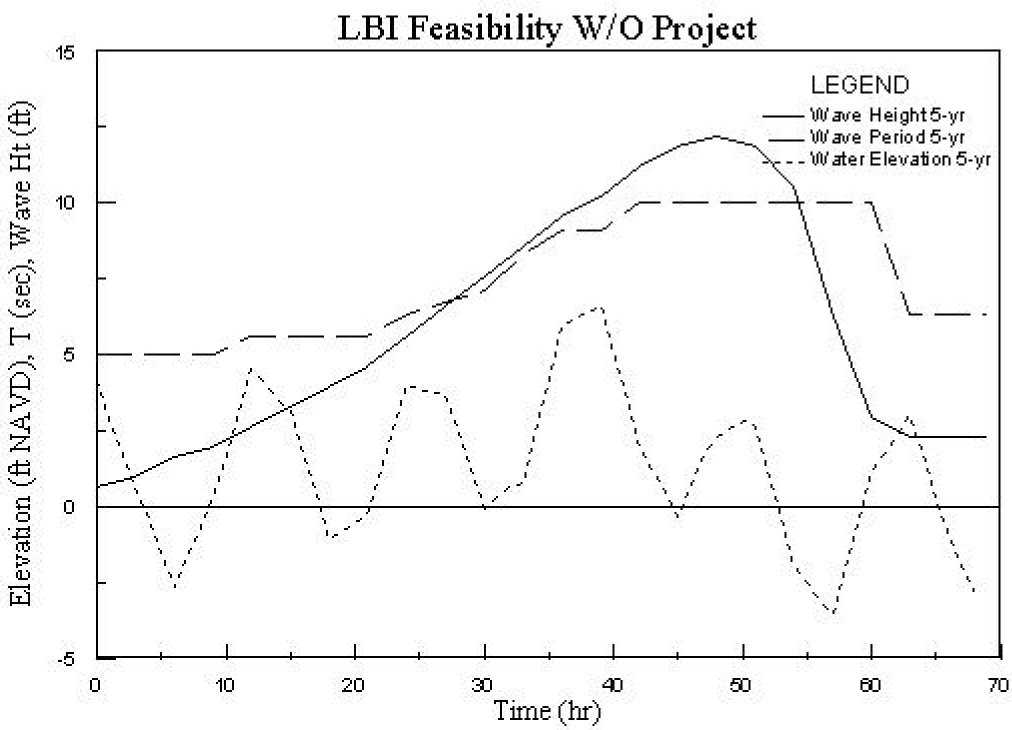


Figure 3-8 "5-yr" Storm Conditions used in Storm Damage Analysis.

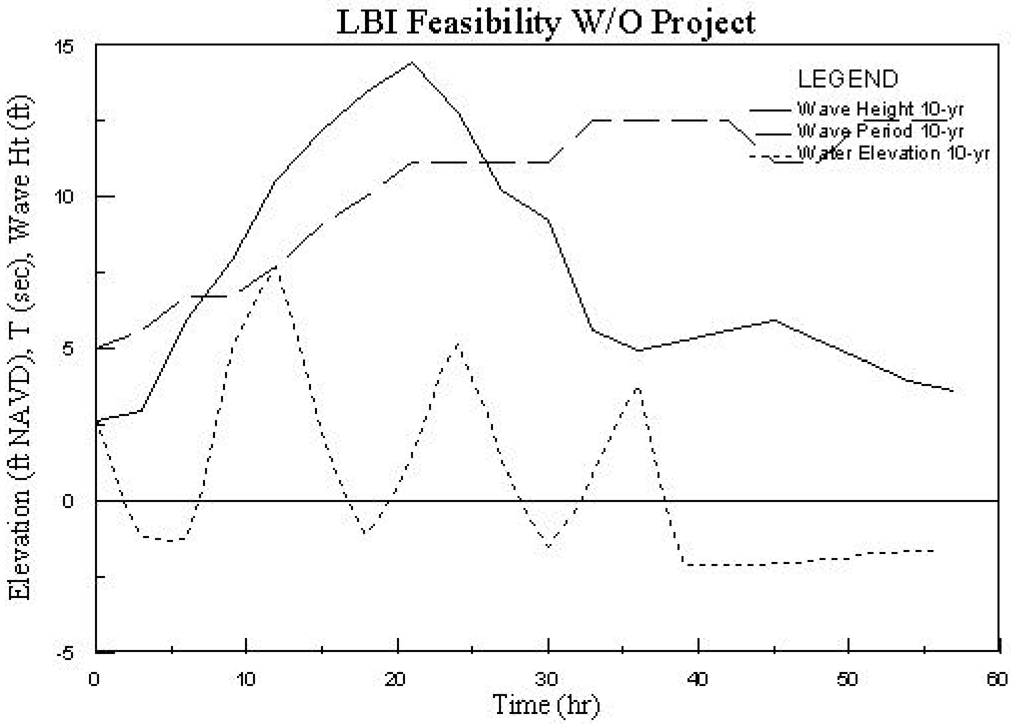


Figure 3-9 "10-yr" Storm Conditions used in Storm Damage Analysis

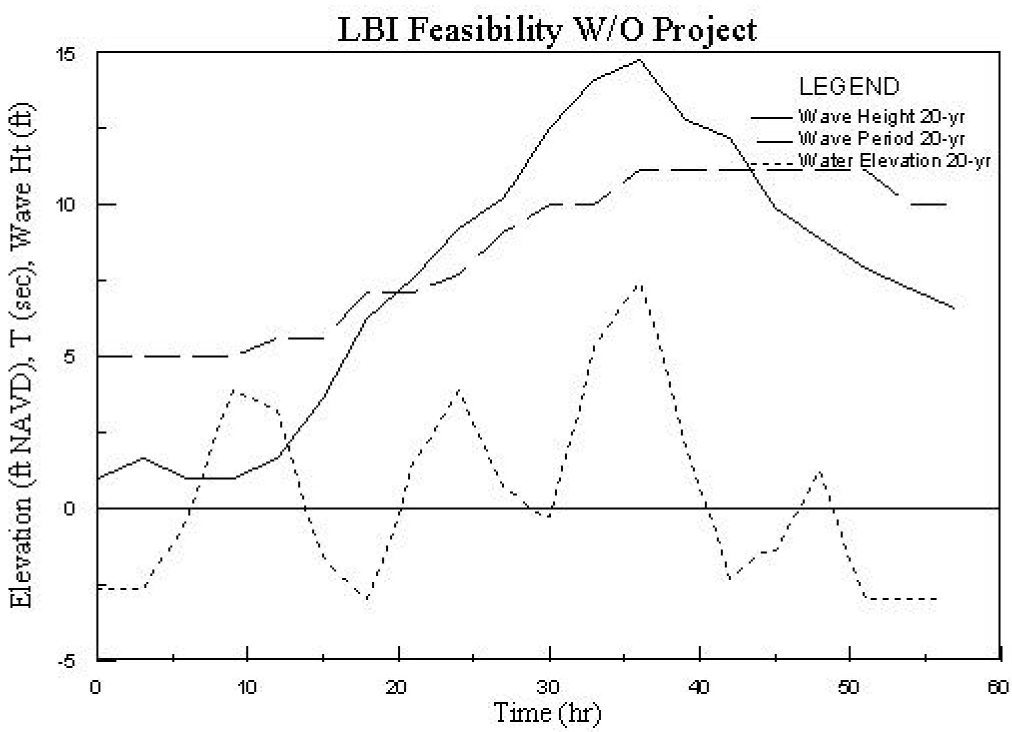


Figure 3-10 "20-yr" Storm Conditions used in Storm Damage Analysis.

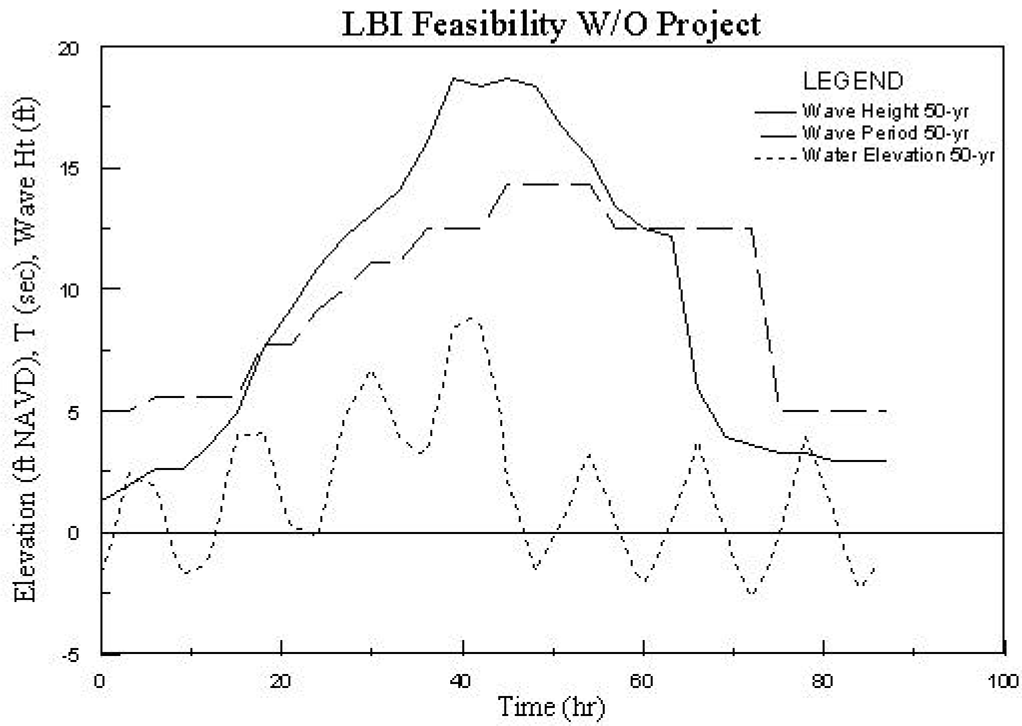


Figure 3-11 "50-yr" Storm Conditions used in Storm Damage Analysis

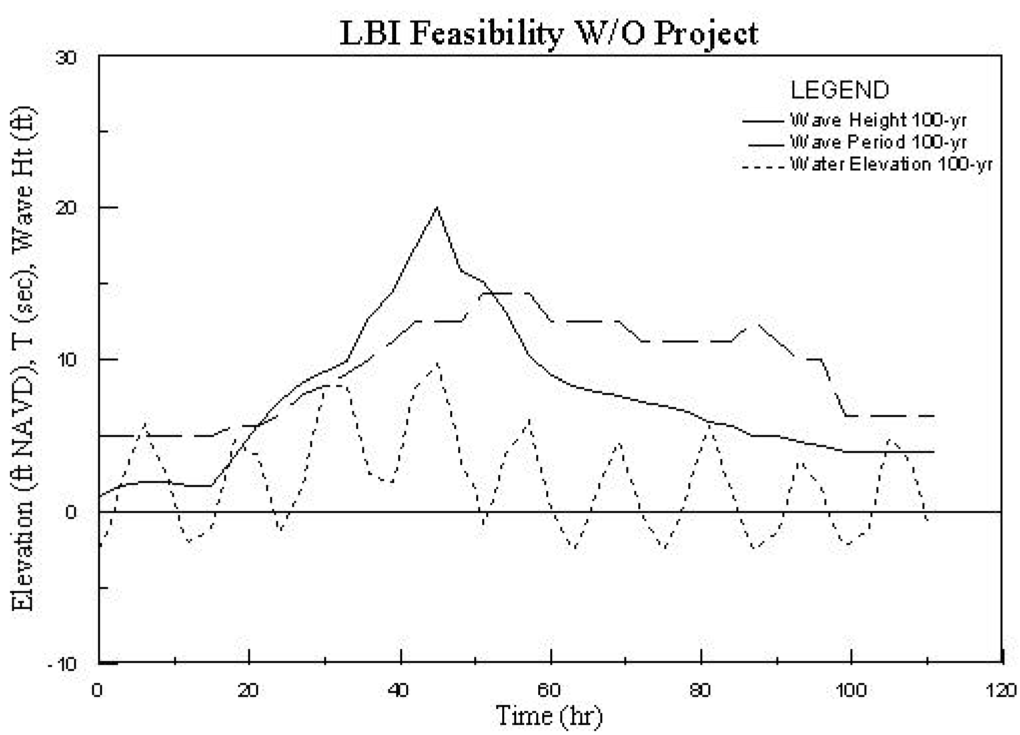


Figure 3-12 "100-yr" Storm Conditions used in Storm Damage Analysis

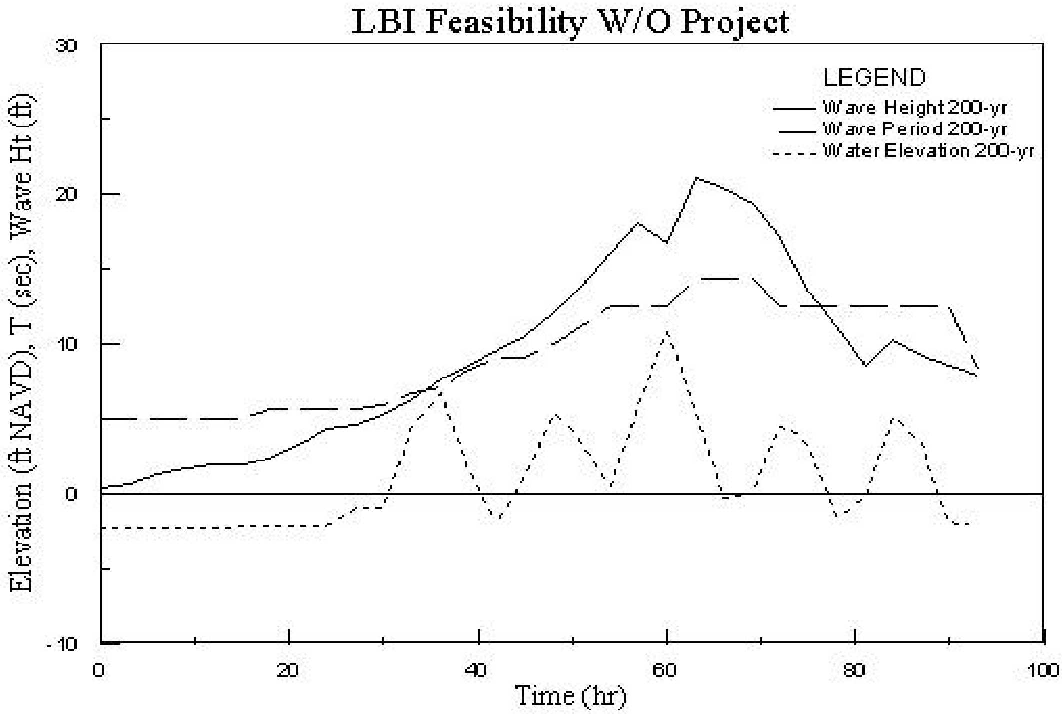


Figure 3-13 "200-yr" Storm Conditions used in Storm Damage Analysis.

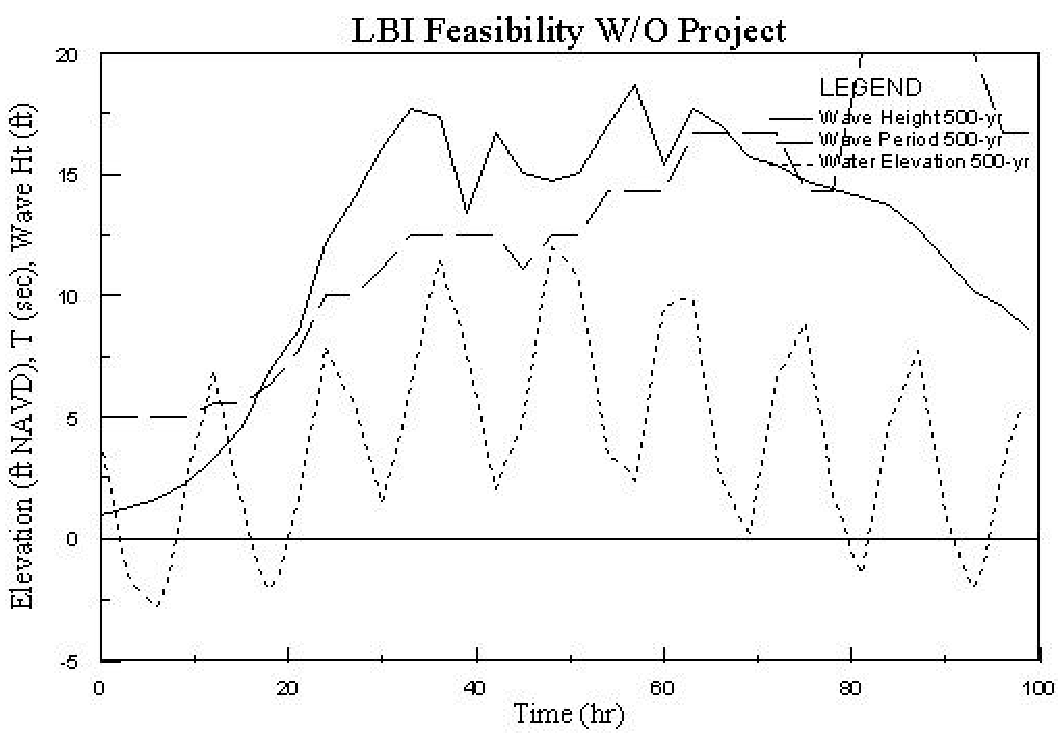


Figure 3-14 "500-yr" Storm Conditions used in Storm Damage Analysis

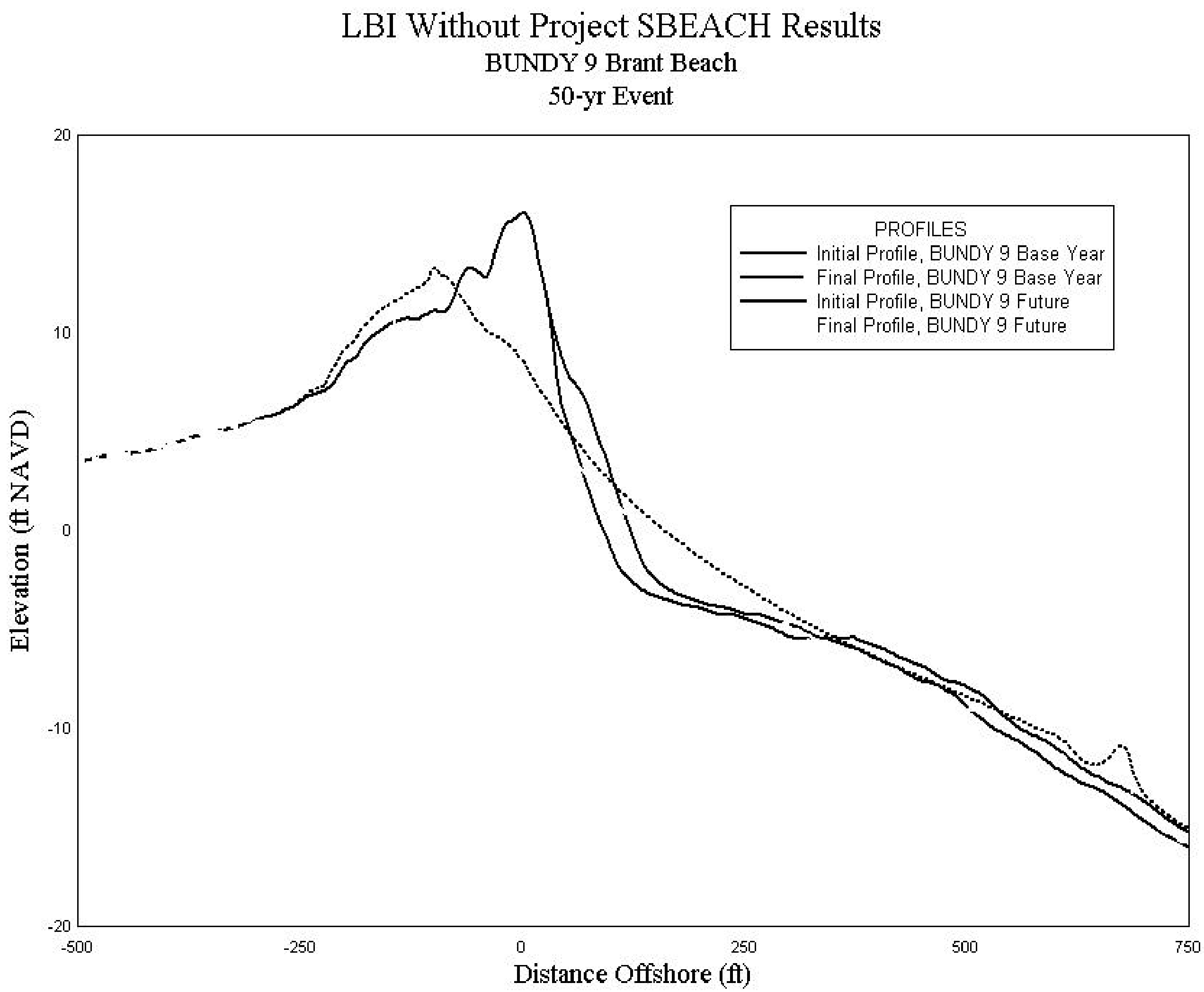


Figure 3-15 Pre- and Post-Storm Conditions for BUNDY 9 (Brant Beach).

Results of the without project storm erosion analysis are presented in **Tables 3-1** and **3-2** for base and future conditions, respectively. Predicted shoreline erosion positions are reported relative to the designated economic baseline. The baseline commonly placed through the centerline of existing dunes. In order to satisfy constraints in the economic analyses, the baseline were offset 500-ft seaward to ensure all structures were landward of the "economic" baseline. The length of the groins along the Island governed the 500-ft offset. For most cells, assuming the majority of structures lie landward of the dune lines, zero erosion (not greater than 500 ft) into the community is reported until the 50-yr event for base year conditions. Slightly increased erosion is reported for the "future" conditions, with erosion typically beginning at the 20-yr event. These erosion values are used as input to the economic model that ultimately computes storm damages associated with storm-related erosion.

Storm Inundation and Wave Attack Evaluation. The project area is subject to inundation from several sources including ocean waves overtopping the beach and/or protective structures as well as flooding from the back bay. The inundation can be analyzed as two separate categories: 1) Static flooding due to super elevation of the water surfaces surrounding the project area and 2) wave attack, the direct impact of waves and high energy runup on coastal structures.

The model SBEACH calculates nearshore wave characteristics, wave runup, wave setup and elevation of the beach profile for each hindcasted event. The wave runup and wave setup values are used, along with the eroded beach elevations, to determine inland water surface profiles, inland wave characteristics, and volumes of eroded material which in turn are used to assess economic damages. SBEACH output parameters are used to define the maximum water depth, runup, and minimum dune crest elevation.

Inundation/Wave Attack Methodology. The inland wave attack and inundation methodology used in this project is based upon FEMA guidelines for coastal flooding analysis. The procedure divides possible storm conditions into four cases as follows:

- Case 1 (shown in **Figure 3-16**): Entire storm-generated profile is inundated. For this case, the maximum water elevation including wave setup is maintained to the crest of the eroded dune. Landward of this point, the wave setup decays at 1-ft vertical drop per 1000 feet of horizontal distance until the bay flood level is met. A wave height of 0.78 times the water depth at the crest of the dune is maintained landward of the dune.

- Case 2 (shown in **Figure 3-17**): The top of the dune is above the maximum water level, with wave runup greater than (3-ft above the dune crest elevation. In this case, the runup depth at the crest is limited to 3 ft, the water depth decays to 2-ft over first 50 feet landward of the crest, and stays at 2-ft until intersecting the bay water level. The wave height is limited to 0.78 times the water depth.

TABLE 3-1 Storm Erosion Analysis Predicted Shoreline Positions (Base Year Conditions)								
	Storm Return Period							
LOCATION	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
BUNDY 1	0.0	0.0	0.0	0.0	0.0	180.0	242.5	322.5
BUNDY 2	292.5	317.5	322.5	340.0	407.0	442.5	463.0	517.5
BUNDY 3	477.5	482.5	477.5	492.5	517.5	545.0	562.5	637.5
BUNDY 4	487.5	562.5	577.5	577.5	582.5	607.5	612.5	657.5
BUNDY 5	407.5	422.5	422.5	482.5	522.5	537.0	547.0	582.5
BUNDY 6	492.5	497.5	492.5	497.5	512.5	532.5	552.5	582.5
BUNDY 7	432.5	437.5	437.5	437.5	452.5	452.5	487.0	502.5
BUNDY 8	407.5	497.5	492.5	507.5	512.5	527.5	532.5	587.5
BUNDY 9	507.5	517.5	507.5	532.5	567.5	597.5	627.5	682.5
BUNDY 10	437.5	502.5	497.5	502.5	527.5	557.5	601.0	627.5
BUNDY 11	517.5	522.5	517.5	547.5	622.5	707.5	758.0	797.5
BUNDY 12	482.5	487.5	482.5	487.5	497.5	522.5	532.5	577.5
BUNDY 13	427.5	442.5	442.5	452.5	462.5	487.5	522.5	572.5
BUNDY 14	492.5	507.5	507.5	577.5	577.5	587.0	604.0	632.5
BUNDY 15	522.5	522.5	527.5	527.5	532.5	567.5	572.5	617.5
Erosion Distance (ft) measured from Baseline								

TABLE 3-2 Storm Erosion Analysis Predicted Shoreline Positions (Future Conditions)								
	Storm Return Period							
LOCATION	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
BUNDY 1	0.0	0.0	0.0	0.0	0.0	180.0	242.5	322.5
BUNDY 2	292.5	317.5	322.5	340.0	407.0	442.5	463.0	517.5
BUNDY 3	482.5	482.5	487.5	507.5	547.5	580.5	607.5	697.5
BUNDY 4	572.5	582.5	582.5	587.5	592.5	627.5	637.5	682.5
BUNDY 5	497.5	512.5	512.5	532.5	542.5	570.0	592.5	682.5
BUNDY 6	507.5	512.5	512.5	527.5	552.5	572.5	642.5	704.0
BUNDY 7	452.5	452.5	452.5	457.5	477.5	484.8	500.0	542.5
BUNDY 8	432.5	507.5	507.5	512.5	517.5	537.5	542.5	607.5
BUNDY 9	522.5	527.5	527.5	552.5	584.0	624.0	642.5	687.5
BUNDY 10	497.5	507.5	507.5	507.5	532.5	562.5	604.0	712.5
BUNDY 11	517.5	527.5	522.5	557.5	647.5	757.5	792.0	840.0
BUNDY 12	487.5	487.5	492.5	492.5	507.5	522.5	537.5	577.5
BUNDY 13	457.5	467.5	467.5	472.5	487.5	537.5	582.5	617.5
BUNDY 14	502.5	532.5	552.5	627.5	687.5	702.0	730.0	770.0
BUNDY 15	527.5	532.5	537.5	537.5	557.5	592.0	622.5	652.5
Erosion Distance (ft) measured from Baseline								

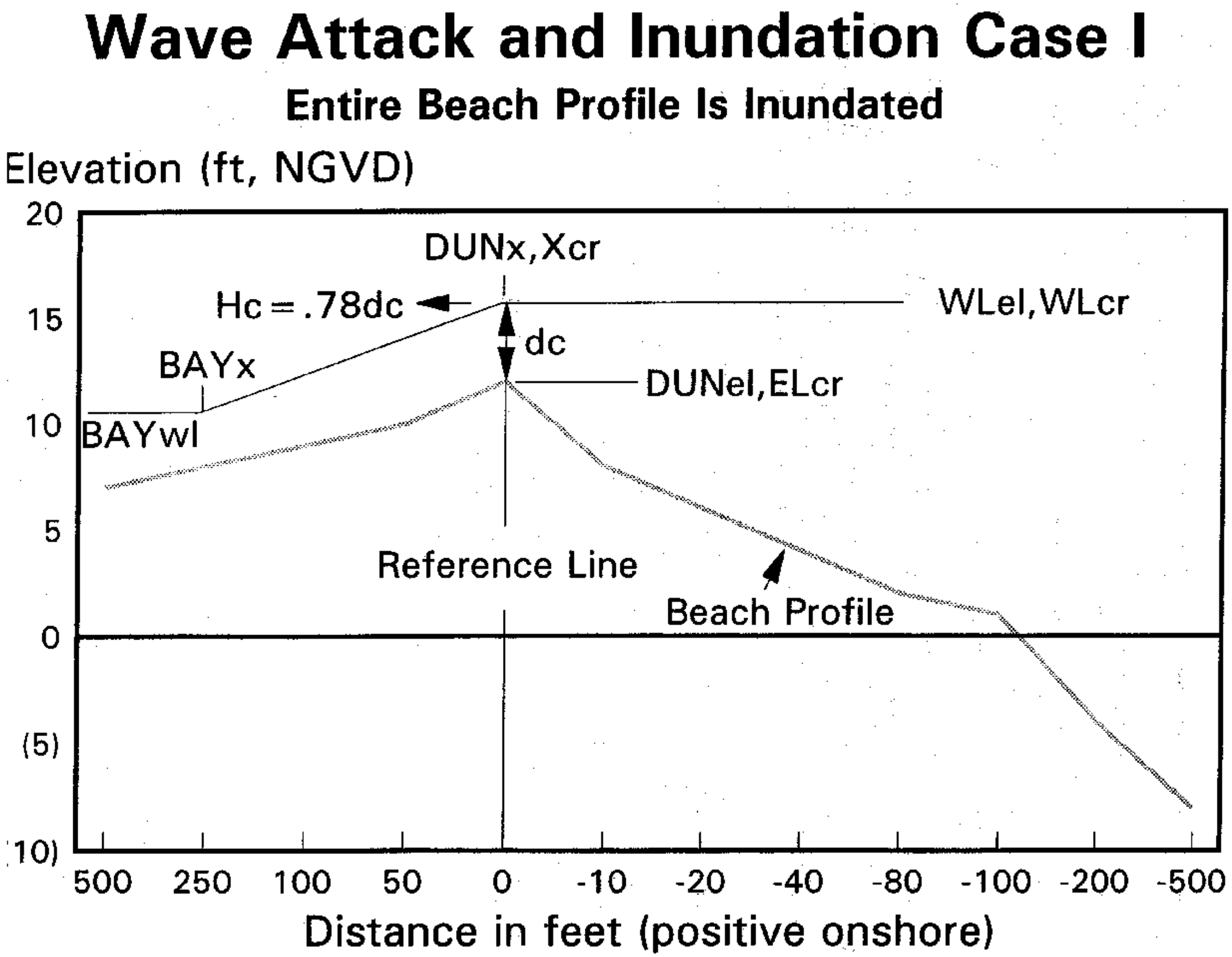


Figure 3-16 Illustration of FEMA Inland Wave Attack and Inundation CASE I.

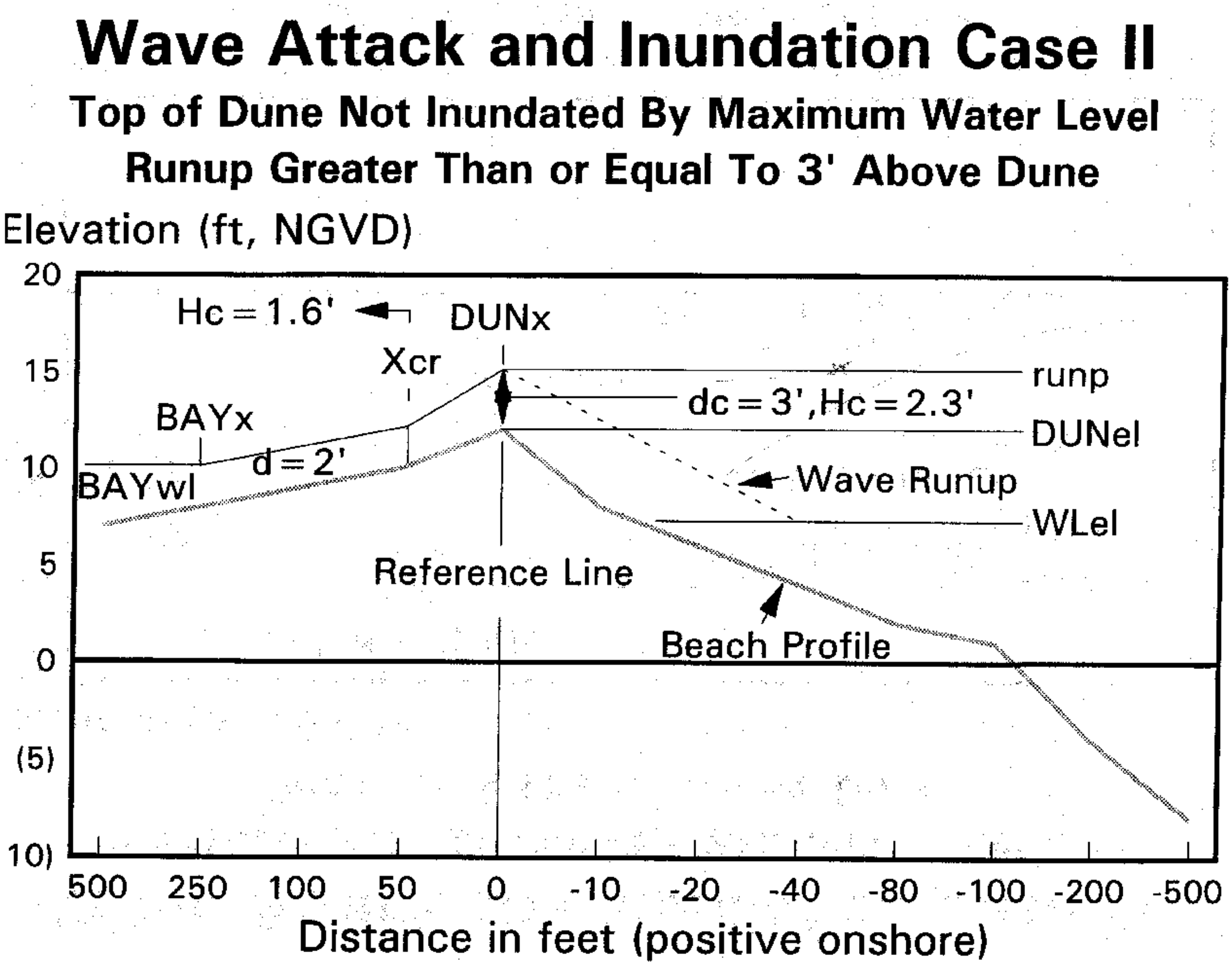


Figure 3-17 Illustration of FEMA Inland Wave Attack and Inundation CASE II.

- Case 3 (shown in **Figure 3-18**): The top of the dune is above the maximum water level, with wave runup exceeding but still less than 3 ft above the dune crest elevation. In this case, the depth at the dune crest is the calculated runup depth, which decays to 1 ft over the first 50 ft landward of the crest, and stays at 1 ft until it intersects the bay water level. The wave height is limited to 0.78 times the water depth.

- Case 4 (shown in **Figure 3-19**): The wave runup does not overtop the dune. In this case, the wave height seaward of the dune is limited to 0.78 times the water depth.

Back Bay Flooding. The project area is subject to flooding from back bay and adjacent waterways as well as direct ocean inundation. This elevated stage flooding is referred to as back bay still water flooding and is accounted for by subtracting the residual damages due to back bay flooding from the damages caused by ocean front inundation. In order to quantify back bay water levels, the numerical model DYNLET (Amein and Cialone, 1994) was used. DYNLET is based on full one-dimensional shallow water equations employing an implicit finite-difference technique. The model simulates one-dimensional fluid flow through a tidal inlet and its tributaries. Flow conditions can be predicted in channels with varied cross section geometry and friction factors. Water surface elevation and average velocity can be computed at selected locations and times both across and along channels.

The model conducted for this study included Little Egg, Barnegat, and Manasquan Inlets. **Figure 3-20** depicts the channels that were modeled. A total of 114 cross-sections or nodes were input to describe the system. Depth soundings for each cross section were interpolated from the National Oceanic Atmospheric Administration (NOAA) Nautical Chart for Little Egg Harbor to Cape May. Recent bathymetric data from Barnegat and Manasquan Inlets were incorporated into the model. The model was calibrated to measured currents through Barnegat Inlet and water levels throughout Barnegat Bay. Predicted stages for 5 through 500-year storms were then used to drive the model. The tidal range is rapidly attenuated through the Barnegat Inlet system, with water levels throughout most of Barnegat Bay being fairly uniform. Therefore, it is assumed that Bay water levels for all communities can be represented by predicted water levels for Loveladies, as described in ***Section 2.9 Coastal Processes***.

Other Parameters. The output from the SBEACH modeling at each of the profile lines and 8 storm events was used to compute inland wave attack and inundation for each case. Inland island ground elevations for each shoreline cell were taken from quad sheets and recent surveys. Bay elevations were used as specified above. For all but the most extreme events, failure of the protective structures (dunes) is required for significant wave attack to occur. However, extreme waves on certain profiles can plunge over the fixed barriers and attack the adjacent structures causing significant damage. The recurrence interval in which the protective structure will fail was determined previously in conjunction with the erosion analysis.

Without Project Inundation and Wave Attack Results. Volume 2 Engineering Technical Appendix Section 2 contains detailed results of the inundation and wave attack analyses for base and future conditions. Inundation curves and wave attack limits are provided in modified COSTDAM model format for each of the cells and respective storm conditions.

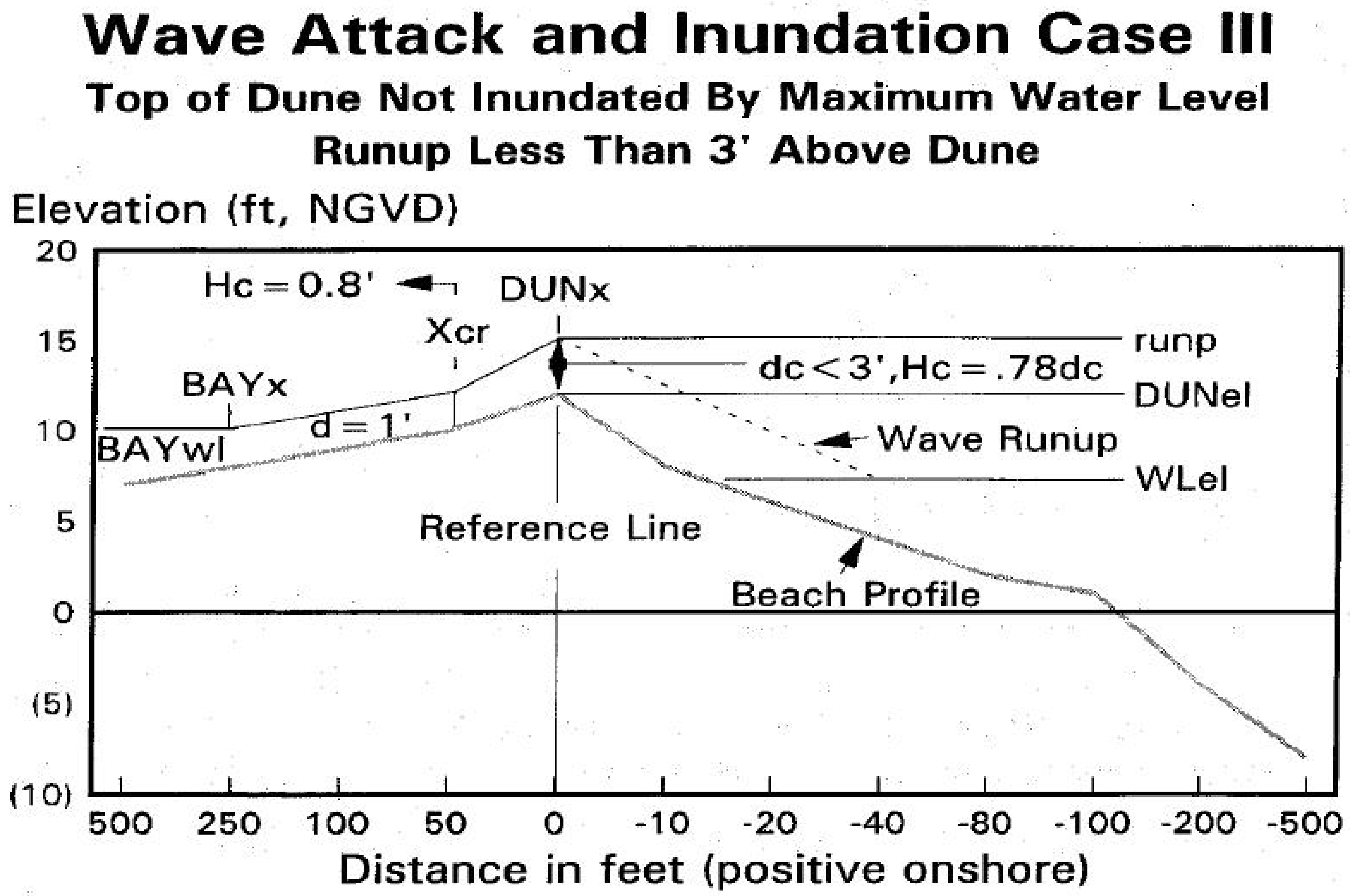


Figure 3-18 Illustration of FEMA Inland Wave Attack and Inundation CASE III.

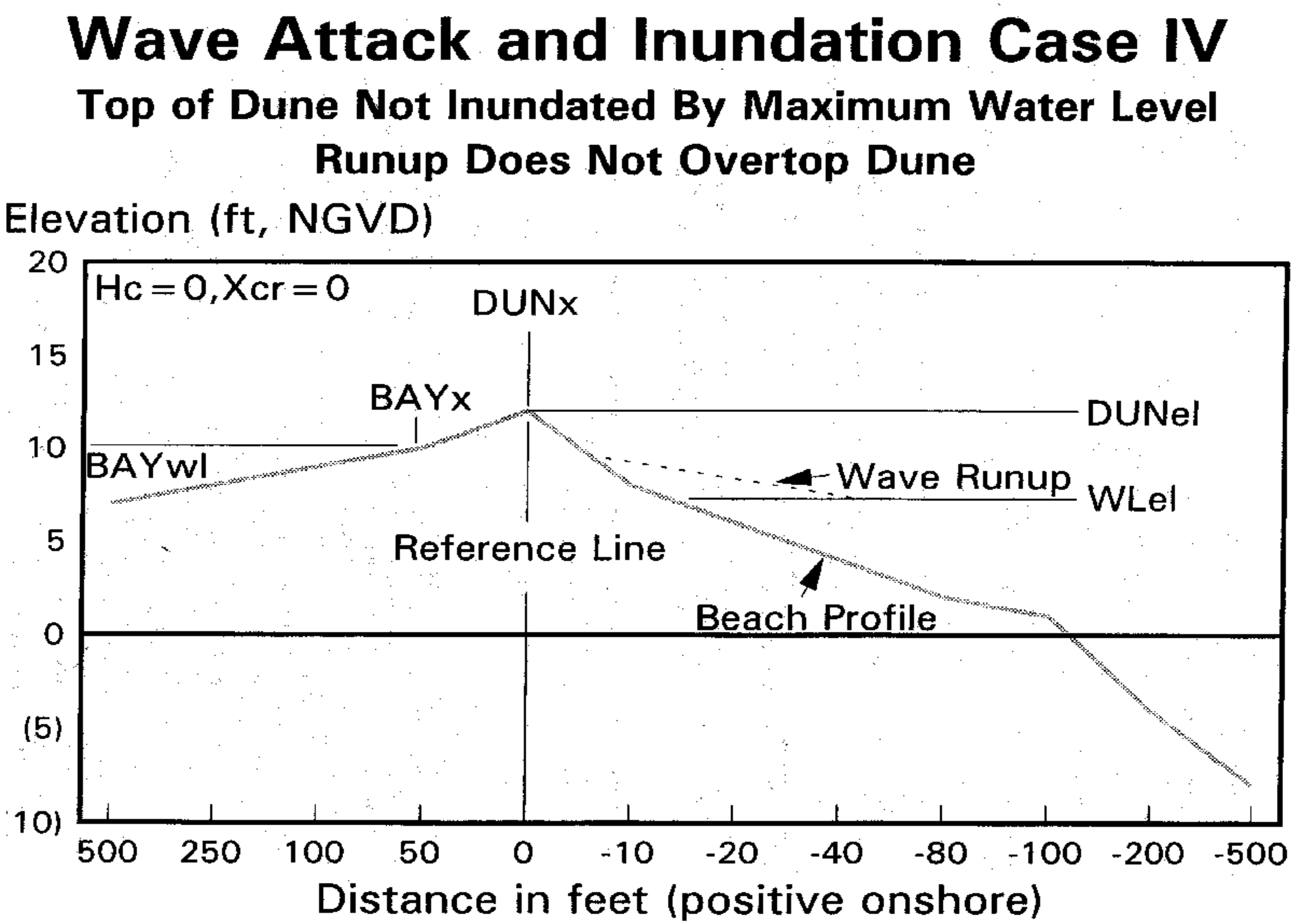


Figure 3-19 Illustration of FEMA Inland Wave Attack and Inundation CASE IV.

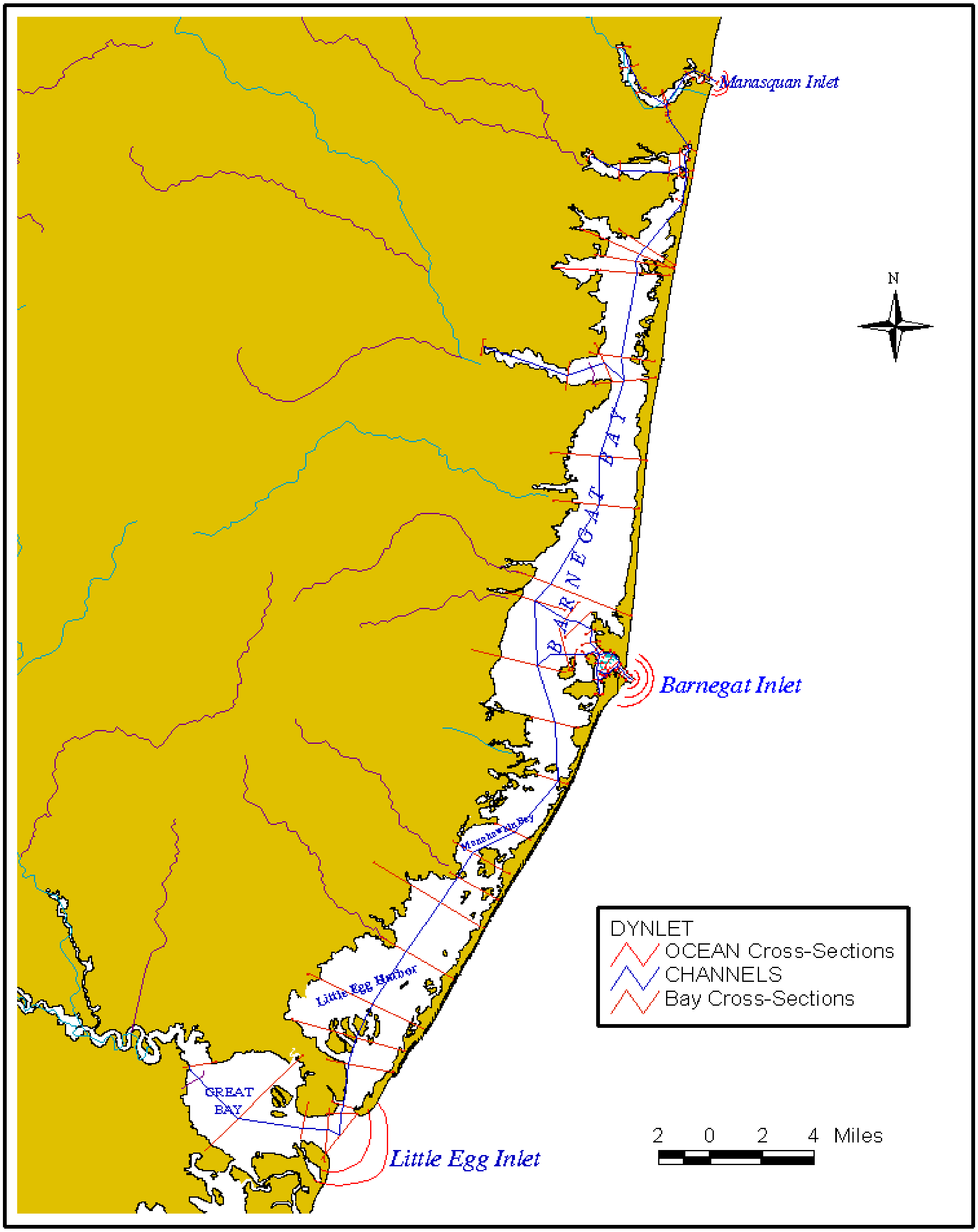


Figure 3-20 DYNLET Layout (Cross-Sections and Channels) used in Back-Bay Water Level Analysis.

3.2 WITHOUT PROJECT ECONOMIC DESCRIPTION.

Study Area Definition

The study area is approximately 18 miles of developed shoreline that extends from Barnegat Light to Beach Haven Inlet. At the time of the most recent inspection there were 99 groin compartments within this area. Based on the hydrologic and hydraulic characteristics and development of the shoreline of the study area, groin compartments were aggregated into sections called BUNDY's ((Beach Unit Nomenclature for Distance along Y axis (north to south)). The BUNDY's are numbered 1 to 15, starting with Barnegat Light Township and ending at an area of Long Beach Township known as Beach Haven Inlet.

A unique reference line was established for each section. All structures were measured from this reference line, which served as the "zero point" from which erosion, wave, and inundation effects were measured for a without and with project conditions. **Table 3-3** shows the definitions and the station boundaries of the reference line parameters.

Structure Inventory

The structures within the delineated sections were inventoried during the summer of 1996. The structures inventoried were selected based on the assessment of damage susceptibility to oceanfront storm damages. It was not necessary to include structures not subject to storm damages, or those subject to Back Bay flooding only. A total of 2003 structures comprised the structure inventory. **Table 3-4** displays the number of structures in the inventory by section. The Marshall and Swift Residential Estimator were used to estimate replacement cost less depreciation using a December 1996 price level. The associated content value of each residential structure was estimated to be 30% of the structural replacement cost. Commercial content values varied based on the activity from fifty to eighty percent of structure value.

Table 3-5 shows the average, standard deviation, minimum, maximum and median replacement values for the structure inventory by section. For each section the beachfront structure replacement value is shown side by side to the near shore structures in the inventory. In all cases the mean (and median) beachfront property value is higher than that of the near shore property. (Table 16 found in Economic Section of Appendix B shows the commercial replacement value for the twenty-one commercial structures in the inventory.) The mean and median value for commercial structures and for beachfront structures is also higher than those in the near shore.

Storm Damages Methodology

Without project condition damages were calculated for eight frequency storm events (2, 5, 10, 20, 50, 100, 200 and 500 year events) for erosion, wave and inundation damage to structures, infrastructure and improved property. The calculations for the structural property storm damages were performed using COSTDAM (Coastal Storm Damage Assessment Model), a Fortran program model that computes storm damages for coastal storm processes.   Data for the structures in the study area are coded in a 'Structure' ASCII file that contains information on a structure by structure basis gathered from the pen-based PC automated inventory process, digital photography documentation, photogrammetric mapping, ArcInfo, GIS, AutoCAD, and structure evaluation. ((Table 17 found in the Economic Section of Appendix B displays an excerpt for the setup requirement for the Structure database with a brief description of the model parameters (columns)). Each record (line) represents a structure in the study area.

TABLE 3 - 3

ECONOMIC REFERENCE DELINEATION
FOR STUDY AREA

AREA ID	SECTION	GROIN COMPARTMENTS AGGREGATION	STATION BOUNDARIES	LENGTH (ft)
			-28+19.91	
1	Barnegat Light	1		6,910
			40+90.21	
2	Barnegat Light/Loveladies 1	2-3		4,298
			83+88.39	
3	Loveladies 2	4-12		7,664
			160+52.50	
4	Harvey Cedars 1	13-17		4,491
			205+43.17	
5	Harvey Cedars 2	18-22		4,551
			250+94.50	
6	North Beach	23-33		9,815
			349+09.57	
7	Surf City	34-39		6,426
			413+35.10	
8	Ship Bottom	40-44		5,285
			466+19.96	
9	Brant Beach	45-55		9,252
			558+71.59	
10	Beach Haven Crest to Beach Haven Park	56-66		9,199
			650+70.24	
11	Haven Beach to Beach Haven Gardens	67-73		6,438
			715+08.71	
12	Spray Beach to Beach Haven Borough 1	74-80		7,260
			787+69.14	
13	Beach Haven Borough	81-84		4,761
			835+29.91	
14	Beach Haven Borough 2	85-89		3,156
			866+85.63	
15	Beach Haven Borough, Holgate	90-99		6,646
			933+31.17	--------------
			TOTAL (FT)	96,152

TABLE 3 - 4

INVENTORY OF STRUCTURES
BY BUNDY ID

BUNDY	SECTION	STRUCTURES IN INVENTORY
1	Barnegat Light	79
2	Barnegat Light/Loveladies 1	34
3	Loveladies 2	176
4	Harvey Cedars 1	137
5	Harvey Cedars 2	139
6	North Beach	290
7	Surf City	139
8	Ship Bottom	74
9	Brant Beach	280
10	Beach Haven Crest	149
11	Haven Beach to	114
12	Spray Beach to	124
13	Beach Haven Borough	67
14	Beach Haven Borough 2	64
15	Beach Haven Borough, Holgate	137
	TOTAL	2003

TABLE 3- 5
STRUCTURE REPLACEMENT VALUE

BUNDY 1

BEACHFRONT COUNT =		68	NEAR SHORE COUNT =	11
AVERAGE (MEAN) --	AVG	$199,488	AVG	$173,076
STANDARD DEVIATION --	STD	$102,948	STD	$102,459
MAXIMUM--	MAX	$531,778	MAX	$395,053
MINIMIUM --	MIN	$70,805	MIN	$32,514
MEDIAN --	MED	$171,070	MEDIAN	$166,724

BUNDY 2

BEACH FRONT COUNT =		13	NEAR SHORE COUNT =	21
	AVG	$427,135	AVG	$292,107
	STD	$256,202	STD	$139,389
	MAX	$1,076,373	MAX	$525,112
	MIN	$108,349	MIN	$99,481
	MED	$468,309	MEDIAN	$273,752

BUNDY 3

BEACHFRONT COUNT =		63	NEAR SHORE COUNT =	112
	AVG	$395,801	AVG	$216,382
	STD	$244,142	STD	$111,406
	MAX	$1,024,699	MAX	$642,948
	MIN	$83,585	MIN	$39,987
	MED	$334,707	MEDIAN	$179,716

BUNDY 4

BEACHFRONT COUNT=		37	NEAR SHORE COUNT =	100
	AVG	$251,636	AVG	$158,931
	STD	$164,378	STD	$75,924
	MAX	$164,378	MAX	$401,930
	MIN	$78,285	MIN	$60,300
	MED	$218,864	MEDIAN	$133,537

BUNDY 5						
	BEACHFRONT COUNT =		50	NEAR SHORE COUNT =		89
		AVG	$201,841	AVG	$143,396	
		STD	$97,145	STD	$77,266	
		MAX	$498,105	MAX	$554,359	
		MIN	$53,416	MIN	$57,529	
		MED	$180,505	MEDIAN	$118,990	
BUNDY 6						
	BEACHFRONT COUNT =		109	NEAR SHORE COUNT =		175
		AVG	$256,500	AVG	$180,548	
		STD	$146,136	STD	$91,080	
		MAX	$914,272	MAX	$534,481	
		MIN	$64,596	MIN	$37,890	
		MED	$214,663	MEDIAN	$171,332	
BUNDY 7						
			-		-	
	BEACHFRONT COUNT =		89	NEAR SHORE COUNT =		50
		AVG	$200,258	AVG	$105,714	
		STD	$120,489	STD	$51,111	
		MAX	$722,050	MAX	$300,216	
		MIN	$77,798	MIN	$28,419	
		MED	$157,271	MEDIAN	$101,845	
BUNDY 8						
			-		-	
	BEACHFRONT COUNT =		46	NEAR SHORE COUNT =		25
		AVG	$165,826	AVG	$107,282	
		STD	$82,650	STD	$44,057	
		MAX	$449,991	MAX	$266,399	
		MIN	$69.982	MIN	$46.975	
		MED	$138,420	MEDIAN	$98,554	

BUNDY 9						
			-		-	
	BEACHFRONT COUNT =		115	NEAR SHORE COUNT =		165
		AVG	$178,826	AVG	$143,784	
		STD	$80,395	STD	$73,835	
		MAX	$523,475	MAX	$561,940	
		MIN	$66,200	MIN	$60,528	
		MED	$158,176	MEDIAN	$130,952	
BUNDY 10						
			-		-	
	BEACHFRONT COUNT =		115	NEAR SHORE COUNT =		34
		AVG	$182,412	AVG	$129,508	
		STD	$109,335	STD	$40,930	
		MAX	$660,549	MAX	$280,619	
		MIN	$56,839	MIN	$69,097	
		MED	$141,451	MEDIAN	$125,060	
BUNDY 11						
			-		-	
	BEACHFRONT COUNT =		73	NEAR SHORE COUNT =		41
		AVG	$235,500	AVG	$150,017	
		STD	$139,185	STD	$52,685	
		MAX	$683,015	MAX	$276,434	
		MIN	$42,985	MIN	$74,865	
		MED	$169,972	MEDIAN	$148,013	
BUNDY 12						
			-		-	
	BEACH FRONT COUNT =		77	NEAR SHORE COUNT =		45
		AVG	$184,437	AVG	$156,602	
		STD	$77,705	STD	$99,208	
		MAX	$394,176	MAX	$435,039	
		MIN	$71,442	MIN	$52,772	
		MED	$158,777	MEDIAN	$118,823	

BUNDY 13					
	BEACHFRONT COUNT =		38	NEAR SHORE COUNT =	24
		AVG	$318,136	AVG	$250,974
		STD	$349,083	STD	$180,567
		MAX	$1,874,439	MAX	$925,709
		MIN	$76,489	MIN	$77,750
		MED	$214,996	MEDIAN	$189,895
BUNDY 14					
			-		-
	BEACH FRONT COUNT =		37	NEAR SHORE COUNT =	27
		AVG	$182,955	AVG	$154,785
		STD	$122,053	STD	$56,665
		MAX	$772,108	MAX	$318,453
		MIN	$35,470	MIN	$51,874
		MED	$159,539	MEDIAN	$150,790
BUNDY 15					
			-		-
	BEACHFRONT COUNT =		88	NEAR SHORE COUNT =	46
		AVG	$188,083	AVG	$88,806
		STD	$76,643	STD	$57,423
		MAX	$480,385	MAX	$260,908
		MIN	$63,241	MIN	$17,564
		MED	$166,477	MEDIAN	$91,779

COSTDAM concurrently reads an ASCII 'Control' file that contains the frequency parameters for the representative hydraulic profiles. COSTDAM checks if a structure has been damaged by wave attack, based on the relationship between the structure's first floor elevation and the total wave elevation that sustains a wave in the wave zone. COSTDAM then checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation based on Federal Insurance Administration (FIA) depth-damage curves adjusted for increased salt-water destruction. To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any one given mechanism (wave, erosion, or inundation) and disregards the rest of the damages from the structure's total damages.

Erosion Damages

The distance between the reference line and the oceanfront and back walls of structures were obtained through a software program created in ArcInfo by the District to run using the GIS program data. The results were input into the Structure file. It was assumed that structures not on open pile foundations are destroyed at the point the land below the structure is eroded halfway. If the structure is on piles, erosion needs to retreat entirely through the footprint before total damage is claimed. Before total failure for both foundation types, the percent damage claimed is equal to the proportion of erosion under the structure's footprint compared to the total footprint.

Wave-Inundation Damages

A structure is considered damaged by a wave when there is sufficient force in the total water elevation to destroy a structure. Partial wave damages are not calculated; instead the structure is subject to inundation damages. A flood can potentially cause damages to property and their contents through several mechanisms. The predominant damage-inducing mechanisms, as typical to riverine flooding, are depth and duration of flooding. However, ocean flooding has been shown to cause more damages than inundation in fresh water for the same depth. Also, the depth and velocity of the floodwater may be sufficient to result in structural damage and ultimately failure.

Depth damage curves were used to estimate the damage to structures. The distinguishing characteristics of these curves were foundation type and the number of stories in the structure. For commercial structures, the business activity was also a distinguishing factor for content. The depth-damage curves encode the percent damaged at various depths relative to the first floor. (Examples of depth-damage curves are displayed in Table 18, found in the Economic Section of Appendix B.)

Without Project Damages

The without project condition was computed based on the hydrologic and hydraulic profiles and housing characteristics of the study areas. Damages under a without project condition are the expected value of the losses that would be anticipated to result from ocean flooding and beach erosion. The expected value is calculated by estimating the losses that would result from each of a series of events of different return periods, or exceedance probabilities. Discounting this stream of losses (at the FY98 7.125% discount rate) over the anticipated life of the project (50 years) gives the present value of the damages under existing conditions reflecting a December 1996 price level. The present value of the damages is then annualized using the appropriate capital recovery factor. (Table 19 found in the Economic Section of Appendix B displays the cumulative residential and commercial structure distribution by frequency zone for the defined sections of Long Beach Island.) There are a total of 1,744 structures in the 500-yr. storm zone of the defined study area of which twenty-one are commercial structures. Table 3-8 displays the damage per frequency by damage mechanism and by section by section. Table 3-9 displays the expected average annual damage (EAD) for without project existing conditions for the structures and infrastructure. The EAD for erosion, inundation, and wave are $2,839,000, $1,449,000, and $6,000 respectively. The EAD for infrastructure and cost of fill is $228,000 and $1,313,000 respectively. The total EAD for without project base conditions is $5,835,000.

STORMDB

TABLE 3-6

STRUCTURE DAMAGE BY FREQUENCY
DAMAGE ZONE
WITHOUT PROJECT CONDITION

(DAMAGES IN $000)

SECTION 1

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100 YR	0	0	0	0	0	0	0	0	0
200 YR	0	0	0	0	0	0	0	0	0
500 YR	0	0	0	0	0	0	0	0	0

SECTION 2

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100 YR	0	0	0	0	0	0	0	0	0
200 YR	0	0	0	0	0	0	0	0	0
500 YR	0	0	4	4	0	0	0	0	4

SECTION 3

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	7	7	14	0	0	0	0	14
10 YR	0	7	7	14	0	0	0	0	14
20 YR	0	583	627	1,210	0	0	26	26	1,236
50 YR	0	3,490	1,451	4,941	0	0	255	255	5,196
100 YR	0	10,710	3,763	14,473	0	0	866	866	15,339
200 YR	0	15,143	5,242	20,385	0	0	877	877	21,262
500 YR	0	31,934	8,626	40,560	0	0	1,009	1,009	41,569

SECTION 4

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	3	3	0	0	0	0	3
10 YR	0	2	15	17	0	0	0	0	17
20 YR	0	2	83	85	0	0	0	0	85
50 YR	0	95	498	593	0	0	0	0	593
100 YR	0	1,945	2,886	4,831	0	0	0	0	4,831
200 YR	0	2,289	4,483	6,772	0	0	0	0	6,772
500 YR	0	12,095	5,869	17,964	0	0	0	0	17,964

TABLE 3-6

STRUCTURE DAMAGE BY
DAMAGE
WITHOUT PROJECT

SECTION 5

ZONE	WAVE	RESIDENTIA EROSIO	INUNDATIO	RESIDENTIA TOTAL	COMMERCIA WAVE	EROSIO	INUNDATIO	COMMERICA TOTAL	CUMULATIV TOTAL PER
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	19	19	0	0	0	0	19
20 YR	0	0	203	203	0	0	0	0	203
50 YR	0	3,764	890	4,654	0	0	0	0	4,654
100	0	7,452	1,169	8,621	0	0	0	0	8,621
200	0	10,318	1,226	11,544	0	0	0	0	11,544
500	0	13,945	2,458	16,403	0	0	0	0	16,403

2 YR. FREQUENCY = (0.5 exceedance
5 YR. FREQUENCY = (0.2 exceedance
10 YR. FREQUENCY = (0.1 exceedance
20 YR. FREQUENCY = (.05 exceedance
50 YR. FREQUENCY = (.02 exceedance
100 YR. FREQUENCY = (.01 exceedance
200 YR. FREQUENCY = (.005 exceedance
500 YR. FREQUENCY = (.002 exceedance

SECTION 6

ZONE	WAVE	RESIDENTIA EROSIO	INUNDATIO	RESIDENTIA TOTAL	COMMERCIA WAVE	EROSIO	INUNDATIO	COMMERICA TOTAL	CUMULATIV TOTAL PER
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	4	4	0	0	0	0	4
10 YR	0	0	14	14	0	0	0	0	14
20 YR	0	0	134	134	0	0	0	0	134
50 YR	0	1,603	4,514	6,117	0	0	193	193	6,310
100	0	7,807	6,441	14,248	0	0	371	371	14,619
200	0	18,281	9,376	27,657	0	0	1,160	1,160	28,817
500	0	29,727	18,228	47,955	0	0	1,590	1,590	49,545

SECTION 7

ZONE	WAVE	RESIDENTIA EROSIO	INUNDATIO	RESIDENTIA TOTAL	COMMERCIA WAVE	EROSIO	INUNDATIO	COMMERICA TOTAL	CUMULATIV TOTAL PER
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	15	15	0	0	0	0	15
50 YR	0	64	0	64	0	0	0	0	64
100	0	0	1,340	1,340	0	0	0	0	1,340
200	0	686	2,156	2,842	0	0	0	0	2,842
500	0	2,312	10,570	12,882	0	0	0	0	12,882

SECTION 8

ZONE	WAVE	RESIDENTIA EROSIO	INUNDATIO	RESIDENTIA TOTAL	COMMERCIA WAVE	EROSIO	INUNDATIO	COMMERICA TOTAL	CUMULATIV TOTAL PER
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100	0	0	847	847	0	0	56	56	903
200	0	0	993	993	0	0	78	78	1,071
500	0	3,108	1,698	4,806	0	560	175	735	5,541

TABLE 3-6
(continued)
STRUCTURE DAMAGE BY FREQUENCY
DAMAGE ZONE
WITHOUT PROJECT CONDITION

SECTION 9

	RESIDENTIAL				COMMERCIAL				CUMULATIVE
				RESIDENTIAL				COMMERICAL	TOTAL
ZONE	WAVE	EROSION	INUNDATION	TOTAL	WAVE	EROSION	INUNDATION	TOTAL	PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	530	14	544	0	0	0	0	544
10 YR	0	525	39	564	0	0	0	0	564
20 YR	0	3,796	2,665	6,461	0	0	0	0	6,461
50 YR	0	17,809	5,278	23,087	0	0	0	0	23,087
100 YR	0	25,080	8,940	34,020	0	0	0	0	34,020
200 YR	0	27,913	9,526	37,439	0	0	0	0	37,439
500 YR	0	40,886	7,444	48,330	0	0	0	0	48,330

SECTION 10

	RESIDENTIAL				COMMERCIAL				CUMULATIVE
				RESIDENTIAL				COMMERICAL	TOTAL
ZONE	WAVE	EROSION	INUNDATION	TOTAL	WAVE	EROSION	INUNDATION	TOTAL	PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	1,705	2,762	4,467	0	0	0	0	4,467
100 YR	0	8,632	4,149	12,781	0	0	0	0	12,781
200 YR	0	24,045	1,994	26,039	0	0	0	0	26,039
500 YR	0	29,627	798	30,425	0	0	0	0	30,425

SECTION 11

	RESIDENTIAL				COMMERCIAL				CUMULATIVE
				RESIDENTIAL				COMMERICAL	TOTAL
ZONE	WAVE	EROSION	INUNDATION	TOTAL	WAVE	EROSION	INUNDATION	TOTAL	PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	462	462	0	0	0	0	462
50 YR	0	224	1,960	2,184	0	0	0	0	2,184
100 YR	0	14,270	2,082	16,352	0	0	0	0	16,352
200 YR	0	21,247	3,186	24,433	0	0	0	0	24,433
500 YR	0	27,970	1,197	29,167	0	0	0	0	29,167

SECTION 12

		RESIDENTIAL			COMMERCIAL				CUMULATIVE
				RESIDENTIAL				COMMERICAL	TOTAL
ZONE	WAVE	EROSION	INUNDATION	TOTAL	WAVE	EROSION	INUNDATION	TOTAL	PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	51	0	51	0	0	0	0	51
10 YR	0	51	0	51	0	0	0	0	51
20 YR	0	51	14	65	0	0	0	0	65
50 YR	0	181	52	233	0	0	0	0	233
100 YR	0	2,454	1,327	3,781	0	0	0	0	3,781
200 YR	0	4,330	2,538	6,868	0	0	239	239	7,107
500 YR	0	14,842	2,683	17,525	0	706	425	1,131	18,656

TABLE 3-6
(continued)
STRUCTURE DAMAGE BY FREQUENCY
DAMAGE ZONE
WITHOUT PROJECT CONDITION

SECTION 13

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	262	2,940	3,202	0	0	0	0	3,202
100 YR	0	1,973	4,733	6,706	0	25	0	25	6,731
200 YR	0	6,107	5,533	11,640	0	1,294	5	1,299	12,939
500 YR	0	11,490	5,266	16,756	0	5,602	108	5,710	22,466

SECTION 14

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	21	135	156	0	0	0	0	156
10 YR	0	21	194	215	0	0	0	0	215
20 YR	0	2,175	296	2,471	0	0	0	0	2,471
50 YR	0	2,175	1,123	3,298	0	0	0	0	3,298
100 YR	0	2,517	1,594	4,111	0	0	0	0	4,111
200 YR	0	3,434	1,990	5,424	0	0	0	0	5,424
500 YR	2,229	5,376	1,104	8,709	0	0	0	0	8,709

SECTION 15

ZONE	WAVE	RESIDENTIAL EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100 YR	0	1,190	913	2,103	0	0	63	63	2,166
200 YR	0	1,740	3,520	5,260	0	0	1,576	1,576	6,836
500 YR	0	11,855	4,412	16,267	0	0	2,047	2,047	18,314

LBIEXIST

TABLE 3-7

WITHOUT PROJECT DAMAGES FOR EXISTING CONDITIONS
EXPECTED AVERAGE ANNUAL BASIS
($000)

SECTION	EROSION	INUNDATION	WAVE	INFRA-STRUCTURE	COST OF FILL	TOTAL FOR SECTION
1	0	0	0	0	0	0
2	0	1	0	0	1	2
3	316	145	0	8	236	705
4	56	69	0	22	7	154
5	207	47	0	29	9	292
6	238	244	0	16	98	596
7	10	46	0	1	47	104
8	9	16	0	1	11	37
9	1055	385	0	67	266	1773
10	269	96	0	24	84	473
11	266	89	0	26	168	549
12	94	34	0	13	192	333
13	91	133	0	9	14	247
14	182	98	6	9	118	413
15	46	46	0	3	62	157
	-	-	-	-	-	-
	$2,839	$1,449	$6	$228	$1,313	**$5,835**

TOTAL FOR STRUCTURE	$4,294
ADD: INFRASTRUCTURE	228
COST OF FILL	1,313
EXPECTED AVERAGE ANNUAL DAMAGE	**$5,835**

Future Damages

Due to the affects of long term erosion resulting in a receding shoreline an additional model was set up to evaluate the damage affect of long term erosion. Under a without project condition erosion will continue; the erosion scenario changes given future hydraulic conditions. Long term erosion is a dynamic process, however. From a historical perspective this process is checked at a certain point through local intervention to preclude further erosion. For modeling purposes the natural long-term erosion process is assumed not to retreat beyond the seaward toe of the dune. The limit of this condition is realized approximately fifteen years from the base year. This retreat occurs at different rates in different sections of Long Beach Island and was taken into account in the analysis. The additional modeling allowed the analysis to assess expected average annual damages (EAD) for the 50 year period of analysis, weighing in future damages for the range of exceedance probabilities in the computation of (EAD). **Table 3-8** (see Volume 3 Appendix B) displays the structure distribution under future hydraulic conditions for the study area. Long term erosion potential is most pronounced in BUNDY's 5, 6, 7, 11, 13, 14, and 15. **Table 3-9** displays the dollar damages for this condition. Damages increase with each frequency. With the inclusion of future damages under a without project scenario the EAD is $8,459,000. Total EAD structure damage is $6,315,000; infrastructure damages of $340,000 and cost of fill damages of $1,804,000 account for the remaining damages. **Table 3-10** displays these results on a section by section basis.

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TABLE 3-11

FUTURE WITHOUT PROJECT CONDITIONS(LONG TERM EROSION)
STRUCTURE DAMAGE BY FREQUENCY OF DAMAGE EVENT

DAMAGE IN $000

SECTION 1

ZONE	RESIDENTIAL WAVE	RESIDENTIAL EROSION	RESIDENTIAL INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	COMMERCIAL EROSION	COMMERCIAL INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100 YR	0	0	0	0	0	0	0	0	0
200 YR	0	0	0	0	0	0	0	0	0
500 YR	0	0	0	0	0	0	0	0	0

SECTION 2

ZONE	RESIDENTIAL WAVE	RESIDENTIAL EROSION	RESIDENTIAL INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	COMMERCIAL EROSION	COMMERCIAL INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	0	0	0	0	0	0	0
100 YR	0	0	0	0	0	0	0	0	0
200 YR	0	0	0	0	0	0	0	0	0
500 YR	0	0	438	438	0	0	0	0	438

SECTION 3

ZONE	RESIDENTIAL WAVE	RESIDENTIAL EROSION	RESIDENTIAL INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	COMMERCIAL EROSION	COMMERCIAL INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	7	7	14	0	0	0	0	14
10 YR	0	255	598	853	0	0	30	30	883
20 YR	0	1,926	941	2,867	0	0	30	30	2,897
50 YR	0	11,450	2,649	14,099	0	0	775	775	14,874
100 YR	0	19,750	4,421	24,171	0	0	900	900	25,071
200 YR	0	25,165	5,653	30,818	0	0	903	903	31,721
500 YR	0	40,415	7,705	48,120	0	0	1,046	1,046	49,166

SECTION 4

ZONE	RESIDENTIAL WAVE	RESIDENTIAL EROSION	RESIDENTIAL INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	COMMERCIAL EROSION	COMMERCIAL INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	149	4	153	0	0	0	0	153
10 YR	0	138	41	179	0	0	0	0	179
20 YR	0	377	52	429	0	0	0	0	429
50 YR	0	600	2,465	3,065	0	0	0	0	3,065
100 YR	0	5,033	3,667	8,700	0	0	0	0	8,700
200 YR	0	7,207	5,369	12,576	0	0	0	0	12,576
500 YR	0	17,188	6,674	23,862	0	0	0	0	23,862

SECTION 5

ZONE	RESIDENTIAL WAVE	RESIDENTIAL EROSION	RESIDENTIAL INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	COMMERCIAL EROSION	COMMERCIAL INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	1,806	0	1,806	0	0	0	0	1,806
10 YR	0	1,806	95	1,901	0	0	0	0	1,901
20 YR	0	6,158	809	6,967	0	0	0	0	6,967
50 YR	0	9,190	1,100	10,290	0	0	0	0	10,290
100 YR	0	13,208	1,699	14,907	0	0	0	0	14,907
200 YR	0	14,747	2,288	17,035	0	0	0	0	17,035
500 YR	0	24,207	1,975	26,182	0	0	0	0	26,182

SECTION 6

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	6	6	0	0	0	0	6
5 YR	0	1,846	19	1,865	0	0	0	0	1,865
10 YR	0	1,809	93	1,902	0	0	0	0	1,902
20 YR	0	6,022	4,460	10,482	0	0	202	202	10,684
50 YR	0	18,607	7,014	25,621	0	0	1,051	1,051	26,672
100 YR	0	27,229	7,339	34,568	0	0	1,121	1,121	35,689
200 YR	0	45,208	6,524	51,732	0	0	1,632	1,632	53,364
500 YR	0	56,596	10,175	66,771	0	65	1,909	1,974	68,745

SECTION 7

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	64	0	64	0	0	0	0	64
10 YR	0	64	0	64	0	0	0	0	64
20 YR	0	90	0	90	0	0	0	0	90
50 YR	0	327	1,779	2,106	0	0	0	0	2,106
100 YR	0	655	2,202	2,857	0	0	0	0	2,857
200 YR	0	2,223	4,725	6,948	0	0	0	0	6,948
500 YR	0	8,230	6,806	15,036	0	0	0	0	15,036

SECTION 8

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	0	0	0	0	0	0	0	0
20 YR	0	0	0	0	0	0	0	0	0
50 YR	0	0	918	918	0	0	57	57	975
100 YR	0	0	1,097	1,097	0	0	180	180	1,277
200 YR	0	24	1,340	1,364	0	0	437	437	1,801
500 YR	0	1,581	1,686	3,267	0	1,239	182	1,421	4,688

SECTION 9

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	7	7	0	0	0	0	7
5 YR	0	2,443	35	2,478	0	0	0	0	2,478
10 YR	0	2,386	2,302	4,688	0	0	0	0	4,688
20 YR	0	12,185	3,007	15,192	0	0	0	0	15,192
50 YR	0	22,788	5,963	28,751	0	0	0	0	28,751
100 YR	0	27,499	8,881	36,380	0	0	0	0	36,380
200 YR	0	31,359	7,949	39,308	0	0	0	0	39,308
500 YR	0	42,066	7,599	49,665	0	0	0	0	49,665

SECTION 10

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	26	0	26	0	0	0	0	26
10 YR	0	26	2	28	0	0	0	0	28
20 YR	0	26	7	33	0	0	0	0	33
50 YR	0	2,613	3,215	5,828	0	0	0	0	5,828
100 YR	0	10,443	2,560	13,003	0	0	0	0	13,003
200 YR	0	24,673	1,760	26,433	0	0	0	0	26,433
500 YR	0	32,992	0	32,992	0	0	0	0	32,992

SECTION 11

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	136	1	137	0	0	0	0	137
10 YR	0	33	336	369	0	0	0	0	369
20 YR	0	5,610	2,142	7,752	0	0	0	0	7,752
50 YR	0	26,970	935	27,905	0	0	0	0	27,905
100 YR	0	30,353	0	30,353	0	0	0	0	30,353
200 YR	0	30,353	0	30,353	0	0	0	0	30,353
500 YR	0	30,353	0	30,353	0	0	0	0	30,353

SECTION 12

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	51	0	51	0	0	0	0	51
10 YR	0	110	27	137	0	0	0	0	137
20 YR	0	0	209	209	0	0	0	0	209
50 YR	0	521	2,044	2,565	0	0	0	0	2,565
100 YR	0	2,179	4,173	6,352	0	0	0	0	6,352
200 YR	0	5,154	4,494	9,648	0	0	220	220	9,868
500 YR	0	14,478	4,815	19,293	0	706	1,439	2,145	21,438

SECTION 13

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	567	0	567	0	0	0	0	567
10 YR	0	567	0	567	0	0	0	0	567
20 YR	0	855	2,612	3,467	0	0	0	0	3,467
50 YR	0	1,972	4,195	6,167	0	25	0	25	6,192
100 YR	0	8,053	4,435	12,488	0	2,353	0	2,353	14,841
200 YR	0	12,691	3,972	16,663	0	6,548	24	6,572	23,235
500 YR	0	18,441	2,023	20,464	0	8,792	267	9,059	29,523

SECTION 14

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	2	2	0	0	0	0	2
5 YR	0	535	91	626	0	0	0	0	626
10 YR	0	1,059	323	1,382	0	0	0	0	1,382
20 YR	0	5,836	311	6,147	0	0	0	0	6,147
50 YR	0	11,388	265	11,653	0	0	0	0	11,653
100 YR	0	11,927	346	12,273	0	0	0	0	12,273
200 YR	0	12,451	339	12,790	0	0	0	0	12,790
500 YR	2,865	10,286	397	13,548	0	0	0	0	13,548

SECTION 15

ZONE	RESIDENTIAL WAVE	EROSION	INUNDATION	RESIDENTIAL TOTAL	COMMERCIAL WAVE	EROSION	INUNDATION	COMMERICAL TOTAL	CUMULATIVE TOTAL PER FREQUENCY
2 YR	0	0	0	0	0	0	0	0	0
5 YR	0	0	0	0	0	0	0	0	0
10 YR	0	17	0	17	0	0	0	0	17
20 YR	0	17	80	97	0	0	0	0	97
50 YR	0	436	174	610	0	0	0	0	610
100 YR	0	5,474	1,658	7,132	0	0	1,077	1,077	8,209
200 YR	0	13,600	2,514	16,114	0	0	1,579	1,579	17,693
500 YR	6,378	13,220	3,059	22,657	0	0	2,321	2,321	24,978

2 YR. FREQUENCY = (0.5 exceedance probability)
5 YR. FREQUENCY = (0.2 exceedance probability)
10 YR. FREQUENCY = (0.1 exceedance probability)
20 YR. FREQUENCY = (.05 exceedance probability)
50 YR. FREQUENCY = (.02 exceedance probability)
100 YR. FREQUENCY = (.01 exceedance probability)
200 YR. FREQUENCY = (.005 exceedance probability)
500 YR. FREQUENCY = (.002 exceedance probability)

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TABLE 3-10

WITHOUT PROJECT DAMAGES FOR EXISTING CONDITIONS

FUTURE CONDITIONS WITH LONG TERM EROSION

EXPECTED AVERAGE ANNUAL BASIS
($000)

SECTION	EROSION	INUNDATION	WAVE	INFRA-STRUCTURE	COST OF FILL	TOTAL FOR SECTION
1	0	0	0	0	0	0
2	0	1	0	0	1	2
3	436	179	0	11	262	888
4	96	86	0	24	13	219
5	521	61	0	36	15	633
6	703	324	0	23	223	1.273
7	28	59	0	2	115	204
8	13	24	0	1	21	59
9	1388	436	0	79	348	2.251
10	286	94	0	29	111	520
11	318	99	0	86	191	694
12	98	62	0	14	211	385
13	212	171	0	15	48	446
14	393	88	6	15	143	645
15	77	51	5	5	102	240
	-	-	-	-	-	-
	$4,569	$1,735	$11	$340	$1,804	**$8,459**
	TOTAL FOR	$6,315				
	ADD: COST	340 1,804				
		-				
	EXPECTED AVERAGE ANNUAL DAMAGE	**$8,459**				

4. PLAN FORMULATION.

4.1 PLANNING OBJECTIVES.

The purpose of this section is to provide the background for the criteria used in the formulation process. The plan formulation process involves:

a. The establishment of a plan formulation rationale,

b. Identification and screening of potential solutions

c. Assessment and evaluation of detailed alternatives, and

d. Establishment of a viable plan responsive to the identified problems and needs.

The Federal objective of water and related land resources project planning is to contribute to the national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. The U.S. Water Resources Council's Economic and Environmental Principles and Guidelines established the objective for Water and Related Land Resources Implementation Studies on 10 March 1983. Plans developed for the Barnegat Inlet to Little Egg Inlet Feasibility Study will be evaluated using NED benefits.

In general, the planning objectives utilized an integrated approach to the solution of erosion and inundation problems and storm damage vulnerability along the coastline from Barnegat Inlet to Little Egg Inlet. The shore protection improvements considered were developed to address the following objectives:

a. Reduce shoreline erosion and the potential for storm damages caused by erosion, inundation and wave attack along the oceanfront of Long Beach Island,

b. Minimize the degradation of the natural environment in areas impacted by such shore protection measures, and

c. Assess the need for ecosystem protection along the Holgate Unit of the Forsythe National Wildlife Refuge.

4.2 PLANNING CONSTRAINTS.

The formulation and evaluation of alternative plans are constrained by technical and economic considerations, environmental laws and institutional policies. The formulation of all alternative shore protection designs will be conducted in accordance with all Federal laws and guidelines established for water resources planning. For the initial plans analyzed in the without project conditions report, and further alternatives considered in the feasibility study, these constraints should be considered.

Technical Constraints. Technical constraints include physical or operational limitations. Plan formulation technical constraints include the following criteria:

a. Federal participation in the cost of restoration of beaches should be limited so that the proposed beach will not extend seaward of the historical shoreline of record.

b. Natural berm elevations and foreshore beach slopes should be used at least as a preliminary basis for the restoration of beach profiles,

c. Design tide and wave data should be based on calculations and investigations as detailed in the Existing Conditions section of this report,

d. Several potential sand source areas should be investigated for the purpose of identifying feasible and suitable beachfill,

e. Appropriate consideration should be given to wave run-up and overtopping for alternatives in which these are significant factors, and

f. Analyses are based on the best information available using accepted methodology.

Economic Constraints. Economic constraints limit the range of alternatives considered. The following items constitute the economic constraints foreseen to impact selection of the plan to be considered in this study and any subsequent formulation of alternatives:

a. Analyses of project benefits and costs should be conducted in accordance with Corps of Engineers' guidelines and must assure that any plan is complete within itself, efficient and safe, and economically feasible in terms of current prices,

b. Economic evaluations of project modifications should assume that authorized dimensions are maintained and will evaluate the incremental justification of modifications,

c. Tangible benefits should exceed project economic costs. Measurement shall be based on the NED benefit/cost ratio, which must be greater than or equal to 1, and

d. The benefits and costs should be expressed in comparable quantitative economic terms to the maximum practicable extent. The costs for <u>alternative plans</u> of development are based on preliminary designs and investigations, estimates of quantities, and February 1996 price levels. Annual charges are based on a 50-year amortization period and a Federal discount rate of 7.625 percent. The annual charges also include the cost of maintenance and replacement. The selected plan and further optimization use January 99 price levels and the Federal discount rate was updated to 6.875 percent.

Institutional Constraints. The formulation of alternative projects will be conducted in accordance with all Federal laws and guidelines established for water resources planning. According to the Planning Guidance Notebook (ER 1105-2-100), Section IV--Shore Protection, "Current shore protection law provides for Federal participation in restoring and protecting publicly owned shores available for use by the general public." Typically, beaches must be either public or private with public easements/access to allow Federal involvement in providing shoreline protection measures. Private property can be included, however, provided that the "protection and restoration is incidental to protection of publicly owned shores or if such protection would result in public benefits". Items that can affect the designation of beaches being classified as public include the following:

a. A user fee may be charged to aid in offsetting the local share of project costs, but it must be applied equally to all,

b. Sufficient parking must be available within a reasonable walking distance on free or reasonable terms. Public transportation may substitute for, or compliment, local parking, and street parking may only be used if it will accommodate existing and anticipated demands,

c. Reasonable public access must be furnished to comply with the planned recreational use of the area. However, public use is construed to be effectively limited to within one-quarter mile from available points of public access to any particular shore,

d. Private beaches owned by beach clubs and hotels cannot be included in Federal shore protection activities if the beaches are limited to use by members or paying guests, and

e. Publicly owned beaches which are limited to use by residents of the community are not considered to be open to the general public and cannot be considered for Federal involvement.

Environmental Constraints. (ER 1165-2-501, November 1998) Appropriate measures must be taken to ensure that any resulting projects are consistent with local, regional, state, and Federal regulations. It must be evident that all necessary permits and approvals are likely to be issued by the regulatory agencies. Further environmental constraints relate to the protection and maintenance or control of flora and fauna species found within the ecosystem that may be affected by a project. This includes areas of prime fishing habitat, essential fish habitat and significant commercially harvestable surf clam areas. The following environmental and social well-being criteria were considered in the formulation of alternative plans:

a. Consideration should be given to public health, safety, and social well being, including possible loss of life,

b. Wherever possible, provide an aesthetically balanced and consistent appearance,

c. Avoid detrimental environmental and social effects, specifically eliminating or minimizing the following where applicable:

i. Air, noise and water pollution;
ii. Destruction or disruption of man made and natural resources, aesthetic and cultural values, community cohesion, and the availability of public facilities and services;
iii. Adverse effects upon employment as well as the tax base and property values;
iv. Displacement of people, businesses, and livelihoods; and,
v. Disruption of normal and anticipated community and regional growth.

d. Maintain, preserve, and, where possible and applicable, enhance the following in the study area:

i. Water quality;
ii. The beach and dune system together with its attendant fauna and flora;
iii. Wetlands and other emergent coastal habitats;
iv. Commercially important aquatic species and their habitats;
v. Nesting sites for colonial nesting birds;
vi. Habitat for endangered and threatened species.

4.3 DESCRIPTION AND DISCUSSION OF ALTERNATIVES.

Coastal protection alternatives can be classified into two groups: Non-structural and structural. Non-structural alternatives primarily consist of those measures that control or regulate the use of land and buildings such that damages to property are reduced or eliminated. These measures may establish oceanfront setback limits or restrict building below a certain elevation. The retreat option is also a non-structural measure. This option is not considered feasible due to the level of development and/or economic base of this region. Since the study area is already fully developed, implementation of other non-structural alternatives could only affect future construction.

Structural alternatives are composed of those measures that block or otherwise retard erosive coastal processes, or restore or nourish beaches to compensate for erosion. Typically, the hardened structural alternatives consist of seawalls, bulkheads, revetments, breakwaters, or groins. Beach and dune fill is considered a soft structural alternative. In general, seawalls, bulkheads and revetments are shore parallel structures used to retain fill and/or reduce direct wave attack on the backshore. Typical construction materials are timber and steel sheet piles, rock and/or concrete. Breakwaters are also shore parallel structures, typically constructed of rock or concrete, and placed offshore to reduce incoming wave energy. Groins, on the other hand, are typically shore perpendicular structures used to interrupt the long shore sediment transport to build a protective beach, retard erosion of an existing beach or prevent longshore transport of sand to some downdrift point. Groins can be constructed of a wide variety of materials. The most widely used in LBI study area is timber and rock. The placement of sand on the beach to provide a larger berm and/or dune and to offset erosion is known as beach or dune fills. Of the structural alternatives, seawalls, bulkheads, revetments, breakwaters and groins are typically expensive to construct. The beach/dune fill option, however, is usually less expensive and more environmentally favorable since it responds to the natural beach environment.

In order to facilitate the investigation, the island was segmented into Beach Units or BUNDY's. This nomenclature considers the linear extent of geographic areas that exhibit like characteristics based on dunes, berms, offshore bathymetry and economic conditions and separates them into BUNDY's. For the entire reach of Long Beach Island there are 15 BUNDY's. Each BUNDY is then analyzed using the appropriate hydraulic and economic models. As shown in **Figures 4-1 A and B**, there are (15) primary BUNDY's created for use in the analysis. The primary BUNDY's range in length from approximately 3,100 to 9,800 feet.

Alternative Plans Considered. This section describes the first two cycles of the formulation procedure and results for the Barnegat Inlet to Little Egg Inlet Feasibility Study. **ER 1165-2-501 November 1998** requires the systematic preparation and evaluation of alternative solutions for addressing identified problems, needs and opportunities. The purpose of the formulation analysis is to identify plans, which are publicly acceptable, "implementable", and feasible from environmental, engineering, economic and social standpoints. **ER 1165-2-501 November 1998** requirements for plan formulation for ecosystem restoration projects were also followed.

The formulation is being undertaken in three phases or cycles: Cycle 1 - Initial Screening of Solutions Considered, Cycle 2 - 2nd Level Screening of Solutions Considered and Cycle 3 - Final Screening and Optimization of the Selected Alternative Solutions. By analyzing the alternative solutions in this manner, the solution that best fits the planning objectives and constraints can be formulated in a logical and efficient fashion. **ER 1165-2-501** requirements for plan formulation were followed. This includes performing an incremental analysis as appropriate to optimize solutions. It should be noted that recreation benefits achieved by any of the alternative plans are considered to be incidental and are not included in the formulation of a shore protection plan.

4.4 CYCLE 1 - INITIAL SCREENING OF SOLUTIONS CONSIDERED

In Cycle 1, storm damage reduction measures were identified and evaluated individually and in combination on the basis of their suitability, applicability and merit in meeting the planning objectives and constraints and the economic, environmental and social criteria for the study.

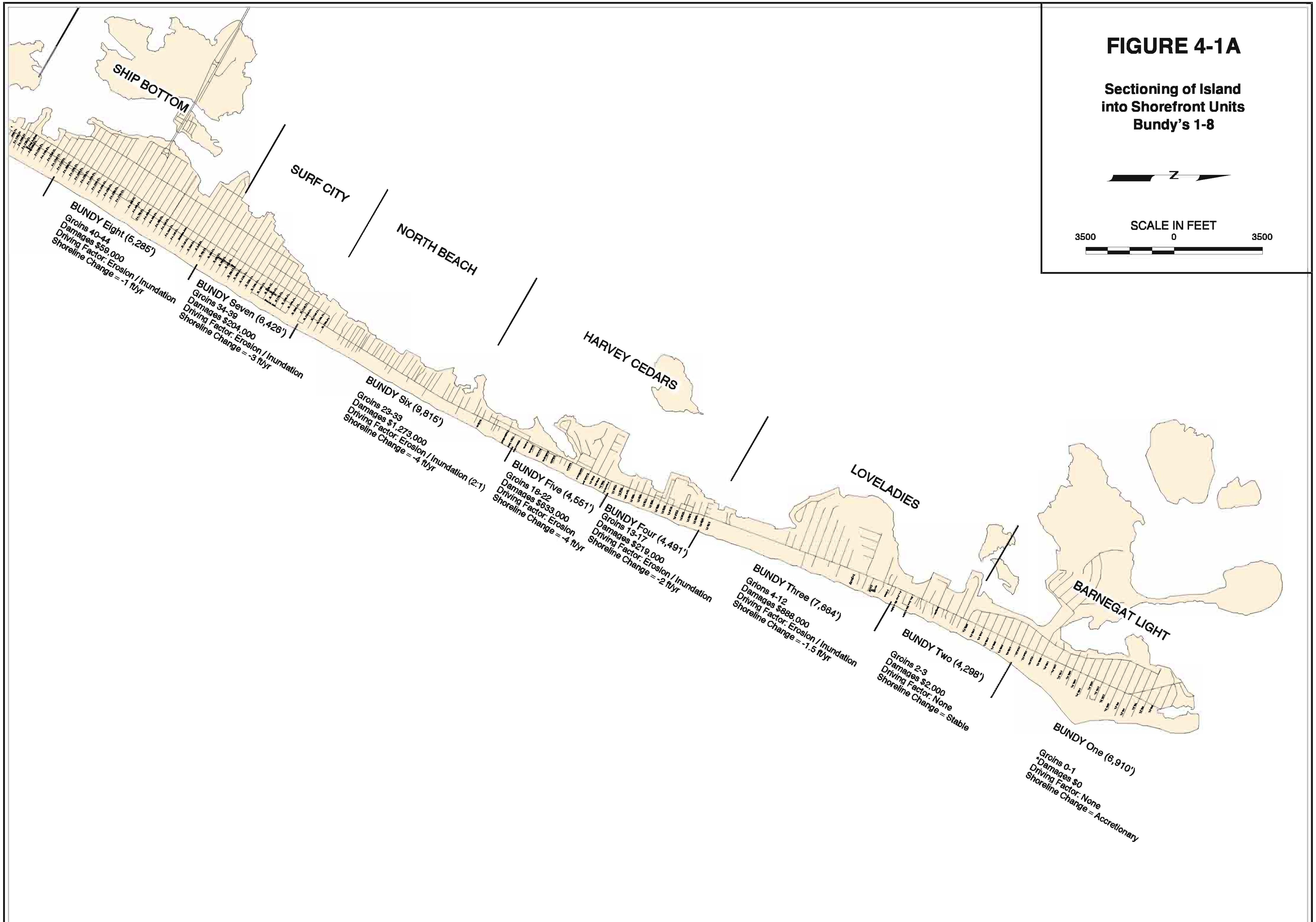

FIGURE 4-1A

Sectioning of Island into Shorefront Units Bundy's 1-8

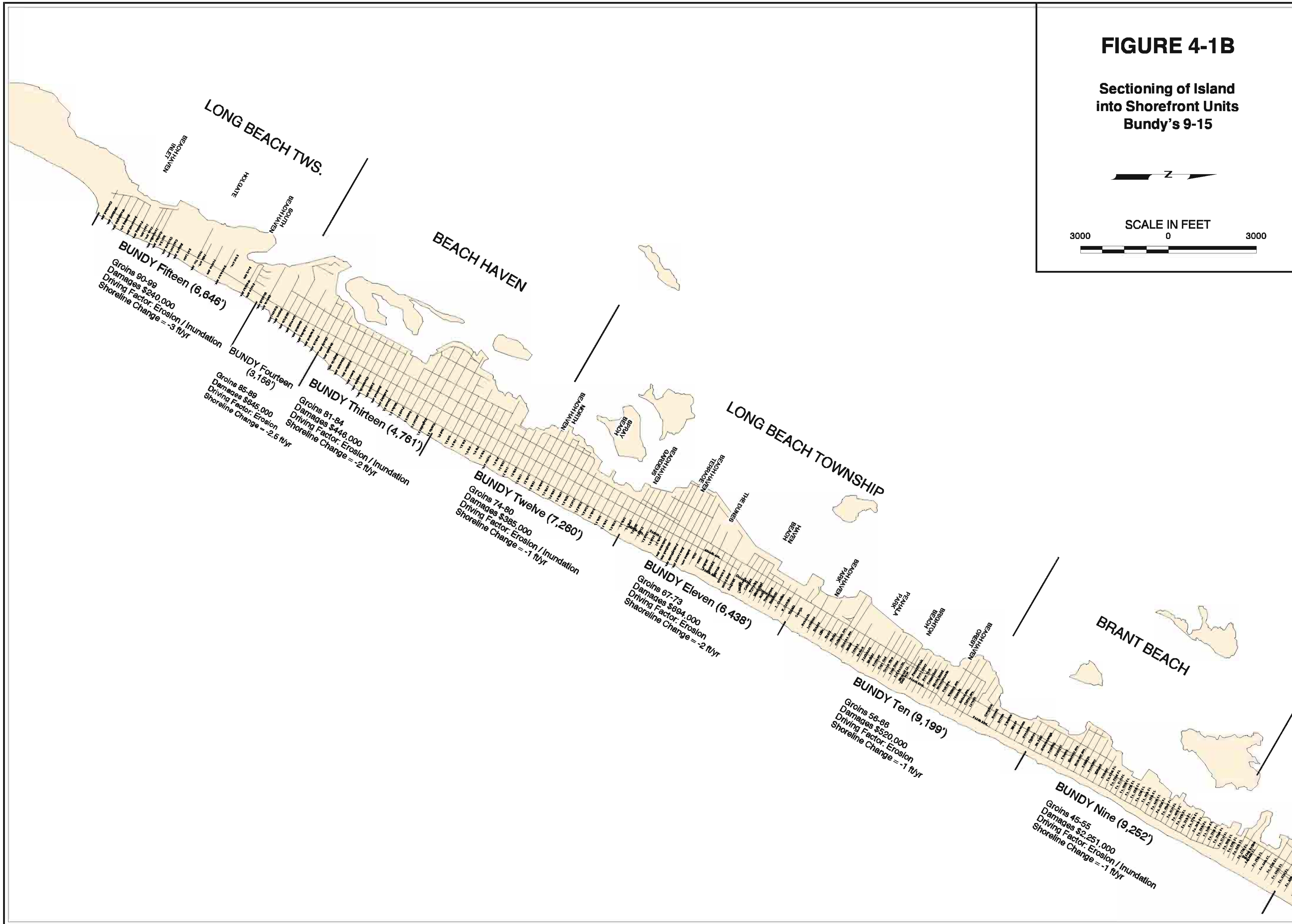

FIGURE 4-1B

Sectioning of Island into Shorefront Units Bundy's 9-15

The goal of Cycle 1 analysis is to identify the potential spectrum of alternatives without undertaking an in-depth analysis. Alternatives that obviously do not fulfill the storm protection needs of the study area or are inappropriate due to other factors such as prohibitively high costs of implementation are screened out. Judgements were made about each alternative based on knowledge gained from researching reports, the professional experience of each study team member and other District personnel. In addition, in accordance with the non-Federal sponsor, NJDEP, each of the alternatives were evaluated and discussed in terms of the sponsor's views concerning its effectiveness in meeting the needs along the study area.

Structural alternatives can be categorized as shore protection and shoreline stabilization structures. The purpose of the former is to protect inland development and to armor the shoreline against erosion; the purpose of the latter is to retard beach erosion, increase longevity of a beach fill, and maintain a wide beach for damage reduction and recreation. Seawalls, revetments and bulkheads, are shore protection structures, whereas groins nearshore breakwaters and sills are shoreline stabilization structures. Generally, the "hard" structures require special siting considerations and an accompanying beach fill to mitigate adverse effects on adjacent beaches. Beach fills are often the preferred and sometimes most cost-effective alternative. These "soft" structures include artificial beach berms and dunes accompanied by periodic beach nourishment, feeder beaches, or sand bypassing systems. Periodic or continuous replenishment through beach fills allows the created beach to erode and adjust to the dynamic requirements of the ocean shore and prevent return of the damaging erosion processes to the landward development. Beach fills emulate nature, are aesthetically pleasing, contribute to recreation, and add needed material to the shore processes rather than simply redistributing available sand (EM 1110-2-1617). Descriptions of other structural alternatives can be found in the Cycle 1 analysis that follows.

4.5 CYCLE 1 ALTERNATIVES

Alternatives are based on applications for the entire study area. Alternatives which are eliminated from further consideration in Cycle 1 and Cycle 2 may be revisited in the Cycle 3 analysis for appropriateness for solving problems associated within "hot spots" of an overall reach or project area.

No Action Alternative: This is synonymous with the without-Federal project plan. The no action alternative is used to compare the effects of alternative plans. It is analyzed as both baseline conditions and future conditions, considering the effects of long term erosion and accretion.

Nonstructural Alternatives

Evacuation from areas subject to erosion and storm damage
Regulation of future development

Structural Alternatives

Beach Restoration With and Without Dunes

Dune Reinforcement
Bulkheading
Offshore Detached Breakwaters
Groin Field (Modifications: including removal, reconstruction)
Perched Beach
Submerged Artificial Reef
Offshore Submerged Feeder Berm
Beach Dewatering
Seawalls
Innovative erosion control low-cost shore protection products

It is noted that all of the above alternatives were evaluated with the goal of providing similar storm damage protection. The following paragraphs summarize the objectives and evaluation of each of the above alternative considered in Cycle 1.

A. No Action. The alternative "no action" will not involve any measures to provide erosion control, recreational beach or storm damage protection to structures landward of the beachfront. This alternative would not check the continuing erosion of the beaches, nor would it prevent property from being subjected to higher storm damages from beach recession, flooding and wave attack. This plan demonstrates the likely future condition in the absence of Federal action.

Non-structural Alternatives: Following are discussions of the nonstructural measures considered under the Cycle 1 analysis.

B. Regulation of Future Development. Regulation or land use controls could be enacted through codes, ordinances, or other regulations to minimize the impact of erosion on lands, which could be developed in the future. The State of New Jersey restricts building at the shore to placement behind existing dune or bulkhead lines as well as other restrictions per CAFRA as amended. Such regulations are traditionally the responsibility of State and local governments. This measure lends itself to relatively large, continuous undeveloped areas rather than developed areas however, regulation of replacement structures after damage due to erosion and/or inundation may lend itself to specific high damage areas. South Carolina for example, has laws that prohibit rebuilding within a specified storm vulnerable area. Such laws can lead to court cases involving takings' issues. Some property owners have won the right to rebuild within the restricted zone, but are not covered by Federal insurance. Again, the responsibility lies with the State and local governments in restricting rebuilding. At this time, there is virtually no oceanfront that is not developed, except for the Holgate Unit of the Edwyn B. Forsythe National Wildlife Refuge regulated by the U.S. Fish and Wildlife Service; and the northernmost dunes of the Borough of Barnegat Light regulated by the borough and CAFRA. Therefore, additional regulation to prevent new development would have little impact. This alternative will not be considered in Cycle 2.

C. Evacuate Areas Subject to Erosion and Storm Damage. Permanent evacuation of existing developed areas subject to inundation involves the acquisition of lands and structures thereon either by purchase or through the exercise of powers of eminent domain, if necessary.

Following this action, all commercial and industrial developments and residential property in areas subject to erosion are either demolished or relocated to another site. Condominiums and hotels with their ancillary parking lots and support industries would require relocation. Additionally, roads, water supply facilities, electric power, and telephone and sewage utilities would also have to be relocated. Lands acquired in this manner could be used for undeveloped parks, or other purposes, which would not result in material damage from erosion. The level of development at the problem areas under study would make this measure prohibitively expensive. Therefore, this alternative will not be considered in Cycle 2.

Structural Alternatives. Following are discussions of structural measures considered under the Cycle 1 analysis.

A. Berm (Beach) Restoration Without Dune. This alternative involves the placement of beach fill material (sand) from an offshore borrow source, directly onto the beach in order to widen and stabilize the existing beach profile. Sand is typically pumped onto the existing shore using a dredge, or hauled in from an inland borrow site by trucks. An appropriate design uses borrow material that has similar properties to the existing native beach sand. In addition, the restored beach is graded to a certain design elevation and width to protect against a desired level of damages. The beach requires additional sand placement, renourishment, on a periodic basis so that the design beach width and elevation is maintained. For purposes of Cycles 1 and 2 evaluations, a uniform berm width of 50 ft from toe of dune at elevation 8-ft NAVD was evaluated for the entire oceanfront. This template corresponds to a several existing beach dune profiles that provide effective damage reduction and protection.

House Document 86-208 ("Shore of New Jersey -Barnegat Inlet to Cape May Canal, Beach Erosion Control Study: 1959") proposed a beachfill consisting of a 50 foot wide berm at elevation +10 MLW (approximately + 7.25 feet NAVD) for 3500 feet in Ship Bottom; 6900 feet in Brant Beach (Long Beach Township); and 3000 feet at Beach Haven. Brant Beach continues to be a high erosion area today, with almost yearly state placed beachfill or beach scraping mitigation efforts. Ship Bottom has remained relatively stable; however there are specific hot spots within this Borough.

B. Berm and Dune Restoration. This alternative is similar to the above with the addition of dune restoration. Dune improvements are often done in conjunction with beach (berm) restoration projects. A healthy dune system can offer significant protection to landward development from inundation and wave attack during frequent storm events. For the purposes of Cycles 1 and 2 evaluations, a uniform dune top width of 30 feet with seaward side slopes of 1V on 5H, at an elevation of +20.0 NAVD was designed for the entire oceanfront. This template corresponds to a several existing beach dune profiles that provide effective damage reduction and protection. This alternative will be evaluated in Cycle 2.

C. Berm and Dune Restoration with Structural Components. This concept alternative is aimed at hot spot areas that experience frequent loss of dune protection. Structural reinforcement such as geotextile tubes, other manufactured structural reinforcement, and or rubble mound can provide greater stability to the dune over natural dunes. A veneer of sand will be place on top of all reinforcement features to provide similar aesthetic and environmental features of natural dunes. This alternative will be further evaluated in Cycle 2.

D. Dune Restoration Only. The dune only scenario involves restoration of the dune with out replenishing the berm or beach area. It assumes there is an ample supply of sand in the system to feed the existing berm, which serves to protect the dune structure. Historic and present erosion of berm profile is evidence that there is not ample sand in the sediment budget to provide nourishment to the beaches naturally. In many areas it is not physically practical to place a dune that is adequate to provide storm damage protection, as it would extend into the ocean. It would immediately be susceptible to wave damage. Berms serve as protection for dunes. They are somewhat sacrificial. In many areas of LBI there is little or no berm to serve the purpose of buffering the dune. A project without berm restoration is not an acceptable alternative to the non-Federal sponsor. The dune width necessary to provide protection against the estimated storm damages would potentially cover existing recreational beach area. The dune height necessary to provide the estimated level of protection would not be acceptable to the locals because of limiting ocean front views.

Since other similar alternatives exist which have less impact to the project area, this alternative will not be evaluated further in Cycle 2.

E. Offshore Detached Breakwaters. Breakwaters can be designed to retard erosion of an existing beach, promote natural sedimentation to form a new beach, increase longevity of a beach fill, and maintain a wide beach for storm damage reduction and recreation (TR CERC-93-19). Breakwaters can be constructed as a single structure or in series. A single structure is used to protect a localized project area, whereas a multiple segmented system is designed to protect an extended length of shoreline. A segmented breakwater system may be used in between existing groin structures along Long Beach Island to enhance shoreline stabilization in critical areas. However, there are several disadvantages associated with the breakwater alternative: construction feasibility, cost, aesthetics, and safety. Water based construction requirements and placement of the structures in considerable depth (due to the steep existing profile) results in a significant cost for this alternative. For these reasons, this alternative will not be considered further in Cycle 2.

F. Groin Field Modifications. Groins are shore-connected structures designed to enhance beach stabilization. They are usually constructed perpendicular to the shore to interrupt the normal transport of sand alongshore. A series of groins already exists along the 18 miles of developed shoreline on Long Beach Island. A large portion of the groins were constructed in response to the March 1962 Storm under the Federal Accelerated Public Works Program (APWP). Since 1955 a total of 97 groins were constructed at an approximate cost of $5,500,000. By the early 1970's, Long Beach Island had a total of 112 groins. Presently, there are a total of 99 visible groin structures spaced at intervals ranging from 750 to 1000 feet, with an average spacing of 900 feet. Several groins on Long Beach Island appear to have improper design characteristics and are not providing adequate performance in terms of shoreline stabilization and are creating downdrift impacts.

Properly designed groin fields placed in conjunction with beach nourishment can often increase the residence time of the sand, keeping it on the beach within the project area for a longer period of time. If the savings that are realized by reducing the time between required nourishment (in order to maintain a design level of protection) exceeds the costs of modifying or constructing such structures, their construction can be justified. Modifications to existing structures may consist of changes to the structure's length, elevation, and permeability to increase or reduce the volume of sand allowed to bypass the structure. Additions to the structures such as hooked ends or T-heads at the seaward end may be used to increase the size of the updrift fillet or to shelter a greater stretch of beach from storm waves approaching from a predominant angle.

Groin notching presents a more difficult alternative to analyze. It is discussed later in the report. For this study, the modification of groins <u>in conjunction with</u> beach and dune restoration alternatives will be evaluated in Cycle 2.

G. Shore Parallel Offshore Sills (Perched Beach). Submerged or semi-submerged, shore-parallel offshore sills are alternative shore protection structures that can reduce the rate of offshore sand movement from a stretch of beach. The sill introduces a discontinuity into the beach profile so that the beach behind it is at a higher elevation (and thus wider) than adjacent beaches. The beach is thus "perched" above surrounding beaches. The sill acts as a barrier to reduce offshore sand movement and causes some incoming waves to break at the sill. The height of the sill is usually at or slightly below low-tide levels, providing limited wave protection to the beach behind it. The low sill/perched beach concept minimizes the visibility of the structure, making it more aesthetically acceptable than a detached breakwater. A disadvantage of the sill, however, is a potential hazard to swimming and navigation. Although the sill reduces offshore transport during storm events, it also hinders natural recovery processes (onshore transport) following storm events. Due to these factors this alternative will not be considered in cycle 2.

H. Submerged Reef Breakwaters. Submerged reef breakwaters are similar to detached breakwaters with emphasis on a lower crest elevation. The reef structures can be effective shoreline stabilization structures that control both alongshore and offshore movement of sediment. Secondary benefits of incident wave reduction during storm events are also provided by the structure. There has been limited experience with reef breakwater design, construction, and performance; thus there is limited documented experience on to which to base a design.

A reef structure composed of interlocking concrete units has been placed adjacent to Townsends Inlet in Avalon, New Jersey. Success to date with this alternative along the New Jersey shore is still uncertain. The units at the Avalon site have had foundation problems, resulting in settlement of the units. Similar prefabricated units have been placed in Palm Beach, Florida. The University of Florida (Browder, 25th ICCE) evaluated the performance of the installation against pre-project expectations during a 3-yr monitoring program. The results of the monitoring program at the end of two years indicated erosion throughout the project area. Erosion, primarily in the lee of the reef, was sufficiently severe to warrant removal of the structure.

Reef structures also may consist of rubble mound material or submerged barges. Lack of performance and the inability to reduce significant wave energy may not address the planning objectives of the study. The alternative will be considered only as a solution to hotspot areas in Cycle 2 analysis.

I. Beach Dewatering. The concept of beach dewatering as a method to increase beach stability has been tried in Florida, Massachusetts, and Denmark. The stated objective of the system is to induce continuous draw-down of the groundwater table at the beach face, and thereby enhance the depositional effect of wave uprush and reduce the erosive effect of wave backrush. Beach dewatering is an innovative and potentially low-cost shoreline stabilization alternative. However, the practical application of the technology as a viable means of coastal protection is yet to be demonstrated (Curtis, 25th ICCE). A field-monitoring program was established at Nantucket Island, Massachusetts to objectively evaluate the operation of a commercial beach dewatering system. Results of the study are to date unavailable. Due to the uncertainties associated with this concept, the beach dewatering alternative will not be considered for cycle 2 analysis.

J. Bulkhead. A bulkhead along the existing dune line is a viable protective measure for areas with minimal dune features or areas, which experience frequent loss of dune protection. The primary purpose of a bulkhead is to retain sediment or prevent upland erosion, with the secondary purpose being to afford protection to backshore areas from wave action and inundation. Bulkheads are normally vertical walls of concrete, timber, or steel sheetpile. Being nearly vertical structures, bulkheads have the disadvantage of being potential wave reflectors that can erode the beach fronting the structure. Depending on the wave climate to which bulkheads are exposed, beach nourishment or toe protection may be required to enhance stability. This alternative will be evaluated in Cycle 2 for appropriateness in minimizing erosion-induced damages.

K. Seawall. Seawalls are massive structures which are primarily intended to deflect or dissipate wave energy on a high-energy ocean shoreline, preventing wave and inundation damages to landward development. The major disadvantage of this alternative is the costs of construction. Although this alternative would provide storm damage protection consistent with other alternatives, it is not expected that the benefits would support its construction. For these reasons, this alternative will not be carried into Cycle 2.

L. Nearshore Berm. This alternative includes submerged feeder berm. Potentially high costs associated with onshore placement have led to the development of alternate, less expensive methods of beach nourishment. One such method is nearshore berm placement. In some areas, nearshore berm can reduce wave damage and provide sand to the littoral system with a cost as little as half that of onshore placement (Allison and Pollock, 1993 and McLellan et. al, 1990).

Prototype experience with near shore berm technique is limited, and proper design techniques are still being researched and developed. For the berm to function successfully as a beach nourishment technique, several factors such as berm depth, wavelength, wave height, and wave velocity must be within proper ratios (Hands and Allison, 1991). Long term sediment transport trends, both longshore and cross-shore, must also be examined. Berm placement site must be a proper distance downdrift of an inlet or jetty to reduce the tendency of the sediment to return to the inlet or be caught by the jetty (McLellan et. al, 1990).

A similar practice has been ongoing off the coast of Loveladies, Long Beach Township, NJ. Periodically the dredge Currituck has placed sand in the nearshore of the Loveladies coast of Long Beach Island, since 1994. Although exact quantities are not known, local residents report an increase the berm width, indicating that some of the sand may travel onshore. The district has reviewed log sheets for the period of November 1995 through August 1996, indicating that approximately 22,000 cubic yards were deposited in that time frame.

Because nearshore placement has had mixed results and current design techniques are limited; nearshore placement is a higher risk option than direct onshore placement at Long Beach Island. However at nourishment areas not located adjacent to the potential borrow sources; the difference in cost between direct onshore and nearshore placement may be significant. Additionally, this alternative may have applications that help solve erosion problems associated in areas where erosion processes are suspected to occur due to nearshore bathymetric features. Therefore, this alternative will receive further evaluation in Cycle 2 for addressing the planning objectives of the study.

M. Sand Recycle Plant at Barnegat Light. Since the completion of the Barnegat Inlet south jetty structure, a fillet south of the jetty structure has developed. Using designs of standard sand bypass plants an evaluation of this alternative was conducted. The plant could back pass sand from the zone of active sedimentation to an area of active erosion, Loveladies. Such material can be cost-effectively recycled. This alternative is simply another method of placing sand in comparison to trucking in sand or dredging sand. It is not meant to be a unique shore protection feature. Placement of the unit may be difficult due to the presence of wetlands. Operation of the unit can not interfere with nesting piping plovers or the recreational experience of shore visitors. High initial costs must be offset by reduced long-term nourishment needs. An exact determination of the volume of material available for pumping must be completed. This alternative will be carried into Cycle 2.

CYCLE 1 - APPLICABILITY SCREENING FOR LONG BEACH ISLAND OCEANFRONT. During the first cycle of formulation the management measure discussed in the previous section were reviewed to determine the acceptability and potential to control the erosion in each problem area. Consideration was given to factors such a potential technical performance, whether it meets the study objectives and relative cost. Based on the information shown in **Table 4-1**, the alternative measures were screened and only those measures which were considered to have potential viability were carried forward as plans or features of plans in the next cycle of formulation.

TABLE 4-1

BARNEGAT INLET TO LITTLE EGG INLET
CYCLE 1-FIRST LEVEL SCREENING RESULTS

Alternative	**Technical Appropriateness/Comments**	**Meet Objective?**			**Relative Cost**	**Consider for Cycle 2?**
	Non-Structural Alternatives	**Erosion**	**Inundation**	**Wave Attack**		
A. No Action	No. Provides no measures to prevent damages from storms or long term erosion for the study area. Use as comparison against various alternative plans proposed.	No	No	No	None	Yes as comparison for other alternatives.
B. Regulation of Future Development	No. Provides no measures to prevent damages from storms or long term erosion for the study area because there is virtually no undeveloped land.	No	No	No	Low	No
C. Evacuate Areas Subject to Erosion.	No. Involves the acquisition of all affected lands and structures either by purchase or through powers of eminent domain.	No	No	No	Very High	No
	Structural Alternatives					
A.Berm (Beach) Restoration	Yes. Berm pushes the breaker zone and the erosion profile seaward. Provides sacrificial sediment during storms as well as recreational beach.	Yes	No	Partial	Moderate	Yes
B. Berm and Dune Restoration	Yes. Berm pushes the breaker zone and the erosion profile seaward. Provides sacrificial sediment during storms as well as recreational beach. Dunes can provide buffer during storms and can provide aesthetic value and provide stability of dune from wave and wind erosion.	Yes	Yes	Yes	Moderate	Yes
C. Dune Restoration	Yes. Dunes provide buffer during storms and can provide aesthetic value but without protective berms, are susceptible to erosion and wave impact which shortens usefulness. Dimensions required to achieve acceptable level of protection would impact existing berm, creating negative recreational impacts and social impacts.	Yes	Yes	Yes	Moderate	No. Although it meets requirements, other alternatives exists, which have less associated social and recreational impacts.
D. Berm and Dune Restoration with structural dune reinforcement	Yes. Structural reinforcement such as geotextile tubes, and others materials provide greater stability during high wave energy environments compared to natural dunes. Aesthetics, vandalism and maintenance requirements need to be considered.	Yes	Yes	Yes	Moderate	Yes

TABLE 4-1 (continued)
BARNEGAT INLET TO LITTLE EGG INLET
CYCLE 1 – FIRST LEVEL SCREENING RESULTS

Alternative	Technical Appropriateness/Comments	Meet Objective?			Relative Cost	Cycle 2 ?
		Erosion	Inundation	Wave Attack		
E. Offshore Detached Breakwater	Partial. Current research at actual installation sites is inconclusive regarding the effectiveness of offshore breakwater. They are site dependent structures. Costs must be offset by reduced periodic nourishment requirements.	Partial	No	Partial	Very High	No
F. Groin Field Modifications	Yes. Many existing groins on Long Beach Island were built at elevations too high or are impermeable interfering with sediment transport. Costs of reconstruction or removal must be offset by reduced periodic nourishment requirements. Could also reduce long term erosion and stabilize beaches within various municipalities. Can cause downdrift erosion.	Yes	No	Yes	High	Yes
G. Berm and Dune Restoration with Perched Beach	Partial. Costs must be offset by reduced periodic nourishment requirements. Less viable in high wave energy environments. Uncertain performance. Swimming and Navigation Hazard.	Partial	No	Partial	High	No
H. Submerged Reef Breakwaters	Partial. Costs must be offset by reduced periodic nourishment requirements. Existing submerged reef in NJ has had mixed results in retaining beachfill. Similar to a detached breakwater.	Partial	No	Partial	High	Yes
I. Beach Dewatering	Partial. Technology/performance is still unproven for an open ocean coastal environment. Requires an initial beachfill placement. Costs would have to be offset by reduced nourishment requirements. Life cycle costs for implementation are unknown.	Partial	No	Partial	Moderate	No
J. Bulkhead	Yes. Bulkheads perform the same function as dunes but are more costly and may require toe protection. No bulkheads exist within the project study area. However, high impact areas, "hot spots"may benefit by a bulkhead rather than a dune.	Yes	Yes	Yes	High	Yes
K. Seawall	Yes. Seawall performs the same function as bulkhead and dune but is much more costly. There is debate that seawalls can actually exacerbate erosion.	Partial	Yes	Yes	Very High	No

TABLE 4-1 (continued)
BARNEGAT INLET TO LITTLE EGG INLET
CYCLE 1 – FIRST LEVEL SCREENING RESULTS

Alternative	Technical Appropriateness/Comments	Meet Objective?			Relative Cost	Consider For Cycle 2?
		Erosion	Inundation	Wave Attack		
L. Nearshore Berm	Partial. Costs must be less than direct placement of material on beach. Success is highly dependant on wave conditions. Loveladies has had success with offshore deposits from Currituck Dredge. Placement of material was on a "as can"basis after dredging of Barnegat Inlet, with deposits more nearshore. No attempt at creating a berm was made. Continual performance is uncertain.	Partial	No	Partial	Moderate	Yes
M. Sand Recycle Plant At Barnegat Light	Partial. Savings from less periodic nourishment must offset costs through traditional methods. Plant design will back pass sand from area of active sedimentation. Placement could be difficult as wetlands have developed and habitat may be critical for piping plover. Limited by off-season operation periods and cost effectiveness for specific pumping distances.	Yes	Partial	Yes	High Initial	Yes

4.6 CYCLE 2 - IN-DEPTH EVALUATION AND SCREENING OF SOLUTIONS CONSIDERED.

The purpose of Cycle 2 is to further narrow down the number of alternatives for consideration in Cycle 3. (**Table 4-2**) This was accomplished through a comparison of annualized cost and the effectiveness of each alternative in providing protection from storm damages. In addition, consideration was given to periodic nourishment as well as alternative borrow sources. Finally, consideration was given to those alternatives which may be appropriate in solving small scale hot spot problems (see **Table 4-3**) within a large scale project area, and have been noted as such for inclusion in Cycle 3.

Only those alternatives that are practical, in terms of the engineering, economics, environmental and social impacts remained after the completion of Cycle 2. General designs for the alternatives were chosen after reviewing accepted coastal engineering practices, existing conditions in the study area, results of the without-project analysis, the Shore Protection Manual and Coastal Engineering Technical Notes.

Without Project Damage Results: Upon the completion of the without project conditions a breakdown of the segregated reaches studied were defined by erosion, inundation and wave damages to structures. Preliminary annualized without project conditions were approximated for long term erosion for the 50-year period of analysis. Additional categories such as local costs forgone and future infrastructure damages must be added. For the purposes of Cycle 2 annualized without project damages of $8,500,000 were used. Further refinements were included in Cycle 3.

Cycle 2 Assessment of Preliminary Plans Long Beach Island Oceanfront.

To help simplify the formulation process problem statements, causal mechanisms and objectives were formed to assist in identifying solutions. Three problem statements were identified.

PROBLEM: Storm Damage Vulnerability Along The Long Beach Island Shoreline

CAUSE: Long-term and storm-induced beach erosion along the Long Beach Island shoreline has left the area susceptible to storm damage (through inundation and erosion) for storm events of a level 20 to 50 year storm or greater.

OBJECTIVE: Reduce storm damage vulnerability along Long Beach Island Oceanfront.

Structural Solutions

Berm and or dune restoration

Berm and dune restoration using structural reinforcement

Feeder Berm

Offshore Reefs

Groin Modifications

PROBLEM: Storm damage erosion and inundation within specific hotspot locations in the municipalities of Brant Beach, Loveladies, and Harvey Cedars, Beach Haven.

CAUSE: Decreased berm and dune widths due to long term erosion; nodal point conditions.

OBJECTIVE: Provide reduction in erosion and inundation damages through beachfill (berm and dune), possibly in conjunction with nearshore structure alternatives.

Structural Solutions

Geotextile tube or rubble mound reinforced dunes

Feeder berm, nearshore

Sand recycle system

PROBLEM: Long-Term Beach and Dune Erosion

CAUSE: Shoreline change due to groin configuration along Long Beach Island. Excessive groin elevations and lengths have resulted in interruption of longshore transport, starving downdrift reaches.

OBJECTIVE: Restore balanced sediment transport regime within groin fields

Structural Solutions

Modify groin dimensions to enhance stabilization of the restoration plan

Based on the previous screening of management measure, several alternative plans were established for further analysis in Cycle 2. These plans consist of one or more individual measures as appropriate to develop a suitable degree of storm damage protection. In addition, consideration was given to alternative methods of beach fill and periodic nourishment, various materials for dune reinforcement, and alternative borrow sources for sand.

As the plan formulation process continued, it became paramount that the erosion process affecting the project area was thoroughly understood. While historic beach erosion rates were factored into potential designs, the study attempted to determine if any more dramatic increases or decreases in erosion occurred recently. In the case of Long Beach Island, erosion rates have increased within the past 30 years. Within the Cycle 3 assessment, analyses was completed that provided data necessary in considering nourishment periods, groin modifications and more appropriate project designs for hot spots within general project reaches.

Cycle 2 analysis only considered designs that conform to the typical project profile, in order to assess costs of the design and general effectiveness of reducing damages. Specific hot spot areas also were incorporated into Cycle 2, and were carried through into Cycle 3. The following sections describe the plans considered for each problem/solution approach. **Table 2-2** table discusses the technical performance, economic analyses, and environmental and social impacts associated with each plan.

A. No Action: The no action alternative does not involve any measures to provide erosion control, recreational beach or storm damage protection to structures landward of the beachfront. It is used as a means to measure other alternatives. If after the with project analysis a NED plan is not identified or it is proven that there is not a Federal interest in constructing a shore protection project than the no action plan would be the appropriate alternative.

<u>Structural Alternatives</u>.

A. Berm (Beach) Restoration. Berm restoration would be conducted along most of the oceanfront length of Long Beach Island, approximately 96,000 linear feet. The sand would be placed along the entire shoreline as needed to match a simplified design template of a 50-ft. berm (for the purposes of this report the berm is considered to extend 125 ft. from centerline of dune) at an elevation of +8.0 NAVD. Three preliminary sand sources are located at three different locations ranging from northern, mid-point and southern areas, approximately 1 to 3 miles offshore. An initial fill quantity of 3,282,000 cubic yards of sand is required. Periodic nourishment requirements are estimated at approximately 40% of the initial fill or approximately 1,300,000 cubic yards every three years.

B. Berm and Dune Restoration. This alternative is similar to the above beachfill with the inclusion of a dune having a top elevation of +20.0 ft. NAVD and a top width of 30 feet. The beachfill quantities used for cost estimating purposes we obtained using the typical sections and lengths mentioned above. Approximately 620,000 cubic yards of additional sand is required to match the working template. Therefore the estimated total quantity of sand required for the initial fill is 3,902,000 cubic yards. Lengths of placement and sand source location are the same as above. Typically three-year nourishment cycles are used provided erosion rates qualify this period, however, the relative stability of the Long Beach Island shoreline may allow longer periods between nourishment cycles. Cycle 3 will more accurately describe potential nourishment requirements, upon the completion of the groin field analysis and GENESIS model runs. Periodic nourishment is considered the same in this comparison.

C. Dune Restoration Only. Dunes provide buffer during storms and can provide aesthetic value but without protective berms, are susceptible to erosion and wave impact that shortens usefulness. Dimensions required to achieve acceptable level of protection would impact existing berm, creating negative recreational impacts, real estate impacts and social impacts. This alternative will not be considered in Cycle 3.

D. Berm and Dune Restoration with Structural Dune Reinforcement. This alternative is applicable to solving erosion problems within hot spots. The alternative is too expensive as an overall project design. If applying it to a reach of 54,000 linear feet, (which includes only BUNDY's with the highest damage potential) construction costs would increase in a range of $4.2 million to $45 million dollars depending upon the type of structural reinforcement: i.e. rubble mound, geotextile or bulkhead. However, for areas such as 38th street through 51st street in Brant Beach, Long Beach Township, complete erosion of the dunes occurs on an almost annual basis. Damage reduction potential may justify the use of structural dune reinforcement. This problem supports further evaluation for a more permanent dune structure. The Brant Beach area will receive further consideration for the structurally reinforced dunes alternative in the Plan Formulation Analysis, Cycle 3.

E. Groin Modification. Groin Modifications will be part of the Cycle 3 analysis. The with project conditions analysis will consider nourishment cycles upon the completion of the groin analysis and GENESIS model runs. Preliminary estimates for large size groin construction involve a 300 linear foot timber groin with a 150 linear foot stone end, and a slope from landward to seaward at + 10.ft. NAVD to 7.0 ft. NAVD. Annualized costs for construction are approximately $60,000. Depending upon the type of modification, costs for notching or lowering should be significantly less.

F. Submerged Reef Structures. This option could reduce wave impact on the most vulnerable areas of the shoreline, depending on placement. This concept was considered as a possible solution to the extreme erosions problems associated with Brant Beach, Long Beach Township, New Jersey. Upon further consideration, the breakwater alternative has many problems within this location: constructability, aesthetics, safety to swimmers and boaters and cost. Since construction of the breakwater must be done entirely from the water, all stone must be brought in on barges and all equipment used must be secured to jack-up barges. There is the additional difficulty of working in an open ocean environment. Additionally, this is a highly recreational area and would not be suitable for swimming and water craft activities. For these reasons the cost to construct an offshore breakwater would be quite high and therefore will not be considered in Cycle 3.

G. Hardened Structure Bulkhead Construction. Construct a timber bulkhead approximately 54,835 feet in length, which encompasses three different project reaches: BUNDY 3,4 and 5, 22,030 feet; BUNDY 9, 10 and 11, 24,899 feet; and BUNDY 13 and 14, 7916 feet. These reaches were chosen due to their high damage potential. The top elevation of this structure would be +10 feet NAVD to +14 feet NAVD to maintain at least a 3 feet exposure above the berm. A unit cost of $850 per linear foot was used and a contingency of 15% was added to the cost. Construction costs would be approximately $53,600,000.00. While a bulkhead provides erosion reduction landward of the structure, it is not as effective in reducing inundation damages. Additionally, some type of berm nourishment is necessary to increase the damage reduction effectiveness and to protect the integrity of the bulkhead itself. Much of the proposed bulkhead reach has well-established dunes. Construction would have a negative impact to the existing dunes.

The above bulkhead design provides damage reduction for 20 to 50 year storm events. Within the reaches used for this comparison average annual damages calculate at approximately $2,300,000.00. The costs for bulkhead construction at an average annual cost calculation are $4,030,000.00. Since the cost - benefit rationale is not appropriate, bulkheads will not be considered further in the formulation process. However, bulkheads may play an important role solving problems associated with area hot spots, therefore a low profile bulkhead used as a core of a dune will be part of Cycle 3 analysis.

H. Nearshore Berm. Dimensions of a feeder beach or feeder berm are generally governed by economic considerations involving comparisons of costs for different nourishment intervals. This alternative will be carried over into the Cycle 3 analysis, where it can be compared to the current effect of the groin field on sediment transport. Generally this approach relies upon littoral processes transporting material at one end of the problem area to the downdrift end. Since supplementary structures such as groins are needed to reduce the material movement longshore, this alternative may be economically justified.

The concept alternative may be further useful in combating the nearshore bathymetric features that are suspected of causing adverse impacts on nearshore wave conditions and resulting longshore transport patterns. The primary objective of this alternative is to reduce long term erosion with the secondary objective of reducing wave attack. However, during storm conditions wave attack reduction is minimal.

The alternative is more applicable as a consideration for nourishment methodology and optimization of the nourishment cycle. The area under consideration as a sand source has an accretion rate, which can produce from 80,000 to 150,000 cu yd per year. The areas that the sand recycle plant would nourish are BUNDY's 3 through 6. Costs for building the plant and operation will be compared against hydraulic dredge operations. A sand recycle plant would consist of a pump house with storage to hold the mobile dredging equipment. Pipes would be buried underground, extending 15,000 to 25,000 linear feet and end at port areas. During pumping periods above ground pipe would be installed in areas to receive fill material. The Recycle Plant may not exist as a plant at all, but as a method of operation. Once the fixed parts are in place the operation could work as a contract effort supervised by the Corps or the non-Federal sponsor.

I. Sand Recycle Plant. The concept alternative was still being developed in Cycle 2 and carried forward to Cycle 3. See explanation under that section.

TABLE4-2
BARNEGAT INLET TO LITTLE EGG INLET
CYCLE 2 - SCREENING RESULTS

Alternative	Preliminary Design Consideration	Environmental Considerations	Social Considerations	Preliminary Annualized Costs (000's)	Approx. W/out annual Damages (000's)	Further Analysis Cycle 3?	Remarks
A. Berm (Beach) Restoration	Fill existing berm out to 125 ft. from centerline of dune at +8 ft NAVD elevation, with nearshore slope at 1V:10H to MLW -1.7 ft. NAVD Map 1.	Destroys benthic habitat in borrow area. Can increase nesting and beach habitat and enhance backshore environment.	Provide usable beach area.	slightly < than $4,000*	$10,000*	Yes	Nourishment Interval may increase without dune sand in system costs may increase; impacts can be minimized through coordination with environmental agencies.
B. Berm and Dune Restoration	Same berm configuration as above with Dune: 30 ft. width at Crest el. +20.0 ft. NAVD; seaward slope 1V:5H	Destroys benthic habitat in borrow area. Can increase nesting and beach habitat and enhance backshore environment. Greater dune design height may necessitate covering the existing dune grasses.	Provide usable beach area. Dunes may cause some inconveniences to residents.	$4,000*	$10,000*	Yes	Adverse environmental impacts can be minimized through coordination with environmental agencies.
D. Berm and Dune Restoration with structural dune reinforcement	Same berm and dune restoration plan as above with utilizing structural reinforcement products in some areas.	Same as berm and dune restoration.	Same as berm and dune restoration.	Geotextile tube costs $100 per l.f. a typical dimension of 30 ft circum. was used	$10,000	Yes	Focus will apply to Brant Beach and other highly erodible dune areas.
F. Groin Field Modifications	Same as berm and dune restoration with the notching elevating, shortening, lengthening.…	Same as berm and dune restoration although some construction may occur in submerged lands.	Same as berm and dune restoration. Removal of groins.	slightly > than $4,000*	$10,000*	Yes	Costs must be offset by reduced periodic nourishment requirements and reduction in the long term erosion rate, modifications are done in combination with berm/dune.

TABLE 4-2 (continue)
BARNEGAT INLET TO LITTLE EGG INLET
CYCLE 2 - SCREENING RESULTS

Alternative	Preliminary Design Consideration	Environmental Considerations	Social Considerations	Preliminary Annualized Costs (000's)	Approx. W/out annual Damages (000's)	Further Analysis Cycle 3?	Remarks
H. Submerged Reef Structures.	Sunken Barges, Interlocking Concrete units, Breakwaters International	Can smother organisms and kill organisms in footprint of structure. Can provide habitat for marine organisms.	Aesthetic and safety problems for swimmers, boaters.	$ greater than $100 per linear foot (lf)	$10,000	No	Beach Restoration on a large-scale project is generally more efficient and less costly.
L. Nearshore Berm	Similar to berm design only placed in nearshore and allowing for longshore transport	Same as berm and groin alternatives	Same as berm and groin alternatives	$unknown	$10,000	Yes	Costs difficult to determine, governed by dimensions involving comparison of renourishment cycle; will be completed in Cycle 3.
M. Sand Recycle Plant At Barnegat Light	Partial. Savings from less periodic nourishment must offset costs through traditional methods. Plant design will back pass sand from area of active sedimentation. Placement could be difficult as wetlands have developed and habitat may be critical for piping plover. Limited by off-season operation periods and cost effectiveness for specific pumping distances.	Temporary disturbance or turbidity of water column; temporary loss to piping plover habitat with reduction of berm size, although recovery expected in full within a year.	Aesthetic pump house must be situated near dune and berm area. Noise levels when pumping can be disturbing to humans and wildlife.	Annualized over 50 period study for comparison to 3-yr. nourishment cycle. Cost is 1 mil to bury pipe and 1.5 mil to run every yr. About $5 cu. Yd.	N/A using for optimizing nourishment	Yes	This alternative more viable as an alternative methodology for nourishment cycle. Environmental impacts can be reduced by pumping at non-nesting periods and with coordination with F&WS.

Nourishment interval quantities are based on a weighted percentage from the Reconnaissance Study. Approximate total damages will be refined in Cycle 3 to include additional damage categories (local costs forgone) resulting in higher annual damages.

TABLE 4-3

BARNEGAT INLET TO LITTLE EGG INLET

LISTING OF HOT SPOTS AND PROBLEM TYPES

Problem Area: Specific Hot Spots	Problem Type	Frequency	Solution or Alternative	Technical Feasibility or Appropriateness
Ship Bottom	No. Easterly storms erode dune to street a	only occasionally intensity of storm, with recovery 2-3 mos. after event	bulkhead, berm with dune, dune only, hardened dune,	Problem area does not have significant damages to warrant further focused analysis
Surf City	12th St. Severe Erosion occurred breachin	Once in 1994 after NE storm event	same as above	Problem area has minimal occurrence ove does not warrant detailed analysis
Brant Beach, Long Beach Township	38th street through 51st street, heavy dune of property	almost yearly	hardened dune structure, offshore breakwater	Hardened dune structure to be analyzed and compared to Berm and Dune Restoration Alternative.
Holyoke Ave. Groin, Beach Haven Towns	Groin is preventing transport of sand southward, groin is too high and or too long	ongoing deterioration of dune and berm south of groin	notch groin, lower groin, bulkhead, dune c combination with other structure alternativ	Groin analysis will focus on this hot spot. More appropriate to study in PED phase to consider groin modifications to reduce nourishment cycle quantities

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4.7 CYCLE 3 PLAN FORMULATION.

The Cycle 1 and Cycle 2 Plan Formulation screening process eliminated many of the alternative measures considered. The solutions recommended for further study in Cycle 3 are listed below. In Cycle 3, designs were formulated and ultimately optimized to develop the NED plan and selected plan for Long Beach Island.

The alternatives evaluated in plan formulation were:

Berm Restoration

Berm and Dune Restoration

Berm and Dune Restoration with Structural Reinforced Dunes at Brant Beach, Long Beach Township, NJ

Groin Field Modifications in combination with Berm and Dune Restoration

Nearshore Feeder Berm

Sand Recycle Plant

Planning Principles Used: Policy Digest 89, ER 1105-2-100, NED Manual, Water Resources Council, "Economic and Environmental Principals and Guidelines for Water and Related Land Resources Implementation studies," 10 March 1983; Policy and Planning Guidance 28 Dec 1990; CECW-A, No. 1165-2-203, Technical and Policy Compliance Review

Description of Plan Formulation Leading to Selected Plan: Cycle 3 Analysis

Objectives for carrying out the Cycle 3 analysis involved; a) identifying high damage BUNDY's, b) developing potential project reaches or limits of construction, c) limiting the number of model runs by combining or eliminating BUNDY's and, d) further reducing Cycle 3 alternatives.

The study team developed a graph to interpret BUNDY characteristics as depicted in **Table 4-4** and **Figure 4-1**. This allowed an easier approach for assessing the BUNDY's together. Normalizing damages at dollars/linear feet provided a more accurate depiction of low, medium and higher damaged areas. Incorporated into the graph were average dune widths and heights and berm width and heights for each BUNDY. Finally, the annualized erosion rate was applied to determine the future berm width (or future long-term erosion) for each BUNDY.

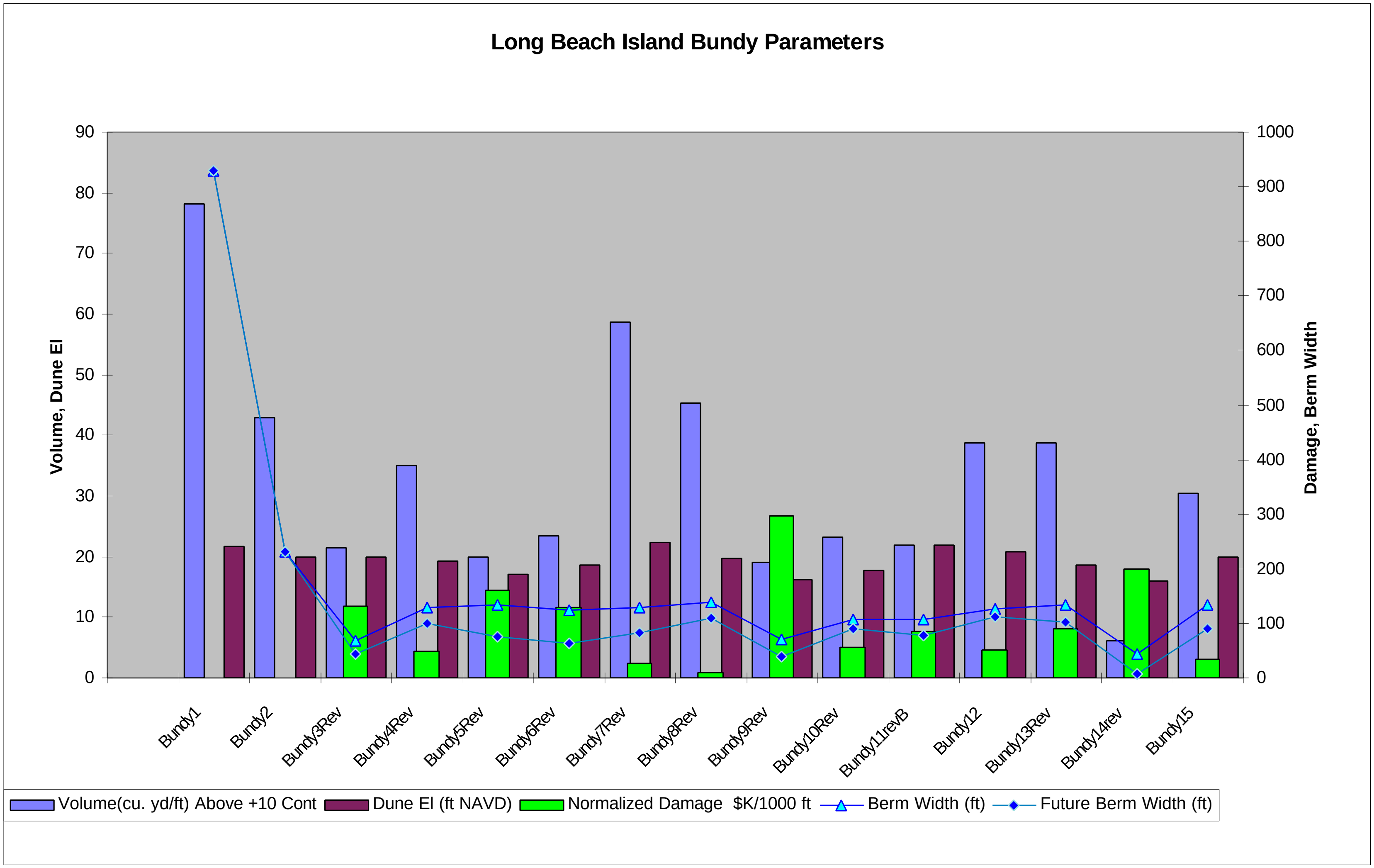
Given the 18-mile study area and the multitude of variables taken into consideration in developing damage assessment, it was important to maintain manageable reaches for evaluation. Eliminating BUNDY's based on no and low damages was the next step ((example, BUNDY 1 and BUNDY 2 no damages; BUNDY 7, BUNDY 8, BUNDY 15 lowest damages)).

Table 4-4

Overview of BUNDY Categories Depicting Dune, Berm and Erosion Averages based on Accumulated Survey Profiles

Profile	Volume(cu. yd/ft) Above +10 Cont	Dune El (ft NAVD)	Berm Width (ft)	Future Berm Width (ft)	Normalized Damage $K/1000 ft
1 Bundy1	**78.27**	**21.60**	**930.00**	**930.00**	**0.00**
2 Bundy2	**43.01**	**19.90**	**230.00**	**230.00**	**0.47**
3 Bundy3Rev	**21.57**	**20.00**	**67.00**	**44.50**	**132.18**
4 Bundy4Rev	**35.13**	**19.20**	**129.00**	**99.00**	**47.87**
5 Bundy5Rev	**19.85**	**17.00**	**135.00**	**75.00**	**159.96**
6 Bundy6Rev	**23.36**	**18.60**	**124.00**	**64.00**	**128.07**
7 Bundy7Rev	**58.69**	**22.40**	**128.00**	**83.00**	**27.86**
8 Bundy8Rev	**45.39**	**19.60**	**139.00**	**109.00**	**9.84**
9 Bundy9Rev	**19.04**	**16.30**	**70.00**	**40.00**	**296.91**
10 Bundy10Rev	**23.16**	**17.80**	**106.00**	**91.00**	**55.55**
11 Bundy11revB	**21.94**	**22.00**	**107.00**	**77.00**	**85.43**
12 Bundy12	**38.69**	**20.90**	**127.00**	**112.00**	**52.20**
13 Bundy13Rev	**38.80**	**18.70**	**133.00**	**103.00**	**90.53**
14 Bundy14rev	**6.10**	**16.00**	**45.00**	**7.50**	**199.94**
15 Bundy15	**30.54**	**20.00**	**134.00**	**89.00**	**34.61**
Bundy's 3 thru 15 Avg	29.40	19.12	111.08	76.46	101.61
Std	13.71	2.01	30.86	30.56	81.16
Min	6.10	16.00	45.00	7.50	9.84
Max	58.69	22.40	139.00	112.00	296.91

Figure 4-2


Long Beach Island Bundy Parameters
Volume, Dune El
Damage, Berm Width
90
80
70
60
50
40
30
20
10
0
1000
900
800
700
600
500
400
300
200
100
0
Bundy1
Bundy2
Bundy3Rev
Bundy4Rev
Bundy5Rev
Bundy6Rev
Bundy7Rev
Bundy8Rev
Bundy9Rev
Bundy10Rev
Bundy11revB
Bundy12
Bundy13Rev
Bundy14rev
Bundy15
Volume(cu. yd/ft) Above +10 Cont
Dune El (ft NAVD)
Normalized Damage $K/1000 ft
Berm Width (ft)
Future Berm Width (ft)

Initial plan formulation sought to create a project area with separate project reaches based on combining high damage BUNDY's. With elimination of BUNDY's 7 and 8 due to their lower damages, a natural break in project reaches was created, north and south of BUNDY's 7 and 8.

A two-reach project area contains lower damage reaches surrounded by higher damage reaches that potentially can maintain positive NED benefits. After analyzing the potential effects of long-term erosion, the groins, and the segmented political boundaries of Long Beach Township, a different approach was realized. In considering the effects of long term erosion most of the BUNDY's will require nourishment within the 50 year period of analysis use for the study. LBI is unique in that it has over 99 groin structures along the coastline. These groins play an important role in longshore sediment transport and further complicate locating separable project reaches boundaries. Additionally, the political boundaries create a potential for the Federal project to be unequal in its protection for similarly cost shared communities. Therefore with the exception of Barnegat Light (BUNDY 1), and a portion of Long Beach Township (BUNDY 2) all remaining BUNDY's were included in the plan alternatives analysis.

Matrix for Model Runs

In order to develop a bracket of plan alternatives, an analysis of the low damage potential areas was performed. One question the analyses sought to answer was: Why were certain areas better protected than others? The without project model runs confirmed what the field studies indicated, that is, certain berm and dune configurations presently are working to limit damages. The existing median berm and dune sizes are dune widths of 29.0 ft.; dune elevations of 19.0 ft. NAVD; and average berm widths of 111.0 feet. After factoring in long-term erosion, berm width averages decrease to 76.0 feet. Areas such as BUNDY 4 and BUNDY 8 have lower damages due to their substantial dune and berm profiles. BUNDY's 4 and 8 have slightly above average wide dunes (35 ft. to 50 ft.) with dune heights of 19-ft. to 22-ft. NAVD and berm widths of 100-ft. to 125-ft. Based on the analyses of the existing conditions the following six plan alternatives were considered under the with project scenario:

Alternative 1: 20 ft. dune, 125 ft. berm
Alternative 2: 20 ft. dune, 150 ft. berm
Alternative 3: 20 ft. dune, 175 ft. berm
Alternative 4: 22 ft. dune, 125 ft. berm
Alternative 5: 22 ft. dune, 150 ft. berm
Alternative 6: 22 ft. dune, 175 ft. berm

4.8 CYCLE THREE REFINEMENT OF ALTERNATIVES

A. Berm and Dune Restoration with Structural Reinforced Dunes at Brant Beach, Long Beach Township, NJ.

Combination alternatives existing of Berm and Dune Restoration with structural dune reinforcement apply only to a few hot spot areas within the overall beachfill plan. This alternative will be optimized separately during Cycle 3. For example, BUNDY 9 covers the highly eroded reach of Brant Beach, Long Beach Township, NJ. The inclusion of a bulkhead alternative is appropriate for this reach only. It necessitates alteration of the SBEACH model. A bulkhead generally will decrease some inundation and erosion landward of the bulkhead. Comparisons between net benefits and costs will indicate if the alternative is a NED plan.

B. Groin Modifications. During plan formulation it became evident that present day models do not effectively model the potential response to the impact of notching a groin. GENESIS modeling allows for altering the permeability ranking of a groin structure but it does not produce the level of detail needed to determine at what height or width a groin would need to be notched to produce the desired degree of sand transport. Specific to this study, the Philadelphia District is developing a model to analyze the effectiveness of lengthening or shortening groin structures.

The team realized that groin modifications done in combination with berm and dune restoration is more applicable as an alternative for optimizing the nourishment quantities. During the PED phase the District will evaluate appropriate hot spots where it is believed groin modifications are needed to increase sediment transport in groin compartments which are starved for sand, or have higher erosion rates.

During the initial analysis the Hydrology and Hydraulics Branch established a routine for analyzing the effects of shortening or lengthening a groin structure. The routine was applied as part of optimizing the selected plan, specifically the nourishment component. Holyoke Groin was selected as a test case. Justification for shortening a groin is determined based on the reduction of sand quantities needed for the nourishment cycle. For example, consider that shortening a groin costs $250,000.00 and increases sediment into subsequent groin compartments by 50,000 cu yd./yr. Hydraulic nourishment of the same affected area requires 75,000 cu yd./yr., at a cost of ($5.50/cu yd) $375,000.00. By reducing the groins length (as done in the Holyoke test), the required nourishment rates decrease to 25,000 cu yd/yr. The cost for hydraulic nourishment for this section then becomes $125,000.00. If you take the original cost for the groin length reduction, plus the costs for the reduced nourishment volumes, you get an amount for comparing against other nourishment alternatives. In this sample case, it appears that the cost for shortening the groin is offset by the reduced cost for nourishment within the groin compartments affected by the construction.

The methodology for the approach discussed above is still undergoing modifications. Use of this tool will assist nourishment optimization during the PED phase of the study. Notching of groins is another modification approach. Notching of groins continues to gain preference among local communities as a way to solve erosion problems within groin compartments. The groin and beach interaction is complex and involves more than 20 variables (Hanson, H. and Kraus, N.C. 1996. Shoreline Change w/ Longshore Sand Waves at a Groin Field. Proceedings 25th Coastal Eng. Conf., ASCE 4024-4037). Presently, processes exerting control on the functioning of notched groins are not included in engineering guidance or in numerical models such as GENESIS (Modern Functional Design of Groins. Proc. 24th Coastal Eng. Conf., ASCE, 1994, 1327-1342). Yet notching groins is a viable alternative towards reducing nourishment needs within groin compartments.

The District began a 9-month long analysis project in cooperation with the New York District, The US Corps of Engineers Waterways Experiment Station (WES) and the Stevens Institute of Technology in developing guidelines for notching groins. This research effort will be specific to ongoing Corps Feasibility Studies. The results of the research effort will not be available to include as part of recommendations for the feasibility study. The district is recommending that the results of the research be included in the PED phase of the project

C. **Nearshore Berm Alternative.** The nearshore berm or, sometimes referred to as the submerged feeder berm, is designed to provide increased shoreline stabilization. The impact the nearshore berm has on larger waves is a function of its placement from the shoreline. It impacts selected features, such as wave climate; larger waves with larger wave periods as opposed to lower period waves with hire frequencies. The public's perception of this alternative is that sand is wasted in the ocean rather than direct placement of the beach. In fact, direct placement on the beach is less risky. The primary benefit of this alternative is sediment transport as it relates to nourishment impacts. Secondary benefits are wave reduction. Therefore it is a less economic alternative compared to direct placement of beachfill, as it will not provide as much protection. The alternative is less visually pleasing than direct onshore placement and does not provide as many recreational benefits. Additionally there are regulatory restrictions regarding placing fill in the nearshore area.

Currently through a contract with WES, the District is analyzing the impact to the shoreline from dredging borrow areas (offshore berm-like features) within the project area. The offshore features may or may not be responsible for the development of hot spots along the island. Many of these offshore features extend from south to northeast. Once the effects of removing these features can be analyzed, determining the effectiveness of adding a nearshore berm can more easily be accomplished.

The alternative may be used as a mitigation measure for removal of similar features. This alternative will be studied in greater detail upon completion of the WES borrow area impact contract. Details of that report will be included in the final Feasibility Study report. **The draft report can be found in Volume 2 Appendix A at the end of the Hydraulic Analysis section.** Additionally, the district can detail the appropriateness as a nourishment alternative, the degree of risk and the potential as a mitigation measure in the PED phase, where it can be compared to the effect of groin field modifications on sediment transport.

D. **Sand Recycle Plan Alternative.** An estimate was prepared based on the permanent in-place features for this alternative including, 20,000 linear feet of pipe and a pavement like structure which would hold the portable pumping station. The second part of the estimate is based on using a contractor to bring in portable equipment for each recycling phase. A cost of $1 million for the permanent features and $1.5 million for each contract effort was used to compare against hydraulic dredging. Again, this alternative is more appropriate for optimizing the renourishment component of the project. Initial comparisons of costs indicate that the sand recycle system cubic yard cost is approximately $5, while offshore dredging is approximately $4.70. The alternative may provide a means for mitigating for the effects of dredging offshore borrow areas. It will be carried forward in optimizing the nourishment cycle costs as part of the PED phase of the study.

The remaining alternatives for the oceanfront consist of a berm and/or dune restoration. Optimization of beachfill design parameters was the next step in the Cycle 3 process. Modeling various beachfill configurations provided insight as to the performance of the design parameters. Groin features were evaluated afterwards, based on that insight.

4.9 DESIGN PARAMETERS.

In Cycle 3, the beach nourishment alternative required optimization of the design parameters. In developing these parameters the Shore Protection Manual, Coastal Engineering Tech Notes (CETN), the existing conditions in the study area and accepted coastal engineering practices were reviewed. Listed below are the boundary condition utilized to construct a logical methodology to efficiently identify the optimum plan. (**Figure 5-31** shows a typical cross section. See section 5.1.)

Berm Elevation. Tides, waves, and beach slope determine the natural berm elevation. If the nourished berm is too high, scarping may occur, if too low, ponding of water and temporary flooding may occur when a ridge forms at the seaward edge. Design berm heights for each alternative have an elevation set at the natural berm crest elevation as determined by historical profiles. The existing berm elevations in the study area vary between + 6.3 ft NAVD and + 9.3 ft NAVD. The average berm elevation is 7.75 ft NAVD. It was determined that a constructable template which closely matches the prevailing natural berm height in the study area is + 8.0 ft. NAVD. This elevation was used for all designs.

Beachfill Slope. The slope of the design berm is based on historical profiles and the average slope of the berm, both onshore and offshore. The foreshore slope for all alternatives was set as 30H: 1 V down to the mean low water elevation. The slope design is typical of many Corps shore protection designs, patterned after designs by Joseph M. Caldwell, a USACE engineer. The “Caldwell Section” was used to design protection of coasts based on results of experiments performed in response to the March 1962 northeaster that devastated much of the East Coast shorefront areas. Below the mean low water line the slope follows that of the existing profile to the point where the design berm meets the existing profile.

Berm Width. An interval between successive berm widths was chosen for modeling purposes. This interval is set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan can not be accurately determined. Additionally, due to the capability of the storm modeling methodology and effectiveness of the existing condition parameters, a 25-ft. interval achieved the desired accuracy. The largest design berm width is based on an analysis of existing beach profile and determining where berm distance quantities increased faster than additional benefits captured. Based on the Cycle 3 analysis, the largest berm width considered was 175 ft. The smallest berm width was determined in a similar manner, by analyzing benefits captured with minimum dimensions.

Design Baseline. All berm widths are referenced from a design baseline, which was established along the ocean frontage of the project study area in order to determine the alignment of the proposed beach restoration alternatives.

Dune Heights. The lowest design dune height evaluated was sufficiently above the height of the berm and existing protective structures in order to provide for additional storm damage protection, principally reducing inundation damages. Dune heights along the oceanfront of LBI average 19 ft. NAVD. Therefore the minimal dune height evaluated was 20 ft. NAVD. Additionally a NAVD 22 ft. and 24 ft dune height were considered with the latter dropped as initial calculations for the additional sand quantities did not capture additional storm damage reduction benefits. The height of +20 ft. and +22 ft. NAVD are the most appropriate to capture significant benefits within this study area.

Dune Shape and Alignment. Dune top widths of 25 ft. and 30 ft. were evaluated as alternatives. Since most dunes are already 25 ft. wide, only the 30-ft. alternative was uses. Side slopes were set at 5H: 1V, which was determined to be the optimum condition base on native sand grain size, and the grain size of sand to be obtained from offshore borrow areas. The landward toe of the proposed dune system was offset from 10-ft. to 20-ft. seaward from the design baseline to allow for construction and maintenance.

Design Beachfill Quantities. Quantities for each alternative were calculated by superimposing the proposed design templates on the existing beach survey cross sections. Average end area methods were used to compute the volumes.

Nourishment Volumes. In order to maintain a minimum design profile, and advanced nourishment or maintenance volume is added to the initial quantity. Without nourishment of beaches on a periodic basis, the design profile would begin to erode. Therefore, an advanced nourishment fill is placed in addition to the design beachfill at the time of initial construction. The nourishment volume is considered sacrificial and protects the design beachfill, and at the end of the periodic nourishment cycle, the design profile remains. For Cycle 3, the nourishment period was taken to be three years. The final nourishment quantities were increased by an overfill factor of a range of 1.05 to 1.60 depending on the grain size. Initial design volumes were determined by adding the advanced nourishment volumes and the design volumes obtained from the survey cross sections.

Matrix of Design Parameters. Based on the design parameters discussed above, 6 combinations of berm widths and dune heights were generated. Several other berm and dune alternatives were easily identified as non-constructable given the footprint requirements of the varying dune options, the toe protection required for dune stability, real estate impacts and the limited sand quantities available.

As the modeling proceeded, it became evident that the “no dune” alternatives provided virtually no inundation benefits. This was important along the entire project area. Inundation was sensitive to dune height and erosion was sensitive to berm width. To a small degree, berm width affected the total storm stage due to the berm’s ability to break the waves further offshore. Both dune and berm affected wave attack.

4.10 ANALYSIS OF 6 PLAN ALTERNATIVES

With the completion of the SBEACH runs, control files were created and a scaled down economic analysis performed. One BUNDY was chosen to test the validity of the plan alternatives. BUNDY 9 had the highest without project damages. It was reasoned that if the highest damaged BUNDY could not yield a positive BCR, Federal interest in pursuing this study further would be reduced. Running models for one BUNDY saved time and simplified determining the proper bracketing for selecting the optimal plan. Infrastructure damages were not part of the analysis, only the initial costs for dredging sand. Initially the results from BUNDY 9 indicated the lesser-sized berm and dune alternatives were more cost effective, alternatives 1 and 2. A detailed analysis was also conducted, which included infrastructure and private land erosion, to determine how it affects alternate plan selection. **Table 4-5** summarizes the damages and damage reduction benefits for the alternatives. It also displays the impact of adding infrastructure and private cost of fill for homeowners. (A complete listing of tables exists in the Economic Appendix, B of Volume 2 for this study.) At this point alternative 1, the 125-foot berm with a 20-foot dune height, had the most potential for the optimal plan.

An additional step was taken to determine the initial cost and nourishment cost for 3, 5, 7 year nourishment cycle. Table 26 in the Economic Appendix (B), Volume 2, shows a sample table for a 125-ft. berm, 22-ft. dune, with a three-year cycle. **Table 4-6** summarizes BUNDY 9 annualized benefits and annualized costs for the six dune and berm alternatives. This precursory analysis indicated that there was a federal interest in pursuing this analysis on a more detailed scale as benefit cost ratios (BCR's) for all the alternatives were favorable.

h:\LBIOPT1.WB1/bundy9

TABLE 4-5

SECTION 9 ANALYSIS FOR ALL ALTERNATIVES

INCLUDES INFRASTRUCTURE AND PRIVATE LAND EROSION (values in $000)

WITHOUT	ALT 1		ALT 2		ALT 3		ALT 4		ALT 5		ALT 6	
PROJECT DAMAGE	with project damage	damage reduced	damage	damage reduced	damage	damage reduced	damage	damage reduced	damage	damage reduced	damage	damage reduced
STRUCTURE												
1824	133	**1691**	101	**1723**	67	**1757**	117	**1707**	98	**1726**	65	**1759**
INFRASTRUCTURE												
79	10	69	4	75	2	77	9	70	3	76	2	77
FILL												
348	44	304	33	315	22	326	30	318	28	320	21	327
Total	-		-		-		-		-		-	
2251	187	**2064**	138	**2113**	91	**2160**	156	**2095**	129	**2122**	88	**2163**
Difference in benefits due to infrastructure and fill in dollars.		**373**		**390**		**403**		**388**		**396**		**404**

Marginal Increase with Dune fixed, berm vary		20 ft. dune		22 ft. dune.	
		(ALT2 vs. ALT 1) Increase in damages reduced.	(ALT3 vs. ALT 2) Increase in damages reduced.	(ALT5 vs. ALT4) Increase in damages reduced.	(ALT6 vs. ALT5) Increase in damages reduced.
Infrastructure		6	2	6	1
cost of fill (private land erosion)		11	11	2	7
Values in $ 000	**total**	**17**	**13**	**8**	**8**

	(ALT4 vs. ALT1)	(ALT5 vs. ALT2)	(ALT6 vs. ALT3)
Marginal Increase with Berm fixed, dune varv	125' BERM	150' BERM	175' BERM
Infrastructure	1	1	0
cost of fill (private land erosion)	14	5	1
total	**15**	**6**	**1**

Alternative	Dune height	Berm width
ALT 1	20 ft dune	125 ft
ALT 2	20 ft dune	150 ft
ALT 3	20 ft dune	175 ft
ALT 4	22 ft dune	125 ft
ALT 6	22 ft dune	175 ft

TABLE 4-6

BUNDY 9 ANALYSIS SUMMARY BCR

	ALT 1 125 FT. BERM 20 FT. DUNE			ALT 4 125 FT. BERM 22 FT. DUNE		
CYCLE		PLAN BCR	NET BENEFITS		PLAN BCR	NET BENEFITS
BENEFITS:	$2,064,000			$2,095,000		
3 YR.	$315,300	6.55	$1,748,700	$368,800	5.68	$1,726,200
5 YR.	$315,600	6.54	$1,748,400	$369,500	5.67	$1,725,500
7 YR.	$344,200	6.00	$1,719,800	$393,600	5.32	$1,701,400
	ALT. 2 150 FT. BERM 20 FT. DUNE			ALT. 5 150 FT. BERM 22 FT. DUNE		
BENEFITS:	$2,113,000			$2,122,000		
3 YR.	$585,900	3.61	$1,527,100	$643,000	3.30	$1,479,000
5 YR.	$568,100	3.72	$1,544,900	$618,900	3.43	$1,503,100
7 YR.	$597,000	3.54	$1,516,000	$642,700	3.30	$1,479,300
	ALT 3 175 FT. BERM 20 FT. DUNE			ALT. 6 175 FT. BERM 22 FT. DUNE		
BENEFITS:	$2,160,000			$2,163,000		
3 YR.	$807,800	2.67	$1,352,200	$853,200	2.54	$1,309,800
5 YR.	$806,400	2.68	$1,353,600	$849,900	2.55	$1,313,100
7 YR.	$812,200	2.66	$1,347,800	$853,200	2.54	$1,309,800

Secondary Screening The analysis for Bundy 9 included the benefits attributed to infrastructure and private land erosion. This analysis revealed that the benefits derived for these two categories increase marginally between plans (as displayed in **Table 4-5**) and would not impact the selection for plan candidates for this stage of the analysis. In the second iteration alternatives were analyzed to filter plans in determining the optimal plan. With the completion of calculating nourishment rates for each BUNDY, a stratified sample of the study area was chosen for additional economic analysis. Six BUNDY's, 3, 6, 7, 9, 11 and 14, were chosen to represent without project high, medium and low damage areas. The BUNDY's were analyzed to determine the with-project damages and damage reduced for the structure database. They also served to validate the decision to maintain a one-project reach study plan. **Table 4-7** displays the damage reduction for each of the alternatives for the secondary screening. Upon further reduction of plan alternatives, infrastructure and cost of fill for private land erosion were computed for remaining alternatives, which occurred, in later iterations.

First cost and nourishment was computed for the same sample areas. Dune grass and dune fencing was included in this phase of the analysis. **Table 4-8** shows a sample for the first cost of a 125-ft. berm, 22-ft. dune, and a seven-year nourishment cycle. **Table 4-9** summarizes the annualized benefits, annualized costs, benefit to cost ratios for the above alternatives and the 3, 5, 7 and 10 year nourishment cycles. This analysis eliminated the 175-ft. berm, 20-ft. and 22-ft. dune alternatives (3 and 6) due to negative or low benefits. The 10-year nourishment cycle also was eliminated based on increased costs and high risk and uncertainty associated with renourishment cycles 10-years a part. The 150-ft. berm and 125-ft. berm plans all had positive net benefits, however, the 125-ft. berm, 20-ft. dune and 22-ft. (Alternatives 1 and 4) had the highest ranges, inclusively for all nourishment cycles. At this level of detail, the alternatives produced over a million dollars per annum. Final iterations and optimization were then applied only to alternatives 1 and 4 using 3, 5 and 7 year nourishment cycles to further bracket the selected plan. The higher level of detail analysis combined all BUNDY's and included the benefit categories of infrastructure and private land erosion.

As shown in Table 4-9, a new alternative (Alternative 4), the 125-foot berm with 22-foot NAVD dune elevation, became the potential selected plan. The benefits derived from the nourishment cycles worked in conjunction with the increased dune elevation to produce higher net benefits for this alternative. In iteration one (the BUNDY 9 analysis discussed previously) benefits from long term nourishment were not reflected. For this particular reach the erosion rate was only –1 foot a year, therefore nourishment became less of a factor towards affecting the modeled alternatives. Comparatively, when more BUNDY's were introduced into the analysis, BUNDY's with lower without project damages but high long term erosion rates affected the BCR ratio of the alternatives. Throughout the process the team honed the data inputs to produce the most realistic results, this included revisions to nourishment rate factors and initial fill quantities. Results using the new initial quantities comparing only the 125-foot berm alternatives using 20-foot and 22-foot high dunes and nourishment cycles of only 3,5 and 7 year comparisons confirmed previous iterations.

An analysis of a 24-ft.dune width, 125-ft. berm alternative was modeled. The analysis used interpolation of given data. The benefits for the 125-ft. berm, 24-ft.dune are estimated as follows. The percentage in damage reduction from the 20-ft. dune to 22-ft.dune has a 6% increase. Applying that increment to the 24-ft.dune alternative results in an expected damage reduction of 91% plus 6% equaling 97% in damage reduction benefits. The 97% damage reduction is unlikely, but for the purpose of this exercise it produced the upper limit of damage reduction for all alternatives considered. The results of the analyses are depicted in **Table 4-10**. Since the net benefits and benefits to cost ratio is less than the other alternatives the 24' NAVD dune alternative was removed from future consideration.

The results of the initial model runs indicated that berm widths in excess of 150 feet would result in exceptionally higher quantities without a commensurate increase in the performance of reducing the storm impacts. A similar conclusion was reached with dune heights in **excess** of +24.0 feet-NAVD. For this reason, alternatives, which included either a 150-foot berm or +24.0 foot-NAVD dune, were not modeled or dropped from further analysis.

As more alternatives were modeled and net benefits calculated, performance trends became evident. These trends helped to identify which alternatives would produce the highest net benefits and, thereby, optimize the design. **Table 4-11** summarizes the full matrix of initial alternatives and the final results of the iterative modeling process described above.

TABLE 4-7

Long Beach Island Initial Optimization for Six Plan Alternatives

BUNDY'S 3,6,7,8,11, and 14

	WITHOUT PROJECT DAMAGE	ALT 1	damage reduced	ALT 2 damage	Damage Reduced	ALT 3 damage	Damage Reduced	ALT 4 damage	damage reduced	ALT 5 damage	damage reduced	ALT 6	damage
3	615	104	**511**	51	**564**	39	**576**	57	**558**	44	**571**	34	**581**
6	1027	445	**582**	260	**767**	155	**872**	291	**736**	196	**831**	155	**872**
7	87	32	**55**	25	**62**	11	**76**	32	**55**	25	**62**	11	**76**
9	1824	133	**1691**	101	**1723**	67	**1757**	117	**1707**	98	**1726**	65	**1759**
11	417	81	**336**	41	**376**	29	**388**	58	**359**	36	**381**	29	**388**
14	487	30	**457**	18	**469**	9	**478**	16	**471**	11	**476**	7	**480**
	T		**3,632**		**3,961**		**4,147**		**3,886**		**4,047**		**4,156**

	(ft)		(ft)	
ALT 1	20	dune	125	Berm
ALT 2	20	dune	150	Berm
ALT 3	20	dune	175	Berm
ALT 4	22	dune	125	Berm
ALT 5	22	dune	150	Berm
ALT 6	22	dune	175	Berm

OPTIMIZE

TABLE 4-8

FIRST COST AND NOURISHMENT
INITIAL CONSTRUCTION AND 7 YEAR CYCLE
(SELECTED BUNDY'S 3,6,7,9,11, AND 14)

125' Berm with 22 FT. Dune

	DISCOUNT RATE =	7.125%		PRESENT
YEAR	CYCLE		PW	
0	22,567,180		1.000000000	22,567,180
1	0		0.933488915	0
2	0		0.871401554	0
3	0		0.813443691	0
4	0		0.759340668	0
5	0		0.708836097	0
6	0		0.661690639	0
7	7,075,354		0.617680876	4,370,311
8	0		0.576598251	0
9	0		0.538248075	0
10	0		0.502448612	0
11	0		0.469030209	0
12	0		0.437834501	0
13	0		0.408713653	0
14	7,075,354		0.381529665	2,699,457
15	0		0.356153713	0
16	0		0.332465543	0
17	0		0.310352899	0
18	0		0.289710991	0
19	0		0.270441998	0
20	0		0.252454608	0
21	7,075,354		0.235663578	1,667,403
22	0		0.219989337	0
23	0		0.205357608	0
24	0		0.191699050	0
25	0		0.178948939	0
26	0		0.167046850	0
27	0		0.155936383	0
28	7,075,354		0.145564885	1,029,923
29	0		0.135883207	0
30	0		0.126845467	0
31	0		0.118408837	0
32	0		0.110533337	0
33	0		0.103181645	0
34	0		0.096318922	0
35	7,075,354		0.089912646	636,164
36	0		0.083932458	0
37	0		0.078350019	0
38	0		0.073138874	0
39	0		0.068274329	0
40	0		0.063733329	0
41	0		0.059494356	0
42	7,075,354		0.055537322	392,946
43	0		0.051843474	0
44	0		0.048395309	0
45	0		0.045176484	0
46	0		0.042171747	0
47	0		0.039366858	0
48	0		0.036748526	0
49	7,075,354		0.034304342	242,715
50	0		0.032022723	0
	TOTAL PRESENT		**33,606,100**	

CAPITAL RECOVERY FACTOR (50 YEARS @ 7. 125 %.)0.0736071
AVERAGE ANNUAL FOREGONE COST (ROUNDED) $2,473,600

TABLE 4-9

INITIAL COST AND NOURISHMENT CYLCE
SUMMARY BCR
BUNDY's 3,6,7,9,11 and 14

	ALT 1 125 FT. BERM 20 FT. DUNE			ALT 4 125 FT. BERM 22 FT. DUNE		
CYCLE		PLAN BCR	NET BENEFITS		PLAN BCR	NET BENEFITS
BENEFITS:	$3,632,000			$3,886,000		
3 YR.	$2,594,700	1.40	$1,037,300	$2,723,700	1.43	$1,162,300
5 YR.	$2,369,100	1.53	$1,262,900	$2,501,100	1.55	$1,384,900
7 YR.	$2,347,900	1.55	$1,284,100	$2,473,600	1.57	$1,412,400
10 YR	$2,481,800	1.46	$1,150,200	$2,589,800	1.50	$1,296,200
	ALT 2 150 FT. BERM 20 FT. DUNE			ALT. 5 150 FT. BERM		
	$3,961,000			$4,047,000		
3 YR.	$3,397,000	1.17	$564,000	$3,532,300	1.15	$514,700
5 YR.	$3,142,700	1.26	$818,300	$3,270,000	1.24	$777,000
7 YR.	$3,098,100	1.28	$862,900	$3,351,700	1.21	$695,300
10 YR	$3,410,700	1.16	$550,300	$3,509,700	1.15	$537,300
	ALT 3 175 FT. BERM 20 FT. DUNE			ALT. 6 175 FT. BERM		
	$4,147,000			$4,156,000		
3 YR.	$4,231,100	0.98	($84,100)	$4,369,100	0.95	($213,100)
5 YR.	$4,054,500	1.02	$92,500	$4,189,000	0.99	($33,000)
7 YR.	$4,029,700	1.03	$117,300	$4,159,700	1.00	($3,700)
10 YR	$4,131,900	1.00	$15,100	$4,349,500	.96	($193,500)

NOTE: ABOVE BENEFITS DO NOT INCLUDE LOCAL COST

TABLE 4-10

24 Ft. Dune Interpolation Analysis

Plan Benefits Reduction	Benefits %Damage	Annualized Cost	BCR	Net Benefits
125= berm 20= dune	$8,077,000 (85%)	$3,733,900	2.16	$4,343,100
125= berm 22= dune	$8,639,000 (91%)	$4,018,400	2.15	$4,620,600
125= berm 24= dune	$9,222 ,000 (97%)	$4,614,103	2.00	$4,607,900
(@ 7.125% discount rate)				

Note: The benefits for the 125= berm, 24= dune are estimated as follows: The percentage in damage reduction from the 20= dune to the 22= dune has a 6% increase. Applying that increment to the 24= dune (91%+6%) would give you an expected damage reduction of $9,222, 000 (i.e., ($8,459,000*.97), the total without project damages*.97 plus $1,017,000 for local cost forgone).

The %Damage Reduction for the 20= and 22= plans were computed from the base of the without project condition plus local cost foregone (ie, 8,459,000+1,017,000=$9,476,000). So for 20= dune 8,077,000/9,476,000=85% and for the 22= dune 8,639,000/9,476,000=91%.

Table 4-11
Matrix of Beachfill Alternatives

Dune Height (feet-NAVD) Dune Width 30 Feet	**Berm Width (feet)**			
	Existing	**125**	**150**	**175**
Existing	M	M	M	M
20	X	M	M	N
22	X	M	M	M
24	X	N	X	X

X = Inappropriate design template (non-constructable or insufficient footprint)
M = Modeled
N =Interpolated/Extrapolated

4.11 DETERMINATION OF THE SELECTED PLAN.

General. Costs for the beachfill alternatives along the LBI oceanfront were developed and compared with shore protection benefits to optimize the NED plan. This was accomplished using the same numerical modeling techniques utilized in the without project analysis coupled with engineering and technical assessments to interpret model results as applied to the various alternatives. Reduced damages based on the predicted reduction in storm impacts due to the with-project alternatives were compared to the without project results to generate project benefits. Costs for each alternative were estimated based on standard construction practices and District experience in the construction of beach nourishment projects.

Storm Impacts. The with-project conditions are the conditions that are expected based on the predicted impacts of storm events on the various project alternatives. The periodic nourishment associated with the project is designed to insure the integrity of the project design. In the case of beachfill, this ensures the project design cross section will be maintained and the elimination of shoreline recession due to long-term erosion. However, coastal processes will continue to impact the shoreline along the project area. Storm induced erosion, wave attack and inundation were evaluated for the with-project condition using the same methodologies utilized during the without project analyses. The following sections describe the coastal processes which were used to estimate the with project damages.

Refinement of the Cycle 3 Alternatives leaves the combination of berm and dune restoration for further formulation. The structural dune reinforcement alternative also was eliminated at this point. After evaluating costs for low profile bulkheads, geotextile tubes and rubble mound structures the damage reduction pool just is not enough to justify the additional cost. As in the 24' dune analysis only approximately $ 1,000,000 is available. The bulkhead or other type of internal hardened dune structure could cost upwards of $150,000 or more. The structure fails during the 200 and 500 year storm events, eliminating its ability to capture the additional benefits that are available. Modeling various beachfill configurations provided insight as to the performance of the design parameters. The final step in the plan formulation sequence is to optimize the selected plan alternatives in order to determine the selected plan and/or the NED plan. A third iteration was run for all BUNDY's. This selected plan bracket concentrated only on the 125 berm with 20 and 22 NAVD feet high dune scenarios and nourishment cycle of 3, 5 and 7-years. Infrastructure costs was also factored into the analysis. The seven-year and ten-year nourishment cycle were analyzed to qualify if existing sand sources can support longer nourishment cycles.

4.12 HYDRAULIC EVALUATION OF ALTERNATIVE PLANS .

Storm Induced Erosion. The numerical model SBEACH was applied to predict storm-induced erosion for the with-project conditions for the Long Beach Island study area. All SBEACH input variables were identical to the without-project runs except the input profiles were modified to include the alternative beachfill designs. As in the without-project condition, storm events from 5-year through the 500-year frequency were simulated for each of the with-project alternatives. Model results were reviewed and analyzed for reasonableness as applied to the various alternatives. The COSTDAM control files, which include a summary of the with-project erosion results, are presented in Appendix B.

Storm Inundation and Wave Attack. The post-storm recession profiles generated by SBEACH were used to analyze the erosion, inundation and wave attack using the same methodologies described in the without-project analyses. The wave height frequency and stage-frequency data utilized to assess the alternative designs were identical to those used for the without-project conditions. Appendix B contains the COSTDAM control files for each alternative and each profile. These control files list the 3-foot damaging wave impact zones for each storm event. Similar inundation profiles were computed for each line in order to determine the total water level across the beach profile and into the community.

4.13 ECONOMIC EVALUATION OF ALTERNATIVE PLANS.

Storm Damage Reduction. Damages for the with-project alternatives are calculated using the same methodologies and databases as previously detailed in the without project conditions. The storm damage reduction benefits for any given project are the difference between without project damages and with project damages. (Tables 4-16, 4-17, and 4-18, see Appendix B, shows the storm damages, storm damage reduction and a comparison to the without project damages for six alternatives on Long Beach Island.) The alternatives were named Alternative 1 through Alternative 6.

Reduced Maintenance Benefits & Local Costs Forgone. The study team obtained maintenance and sand replacement expenditures for the last 10 years from the municipalities. The costs were annualized for comparison against costs generated based on future erosion rates. The goal was to depict a realistic response by the locals and the non-Federal sponsor in combating future without project conditions. On almost a yearly basis some community along LBI pays for other maintenance expenses including, groin repairs, dune and berm maintenance, beach monitoring, and dune grass plantings.

By year 15, persistent erosion will decrease the berm and dune by a significant amount without a Federal project. The locals currently hold the line at the seaward toe of dune, either by scrapping or trucking in sand. Unfortunately at some point after year 15, conditions will have degenerated with little berm remaining in high damage areas. Profiles will reach equilibrium given the effects of beach scraping but little berm/beach area will remain. The locals will want to maintain the berm (beach) as well; therefore, the locals will incur even greater costs. The non-federal sponsor agrees that beyond year 15 a state or local funded beach fill project is necessary to economically provide a sound engineered beach.

Under a with project condition the municipalities of LBI would not have to incur the costs associated with the maintenance of the existing condition, primarily, the maintenance of a dune system. From the base year to year 15, the cost of dune maintenance through trucking of sand would be foregone. This was analytically depicted as a cyclical three-year maintenance from year 1 to year 15, continuous, each year providing for one third of the island. Beyond year 15, a future representative without project profile is in place. This eroded profile requires maintenance at the near shore profile of the dunes to the depth of closure at the berm. At this point the quantity of material is significant enough that it would require sand through offshore dredging. This maintenance is projected for a seven-year cycle. Damages remain unchanged beyond year 15 due to the implementation of a beach fill by the non-Federal Sponsor. Table 31 found in the Economic Section of Appendix B shows an example how this analysis was performed for a selected BUNDY (BUNDY 5). **Table 4-12** shows the summary analysis for all of LBI. The annualized local cost foregone for LBI is estimated at about $1.02 million per year. **Tables 4-13, 4-14** and **4-15** depict the typical analysis used to generate costs.

Table 4-12

Cyclical Maintenance Expenditure Foregone under With Project Conditions

GRAND TOTAL FOR ALL BUNDY'S

DISCOUNT RDISCOUNT RATE=7.125%

YEAR		PW FACTOR	
0	0	1.000000000	0
1	1,114,651	0.933488915	1,040,514
2	841,408	0.871401554	733,204
3	932,640	0.813443691	758,650
4	1,114,651	0.759340668	846,400
5	841,408	0.708836097	596,420
6	932,640	0.661690639	617,119
7	1,114,651	0.617680876	688,499
8	841,408	0.576598251	485,154
9	932,640	0.538248075	501,992
10	1,114,651	0.502448612	560,055
11	841,408	0.469030209	394,646
12	932,640	0.437834501	408,342
13	1,114,651	0.408713653	455,573
14	841,408	0.381529665	321,022
15	932,640	0.356153713	332,163
16	0	0.332465543	0
17	0	0.310352899	0
18	0	0.289710991	0
19	0	0.270441998	0
20	0	0.252454608	0
21	0	0.235663578	0
22	9,704,992	0.219989337	2,134,995
23	0	0.205357608	0
24	0	0.191699050	0
25	0	0.178948939	0
26	0	0.167046850	0
27	0	0.155936383	0
28	0	0.145564885	0
29	9,704,992	0.135883207	1,318,745
30	0	0.126845467	0
31	0	0.118408837	0
32	0	0.110533337	0
33	0	0.103181645	0
34	0	0.096318922	0
35	0	0.089912646	0
36	9,704,992	0.083932458	814,564
37	0	0.078350019	0
38	0	0.073138874	0
39	0	0.068274329	0
40	0	0.063733329	0
41	0	0.059494356	0
42	0	0.055537322	0
43	9,704,992	0.051843474	503,141
44	0	0.048395309	0
45	0	0.045176484	0
46	0	0.042171747	0
47	0	0.039366858	0
48	0	0.036748526	0
49	0	0.034304342	0
50	9,704,992	0.032022723	310,780
	TOTAL PRESENT WORTH		**13,821,979**
	CAPITAL RECOVERY FACTOR (50 YEARS @		0.0736071
	Average Annual Foregone Cost		$1,017,400
	AVERAGE ANNUAL FOREGONE COST		$1,017,400

Table 4-13 Estimate Using Beach Fill Module (Background Erosion Losses Only) and

Bundy	Reach	Erosion	Vol Req'd to Hold Base to Year 15 (yd3/ft)	Vol Req'd to Hold (7 year cycle) Year 15 (yd3/ft)	Vol Req'd to Hold Berm to (7 year cycle) Year 15 - (yd3/ft)
1	6910	0	0.00	0.00	0.00
2	4298	0	0.00	0.00	0.00
3	**7664**	**-0.9**	**9.30**	**4.60**	**8.58**
4	4491	0	10.50	5.10	0.00
5	4551	-3	18.50	9.38	28.58
6	**9815**	**-3.85**	**22.20**	**9.80**	**36.68**
7	**6425**	**-2.5**	**18.80**	**11.60**	**23.82**
8	5285	0	12.30	5.83	0.00
9	**9252**	**-0.554**	**8.50**	**4.52**	**5.28**
10	9199	-1	5.60	2.20	9.53
11	**6438**	**-1.3**	**9.10**	**7.39**	**12.39**
12	7260	0	7.40	3.00	0.00
13	4761	0	11.20	5.22	0.00
14	**3156**	**-3.73**	**12.10**	**6.21**	**35.54**
15	6646	-3	21.60	10.93	28.58

Table 4-14 Volume per BUNDY from BFM (Background
All Volumes should be adjusted with Overfill and

Bundy	Reach	Erosion	Vol Req'd to Hold Base to Year 15 (yd3 @year 15)	Vol Req'd to Hold (7 year cycle) Year 15 (yd3/ 7yr Cycle)	Vol Req'd to Hold Berm to (7 year cycle) Year 15 - (yd3/ 7yr Cycle)
1	6910	0	0	0	0
2	4298	0	0	0	0
3	**7664**	**-0.9**	**71,275**	**35,254**	**65,719**
4	4491	0	47,156	22,904	0
5	4551	-3	84,194	42,688	130,083
6	**9815**	**-3.85**	**217,893**	**96,187**	**360,033**
7	**6425**	**-2.5**	**120,790**	**74,530**	**153,040**
8	5285	0	65,006	30,812	0
9	**9252**	**-0.554**	**78,642**	**41,819**	**48,836**
10	9199	-1	51,514	20,238	87,646
11	**6438**	**-1.3**	**58,586**	**47,577**	**79,742**
12	7260	0	53,724	21,780	0
13	4761	0	53,323	24,852	0
14	**3156**	**-3.73**	**38,188**	**19,599**	**112,160**
15	6646	-3	143,554	72,641	189,965

Table 4-15
Local Cost Foregone, Typical Sequence

Costs are estimated.

Volume (yd^3)

Year	Bundy 3			Bundy 4			Bundy 5			Bundy 6		
	Trucking	Dredging	Total	Trucking	Dredging	Total	Trucking	Dredging	Total	Trucking	Dredging	Total
15	71,275	0	**71,275**	47,156	0	**47,156**	84,194	0	**84,194**	217,893	0	**217,893**
22	35,254	65,719	**100,973**	22,904	0	**22,904**	42,688	130,083	**172,771**	96,187	360,033	**456,220**
29	35,254	65,719	**100,973**	22,904	0	**22,904**	42,688	130,083	**172,771**	96,187	360,033	**456,220**
36	35,254	65,719	**100,973**	22,904	0	**22,904**	42,688	130,083	**172,771**	96,187	360,033	**456,220**
43	35,254	65,719	**100,973**	22,904	0	**22,904**	42,688	130,083	**172,771**	96,187	360,033	**456,220**
50	35,254	65,719	**100,973**	22,904	0	**22,904**	42,688	130,083	**172,771**	96,187	360,033	**456,220**

Costs ($)

Unit Cost	Trucking	Dredging	Trucking	Dredging	Trucking	Dredging	Trucking	Dredging
	$7.50	$4.50	$7.50	$4.50	$7.50	$4.50	$7.50	$4.50

Year	Bundy 3			Bundy 4			Bundy 5			Bundy 6		
	Trucking	Dredging	Total	Trucking	Dredging	Total	Trucking	Dredging	Total	Trucking	Dredging	Total
15	$534,564	$0	**$534,564**	$353,666	$0	**$353,666**	$631,451	$0	**$631,451**	$1,634,198	$0	**$1,634,198**
22	$264,408	$295,735	**$560,143**	$171,781	$0	**$171,781**	$320,163	$585,372	**$905,535**	$721,403	$1,620,15	**$2,341,552**
29	$264,408	$295,735	**$560,143**	$171,781	$0	**$171,781**	$320,163	$585,372	**$905,535**	$721,403	$1,620,15	**$2,341,552**
36	$264,408	$295,735	**$560,143**	$171,781	$0	**$171,781**	$320,163	$585,372	**$905,535**	$721,403	$1,620,15	**$2,341,552**
43	$264,408	$295,735	**$560,143**	$171,781	$0	**$171,781**	$320,163	$585,372	**$905,535**	$721,403	$1,620,15	**$2,341,552**
50	$264,408	$295,735	**$560,143**	$171,781	$0	**$171,781**	$320,163	$585,372	**$905,535**	$721,403	$1,620,15	**$2,341,552**

Final Screening For the Selected Plan. A final iteration based on inclusion of nourishment cycles was performed to finalize the plan design and nourishment cycle selection. This final screening of alternatives is based on storm damage reduction and local cost foregone. Initial nourishment costs played a key role in the process. Nourishment costs are annualized for inclusion with the average annual benefits for a specific project alternative. Inclusion of the nourishment costs aided in bracketing the selected plan. The three nourishment cycles optimized were 3, 5 and 7, indicated as **a**, **b** and **c** for each alternative. Recreation benefits were not included in the optimization procedure. Benefits were updated to an October 1998 price level for comparison to costs. The average annual costs are subtracted from average annual benefits to calculate net benefits and select the optimal plan that maximizes net benefits.

Damages and damage reduction for all areas were evaluated for the 125-ft. berm, 20-ft. and 22-ft. dune alternatives 1 and 4. **Table 4-16** displays all comparison categories, including without project damages, with project damages and achieved benefits for the 20-ft. and 22-ft. dune, 125-ft. berm plan. **Table 4-17** displays the first costs and nourishment cycles optimization. The summary for the benefits, costs, benefit to cost ratios, and net benefits for the six scenarios can be compared in the tables below. For this screening the 125-ft. berm with the 22-ft. dune and the 7-year nourishment cycle has the highest net benefits (BCR of 2.15 to 1, with net benefits of $4.6 million). Plan Alternative 4c was selected as the optimal plan for the shorefront of Long Beach Island. Table 4-26 displays the results.

Table 4-16 LBI Without Project Damages with Damages and Damage Reduction for 125-ft.berm with 20-ft. dune and 22-ft. dune ($000)

BUNDY	Without Project	With Project Damages 20'/125'	With Project Damages 22'/125'	With Benefits 20'/ 125'	With Benefits 22'/125'
1	0	0	0	0	0
2	2	1	1	1	1
3	888	79	53	809	835
4	219	85	78	134	141
5	633	205	122	428	511
6	1273	447	178	826	1095
7	204	34	34	170	170
8	59	25	13	34	46
9	2251	123	108	2128	2143
10	520	54	25	466	495
11	694	71	58	623	636
12	385	77	53	308	332
13	446	120	60	326	386
14	645	20	17	625	628
15	240	58	37	182	203
	$ 8,459	**$1,399**	**$ 837**	**$ 7,060**	**$ 7,622**

Table 4-17

Plan Formulation First Cost and Nourishment Cycle Optimization (3,5 and 7 year cycles)

		Plan Alternative 1 125/20 berm/dune
Nourishment Cycle	**Total Present Worth**	**Average Annual Foregone Cost**
3 (a)	**$53,988,234**	**$3,973,900**
5 (b)	**$51,233,221**	**$3,771,400**
7 (c)	**$50,727,569**	**$3,733,900**
		Plan Alternative 4 125/22 berm/dune
Nourishment Cycle	**Total Present Worth**	**Average Annual Foregone Cost**
3 (a)	**$58,785,179**	**$4,323,000**
5 (b)	**$55,104,058**	**$4,056,000**
7 (c)	**$54,592,249**	**$4,018,000**

TABLE 4-18

BCR Analysis of 125 ft. Berm with 20 ft. and 22 ft. Dune

	125 FT. BERM 20 FT. DUNE				125 FT. BERM 22 FT. DUNE		
		Annualized Benefits $8,077,000				Annualized Benefits $8,639,000		
	CYCLE	Annualized Costs	PLAN BCR	NET BENEFITS		Annualized Costs	PLAN BCR	NET BENEFITS
ALT 1	3 YR.	$3,973,900	2.03	$4,103,100	ALT 4	$4,327,000	2.00	$4,312,000
ALT 2	5 YR.	$3,771,400	2.14	$4,305,600	ALT 5	$4,056,000	2.13	$4,583,000
ALT 3	7 YR.	$3,733,900	2.16	$4,343,100	**ALT 6**	**$4,018,400**	**2.15**	**$4,620,600**

4.14 SELECTED PLAN OPTIMIZATION.

NEPA Environmental Borrow Area Considerations

After the development of the BCR's during optimization of the NED plan, a coordination meeting was held on November 18, 1998 with resource agencies. The agencies in attendance included US Fish & Wildlife Service, National Marine Fisheries, National Oceanic and Atmospheric Agency and NJ State Department of Environmental Protection (NJDEP), including NJDEP Land Use Regulation, NJDEP Engineering and Construction, NJDEP Fish, Game and Wildlife. The District presented a generalized selected plan scenario regarding a design template, borrow area locations, and sand quantity volumes along with potential environmental impacts. The plan called for the depletion of borrow areas B and E in the initial construction, removal of three quarters of borrow area D and a limited use of borrow area A. Of primary concern for the resource agencies are impacts to benthic organisms as well as surf clams and impacts to prime fishing areas. The state referenced Rules on Coastal Zone Management Chapter 7E New Jersey Administrative Code as of August 20, 1990, (updated in 1994) specifically section 7:7E-3.4 Prime Fishing Areas. Policy prohibits uses including sand or gravel submarine mining which would alter existing bathymetry to a significant degree, reducing high fishery productivity of the area.

The meeting surfaced strong opposition to the use of two of the proposed four borrow areas. Borrow Areas B and E were targeted as areas where portions are prohibited for use as sand borrow areas. Loss of these borrow areas involves quantities of approximately 12 million cubic yards, which significantly increases the cost of the proposed project since replacement borrow areas exist further offshore.

The details presented in this section depict the steps taken to optimize use of the proposed borrow areas and identify replacement borrow areas. The Federal agencies, State natural resource agencies and the non-Federal sponsor can compare cost impacts due to the New Jersey State's legal requirement to avoid impacts to prime fishing areas and National Marine Fisheries Service's Essential Fish Habitat.

Eliminating borrow areas B and E requires a reliance on extension of borrow area D (D2), which is outside the three nautical mile dividing zone between State and Federal jurisdiction. Using borrow areas outside the three mile zone requires coordination with INTERMAR, specifically the Minerals Management Agency Branch. These areas were previously considered and dismissed because of the availability of more feasible and less risky sources. Using borrow are D requires pumping sand from distances between 5 to 9 miles; thereby, substantially increasing costs and the potential for greater losses and impacts from storm activity. Using area D2 will require using Hopper Dredges beyond 9-mile distances, overall productivity is reduced at distances beyond 9 miles.

At the time of the formulation period leasing fees for mining or mineral extraction of 18 cents to 25 cents a cubic yard were charged by the Minerals Management Service for using sand from areas of their Federal jurisdiction, however; a recent MOA between the Corps and INTERMAR, could eliminate any leasing fees for projects of this nature. (Get WRDA 99 wording for minerals management agreement.)

Borrow Areas previously eliminated from use include: C, F and Barnegat Light Inlet. Barnegat Inlet is a federally maintained channel and is dredged three times a year by the dredge Currituck. On a annual basis approximately 300,000 cu yards are dredged. (But only 100,000 cu yards each dredge operation.) The median grain size of this material is only adequate for beach fill purposes along LBI. (Finer grain sizes, such as those within the inlet, require more volume to allow for losses while pumping and placing on the beach.) The inlet also is very shallow. The average depth in the inlet is 10 feet, much less than the draft needed for dredges typically used in large beachfill construction projects. Finally, the limited quantities of sand (100,000 yards for initial construction) limit the cost effectiveness of using the inlet as a sand source. Borrow areas C and F were eliminated due to the prevalence of underground cables. The sites are impractical for dredging due to the buffer distance required from each cable.

4.15 SELECTION OF BORROW AREA IMPACT PLAN ALTERNATIVE.

Four borrow area alternatives were developed to present options for using the borrow areas and related costs increases. Table 4-31 contains the costs and net benefits for the cost analysis on each of the four alternative plans. Originally plan A was the selected plan for the study as it met the economic requirements of the NED analysis. It did not however, meet all Federal NEPA requirements, due to the potential for impacts to state essential fish habitat. The Corp determined that it could apply greater avoidance and minimization for impacts to the borrow areas. The borrow area impact analysis is presented below. Further discussions with the resource agencies ensued during the review period for the draft report. Copies of correspondence depicting the resource agency review comments based on the draft report can be found in Volume 2, Appendix B.

Plan A was the selected plan presented to the resource agencies in November 1998. It used Borrow Areas A, D1, and E to the minimal extent possible for initial construction, Sensitive areas B and E were used more extensively during nourishment cycle over a 42- year period. Only a portion of each borrow area was impacted every seven years. Area B would contribute approximately 167,000 cubic yards every seven years after the initial construction. Area E would contribute 379,000 cubic yards for the initial construction and 794,000 cubic yards every seven years until depleted. It would avoid long distance pumping and hopper dredge hauling and also avoid the use of a borrow area in Federal waters. However, further coordination with the resource agencies determined even minimal use of borrow area E to create enhanced fishery habitat with topographic variation and extensive monitoring to document impacts was denied.

Plan D was formerly the selected borrow area impact plan alternative, which was a refinement of Plan A. In an attempt to create a plan based on avoidance, minimization and mitigation to offset impacts to critical environmental resources, Borrow Area B was eliminated. Plan D uses Borrow Areas A, D, D2 and E. Area E is used at only half of its capacity. Cost for initial fill is less than alternatives B and C. Increased costs due to longer pumping distances and hauling by Hopper Dredge are placed in nourishment cycles.

Plan C reflects recognition of NJDEP concerns and lessons some impacts to state EFH. This plan allowed use of Borrow Areas A, D1, D2 and areas B and E at reduced rates and over a 42 year span. Extensive monitoring would allow a scientific approach to assess impacts of such activities in order to alter activities for future nourishment cycles as appropriate. (Relying on D2 if monitoring revealed detrimental impacts to fisheries. Plan C was eliminated due to both its cost and impacts.

Plan B is the resulting selected plan. It will not impact state prime fishing areas or Federal essential fish habitat (EFH). Borrow Areas A, D and D2 are used, while B and E are avoided. Costs are increased significantly. However the plan is the most economical with the least environmental impacts.

1. Plan A. Most economical with most environmental impacts: This was the leading NED plan. It used Borrow Areas A, D1, and E to the minimal extent possible for initial construction. Areas B and E were used more extensively during nourishment cycle over 42- year period. Impacts to environmental resources necessitated more avoidance and minimization.

Table 4-19

Borrow Area Impact Alternative Plans					
Plan A	Construction Phase	BUNDY'S Served	Available Quantity (in millions)	Quantity **Remaining** (post initial)	Cost Estimate (not total project cost)
	Initial				
	Borrow Area A	3	1.50 cu yd	.64 cu yd	
	Borrow Area B	none	3.64 cu yd	3.64 cu yd	
	Borrow Area D	4 through 9	12.0 cu yd	8.11 cu yd	
	Borrow Area E	10 through 15	9.40 cu yd	5.56 cu yd	
					$39,700,000
	Seven Year Nourishment Cycles @42yrs			(post nourishment year 49)	
	Borrow Area A	None	.64 cu yd	.64 cu yd	
	Borrow Area B	3	3.64 cu yd	2.47 cu yd	
	Borrow Area D	4 through 7	8.11 cu yd	1.92 cu yd	
	Borrow Area E	8 through 15	5.56 cu yd	0	
					$ 10,697,000 per cycle

2. Plan C: This plan allows use of Borrow Areas A, D1, D2 and areas B and E at <u>reduced</u> rates and over a 42 year span.

Table 4-20

Borrow Area Impact Alternative Plans					
Plan C	Construction Phase	BUNDY'S Served	Available Quantity (in millions)	Quantity **Remaining** (post initial)	Cost Estimate (not total project cost)
	Initial				
	Borrow Area A	3 through 5	1.50 cu yd	0.05 cu yd	
	Borrow Area B	None	3.64 cu yd	3.64 cu yd	
	Borrow Area D	6 through 15	12.0 cu yd	4.70 cu yd	
	Borrow Area E	None	9.40 cu yd	9.40 cu yd	
					$53,302,543
	Seven Year Nourishment Cycles @42yrs			(post nourishment year 49)	
	Borrow Area A	None	0.05 cu yd	0.05 cu yd	
	Borrow Area B	3	3.64 cu yd	2.14 cu yd	
	Borrow Area D and D2	4 through 12	4.70 cu yd 12.0 cu yd	0 (D) 7.00 cu yd (D2)	
	Borrow Area E	13 through 15	9.40 cu yd	4.40 cu yd	
					$ 12,373,470 per cycle

3. Plan D, The former Selected NED Plan: Used Borrow Areas A, D, D2 and E. Area E is used at only half of its capacity. Area B is not impacted. Cost for initial fill is less than alternatives B and C. Increased costs due to longer pumping distances and hauling by Hopper Dredge are placed in nourishment cycles.

Table 4-21

Borrow Area Impact Alternative Plans					
Plan D	Construction Phase	BUNDY'S Served	Available Quantity (in millions)	Quantity **Remaining** (post initial)	Cost Estimate (not total project cost)
Refinement of Plan A	Initial				
	Borrow Area A	3	1.50 cu yd	0.60 cu yd	
	Borrow Area B	None	3.64 cu yd	3.64 cu yd	
	Borrow Area D	4 through 9	12.0 cu yd	6.86 cu yd	
	Borrow Area E	10 through 15	9.40 cu yd	4.96 cu yd	
					$38,498,000
	Seven Year Nourishment Cycles @42yrs			(post nourishment year 49)	
	Borrow Area A	None	0.60 cu yd	0.60 cu yd	
	Borrow Area B	None	3.64 cu yd	3.64 cu yd	
	Borrow Area D	3 through 15	6.86 cu yd	0	
	Borrow Area E	None	4.96 cu yd	4.96 cu yd	
	Borrow Area D2	3 through 15	12.0 cu yd	2.43 cu yd	
					$ 14,739,000 per cycle

4. Plan B: **The Selected Plan** (the NED plan with the least environmental impacts). This plan will not impact state essential fish habitat (EFH). Borrow Areas A, D and D2 are used, while areas B and E are avoided. Costs are increased significantly.

Table 4-22

Borrow Area Impact Alternative Plans					
Plan B	Construction Phase	BUNDY'S Served	Available Quantity (in millions)	Quantity **Remaining** (post initial)	Cost Estimate (not total project cost)
Resource Agency Preferred Alternative	Initial				
	Borrow Area A	None	1.50 cu yd	1.50 cu yd	
	Borrow Area B	None	3.64 cu yd	3.64 cu yd	
	Borrow Area D	4 through 15	12.0 cu yd	3.85 cu yd	
	Borrow Area E	None	9.40 cu yd	9.40 cu yd	
					$53,409,000
	Seven Year Nourishment Cycles @42yrs			(post nourishment year 49)	
	Borrow Area A	3 through 6	1.50 cu yd	0.10 cu yd	One cycle only
	Borrow Area B	None	3.64 cu yd	3.64 cu yd	
	Borrow Area D	7 through 15	4.80 cu yd	2.90 cu yd	First Cycle Only
	Borrow Area E	None	9.40 cu yd	9.40 cu yd	
	Borrow Area D and D2	3 through 15	2.90 cu yd 12.0 cu yd	0 3.44 cu yd	6 of 7 Cycles
					$ 17,557,535 per cycle

TABLE 4-23

Summary Borrow Impact
BCR Analysis of 125 ft. Berm with 22 ft. Dune

125 FT. BERM
22 FT. DUNE

Annualized Benefits
$8,639,000
(without recreation)

	CYCLE	Approximate Annualized Costs	BCR	Approximate NET BENEFITS	
Plan A	7 YR.	$4,018,400	2.15	$4,620,600	
Plan B	**7 YR.**	$5,771,000	1.50	$, 2,868,000	*
Plan C	7 YR.	$5,650,000	1.53	$2,989,000	
Plan D	7 YR.	$4,822,300	1.79	$3,816,700	

COST SHARING FOR PLANS (approximate costs for the borrow area analysis)

	Initial FED 65%	Initial non-FED 35%	Nourishment FED 65%	Nourishment non-FED 35%
Plan A	$25,800,000	$13,900,000	$6,953,050	$3,743,950
Plan B	**NED Selected Plan** **$25,772,967**	**$47,390,298**	**$11,412,397**	**$6,145,138**
Plan C	$25,772,967	$35,884,190	$8,042,755	$4,330,714
Plan D	$25,772,967	$14,248,837	$9,580,535	$5,158,750

5. SELECTED PLAN

5.1 IDENTIFICATION OF THE NED PLAN

The National Economic Development (NED) Plan is defined as that plan which maximizes beneficial contributions to the Nation while meeting planning objectives. Several of the beachfill plans considered meet the planning objectives in that they provide a degree of storm damage protection, which is greater than the cost of implementation. The NED plan for Barnegat Inlet to Little Egg Inlet is a combination dune and berm restoration, with a berm width of 125 feet and a dune with an elevation of +22.0 feet-NAVD, with periodic nourishment every seven years. This plan was chosen because it provided the maximum net storm damage reduction benefits. In addition special consideration was given to reducing borrow area impacts to special environmental resources. A plan known as Borrow Area Plan D was selected as that which meets the NED criteria.

Description of the Selected Plan. The design of the selected plan is complete and is consistent with Corps criteria as described in the Shore Protection Manual, Coastal Engineering Technical Notes (CETNs) and accepted engineering practice. Additional design work (a Design Memorandum) is not needed with the exception of completion of the optimization of the nourishment cycle plan, which includes a groin analysis, the applicability of a nearshore berm placement alternative, and a sand recycle plant alternative for selected renourishment cycle locations. Additional cultural investigations and environmental coordination, is also needed and can be completed concurrent with the development of plans and specifications. The following section describes the selected plan for the study area.

5.2 PROPOSED PROJECT DIMENSIONS

The selected plan for this feasibility study consists of placement of beachfill and dune construction. Beachfill would be placed on various stretches of Long Beach Island where the existing berm and dune profiles are below the minimum measurements of the design profile. Therefore, some areas will not receive beachfills during the period of initial construction, while other areas may only receive berm or dune fills. Existing dune elevations are at 19 ft on average while berm width averages are 111 feet. Average dune widths are at 29 feet. The plan will provide for a dune with a range of 1V: 5H back slope with a crest width of 30 feet at elevation +22 NAVD. The dune will have a fore slope of 1V: 5H. This will produce a beach width of approximately 125-ft from centerline of dune to the edge of berm, with approximately 105 feet of dry beach from the seaward toe of dune to MHW. Depth of closure is equal to -29.0 ft. NAVD88. From centerline of dune it ranges approximately from a minimum of 1045 ft to a maximum of 4500 ft.

This plan will require 4.95 million cubic yards of sand for initial berm placement, and 2.45 million cubic yards for dune placement. Approximately 1.9 million cubic yards will be needed for periodic nourishment every 7 years over a 50-year period of analysis. In addition, the first cycle of periodic nourishment would be placed at the time of the initial construction. This project will result in a continuous dune line extending the length of the island. The Barnegat Light (northern end of the study area) is not included in the project because it has little or no long term erosion and adequate dune and berm profiles. In the southern most uninhabited portion of the project area, the US Fish and Wildlife Service stated that the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge would remain in its natural state, therefore it also is excluded from the project. Major rehabilitation is calculated for cost estimate purposes to occur in year 28. The project area and construction baseline can be seen in **Figures 5-1 through 5-30.**

Construction of the first cycle of periodic nourishment is placed on top of the proposed dune and berm to protect that template. This "advanced" nourishment material settles naturally overtime to form the berm slope and toe after which the beach reaches a point of equilibrium. Physically no material is placed below the mean low water line, naturally the material erodes overtime or is moved by storm events.

Figures 5-32 through 5-34 show groin profiles for groins 5, 18 and 84 depicting the depth and extent of fill for the landward and seaward portions of each groin. The gray area is the fill, which occurs above the top elevation of the groin. As discussed above, no material is physically placed seaward of the berm slope. The engineering appendix shows a complete analysis for the groins. (Volume 2, Engineering Appendix, Section 6.

Beach Access. The beach access strategy includes natural beach walkover paths, up and over the dunes at a skewed angle and delineated by sand fencing. The sponsor is responsible for maintaining the access ways by replacing fencing as needed, and providing additional sand fill if the access way degrades upon the design dimensions of the dune template. These walkovers will be strategically placed at some street ends or other traffic areas which currently do not have any existing structural walkovers in place. The final location and dimensions of these walkovers and access ways will be coordinated with the sponsor and the local community during the preparation of plans and specifications.

Vehicular access will be provided at existing vehicular access points. The final locations and number of additional vehicular access points will be further coordinated with the sponsor and the local community during the development of plans and specifications, if necessary.

The local community may have special, site specific requirements for beach access appurtenances which may require the construction of additional, or the modification of proposed access paths. This is conditionally acceptable with the Corps of Engineers as long as the access plans are fully coordinated with the Corps of Engineers to ensure no loss of project integrity and with NJDEP for adherence to State coastal zone regulations.

Specific issues raised by resource agencies have been addressed. Corps regulations are described below:

PUBLIC ACCESS: ER 1165-2-130, Para. 6.(h) requires public use by all (including non-residents) on equal terms. This means that the project beaches will not be limited to a segment of the public. Public use is construed to be effectively limited as follows: a) when available public access points to any particular shore are spaced more than one-quarter (1/4) mile apart; b) when there is a lack of sufficient parking facilities for the general public (non-resident-users) located reasonably nearby and with reasonable public access. Generally, parking should be available within a reasonable walking distance of the beach.

The following information was obtained as part of our real estate analysis :

Public access and sufficient parking for the general public is available in the boroughs of Beach Haven, Ship Bottom, Surf City, and Harvey Cedars as prescribed in the regulations. The same holds true for Long Beach Township except in the areas known as Loveladies and North Beach. In an approximately 2.1 mile stretch, Loveladies has three (3) points of public access, while North Beach has one (1) in a 1.3 mile stretch. According to information provided by Long Beach Township, Loveladies has approximately 811 parking spaces, and North Beach 120, primarily located on the bayside of Long Beach Boulevard in each of those areas, that are available for general public use.

In order to bring these two areas of Long Beach Township into compliance with ER 1165-2-130, Para. 6.(h) as cited above so as to be eligible for Federal assistance through this project, the following is required:

1. In addition to the existing public access points, establish new ones to meet the ¼ mile distance between each. This would require the non-Federal sponsor to obtain permanent easements for these access points if they have not already done so. Recommended sites to establish these access points in Loveladies are Tracts 20.07, 20.33, 20.82, 20.107, 20.133 Lot 6; in North Beach, Tracts 18.13, 18.41, 18.93, 18.119.

2. Remove current restrictions prohibiting parking on one side of streets from 9:00am Wed through 9:00pm Sun.

3. Provide at a minimum an additional 100 parking spaces in the North Beach area. The 120 spaces identified by the Township for this 1.3-mile area are essentially located within a .3 mile stretch of the south end. Recommend that parking be made available in the vicinity of the recommended access points 18.41, 18.119, and the existing access point 18.65. Toward this end, it is recommended that the non-Federal sponsor purchase in fee property to satisfy the required parking spaces needed. Possible sites for this purpose, presently listed as vacant land, are Tracts 18.35, 18.67 and 18.111. If this option proves untenable, the non-Federal sponsor should provide parking on Long Beach Boulevard in this North Beach area. This option may require removal of the bike paths and median.

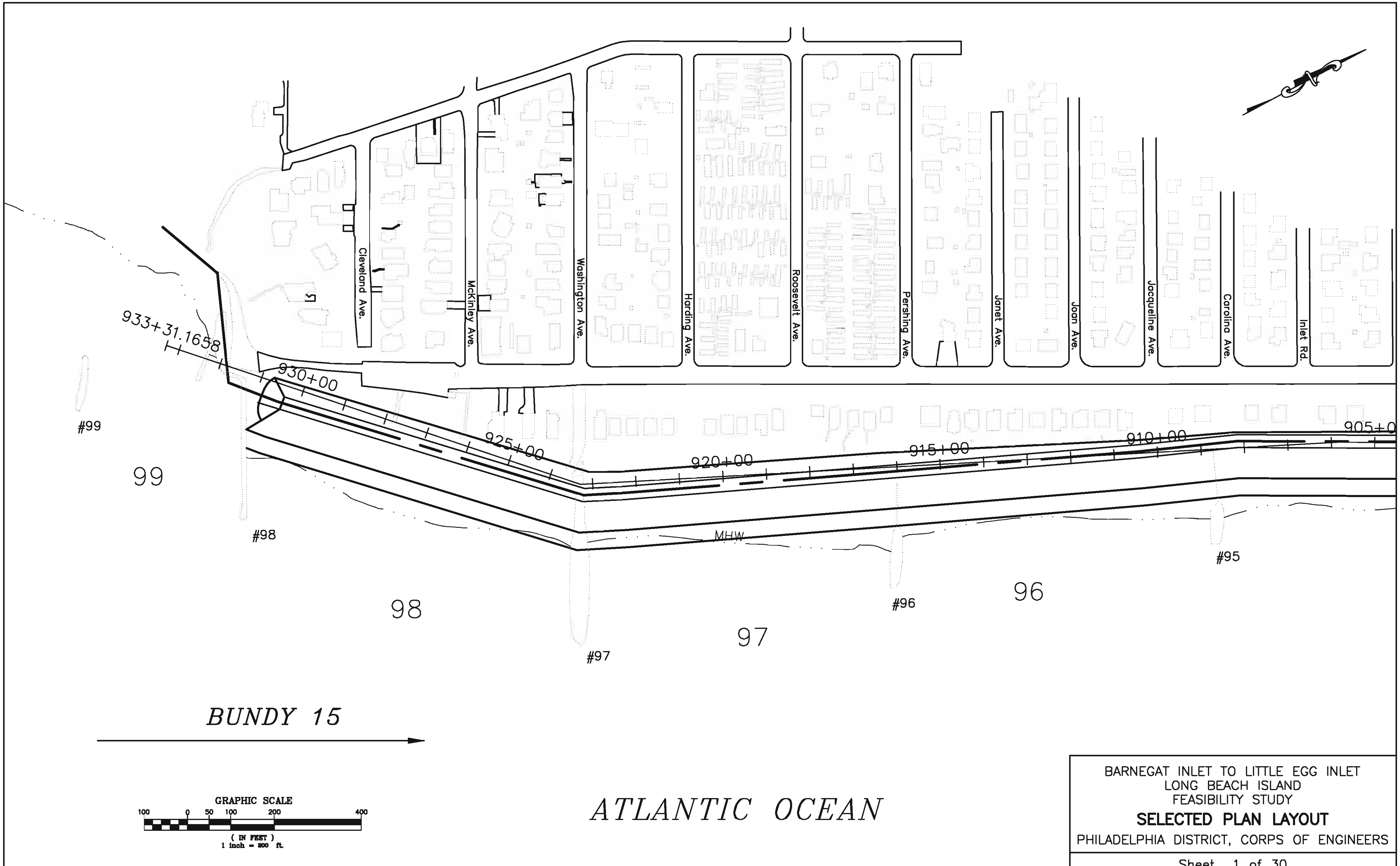
4. As long as no restrictions are placed on the parking spaces as identified by the Township in the Loveladies' area, the availability appears satisfactory. However, since this parking is on the bayside, it is recommended that this 2.1 mile stretch have sufficient lights for the pedestrian public to cross Long Beach Boulevard to access the beach area.

5. The local sponsor as well as the non-Federal sponsor has confirmed that public access will be provided every (1/4) mile and that parking area will be created where possible. The final details regarding public access point will be completed in the PED phase of the study.

The plan also includes the planting 337.0 acres of dune grass and the erection of 509,700 linear feet of sand fence. Sand fencing was estimated based on creating 4 rows along the dune width. Many communities prefer a crisscross or "Y" configuration. The estimate takes this into account. See **Figure 5-31** for a typical view. Survey cross sections used to develop the selected plan beachfill volumes are presented in Appendix A. In addition, access from street to beach will be by using roll-out boardwalks as opposed to compromising the dune by creating a path through the dune at existing street elevations.

Based on the foregone analysis the optimal plan for shore protection for Long Beach Island is the 125-ft. berm with the 22-ft. dune, and the 7-year nourishment plan. It is the federal recommended plan. It has a Planning, Engineering, and Design (PED) of 18 months and construction duration of 12 months. **Table 6-1** includes the initial first detailed cost analysis, which includes PED, Real estate, monitoring during construction. The annualized cost for this plan is $ $5,711,000.

The BCR for the selected plan including recreational benefits is 1.84 to 1 with net benefits of $ 4,844,000. (Price levels are as of January 1999. Discount Rate is 6 7/8 % FY99.)



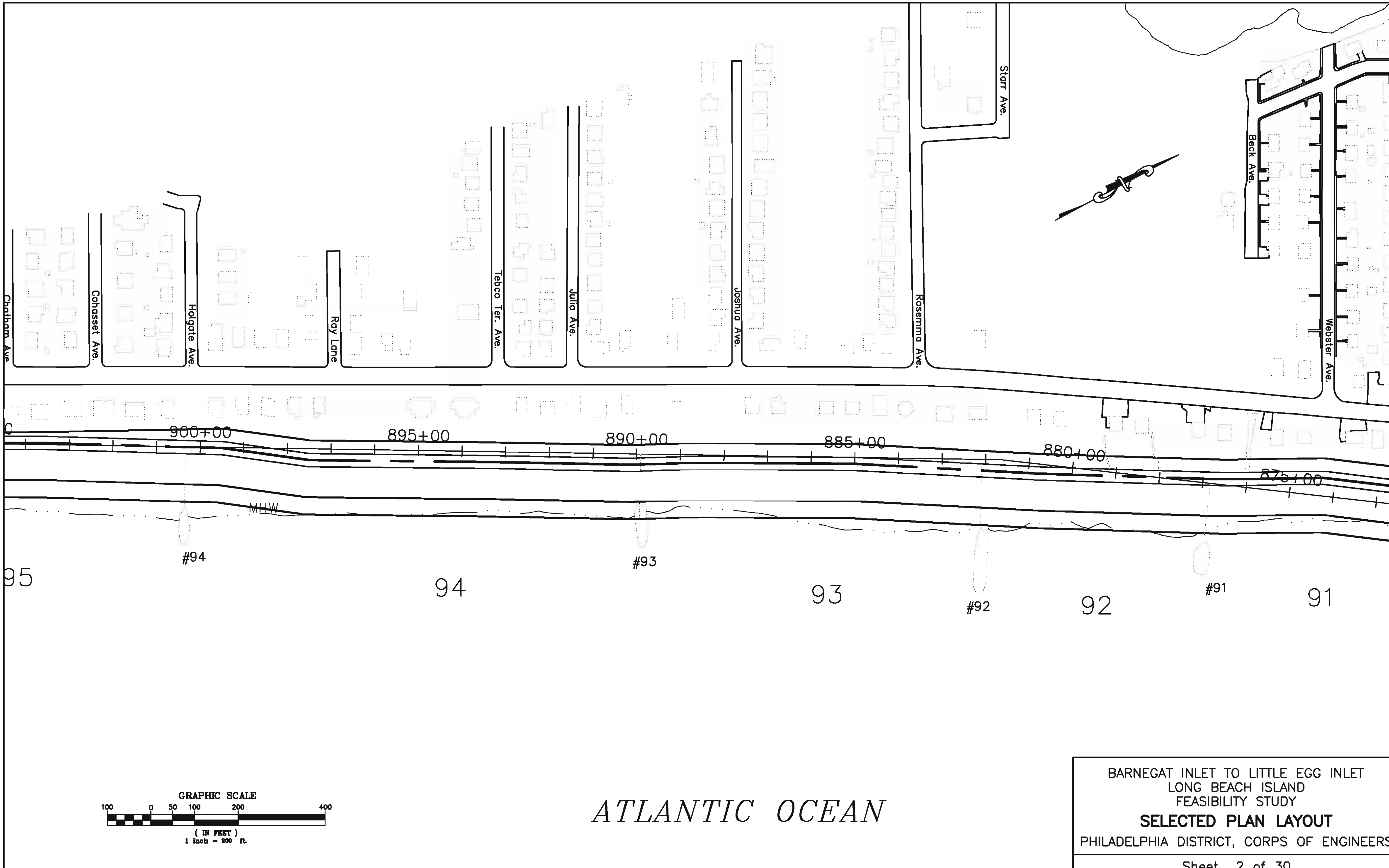
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 1 of 30

Figure 5 – 1

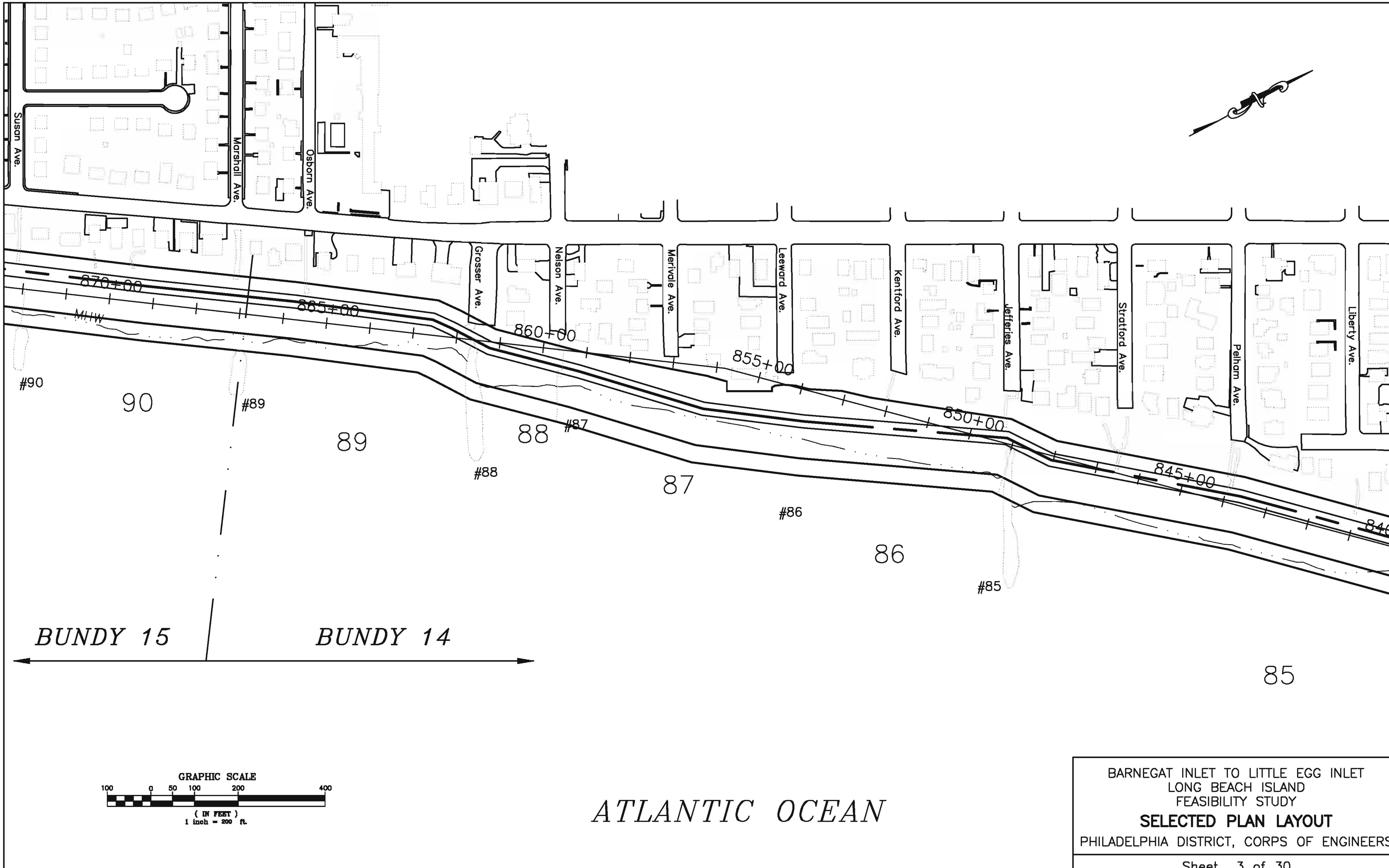


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 2 of 30



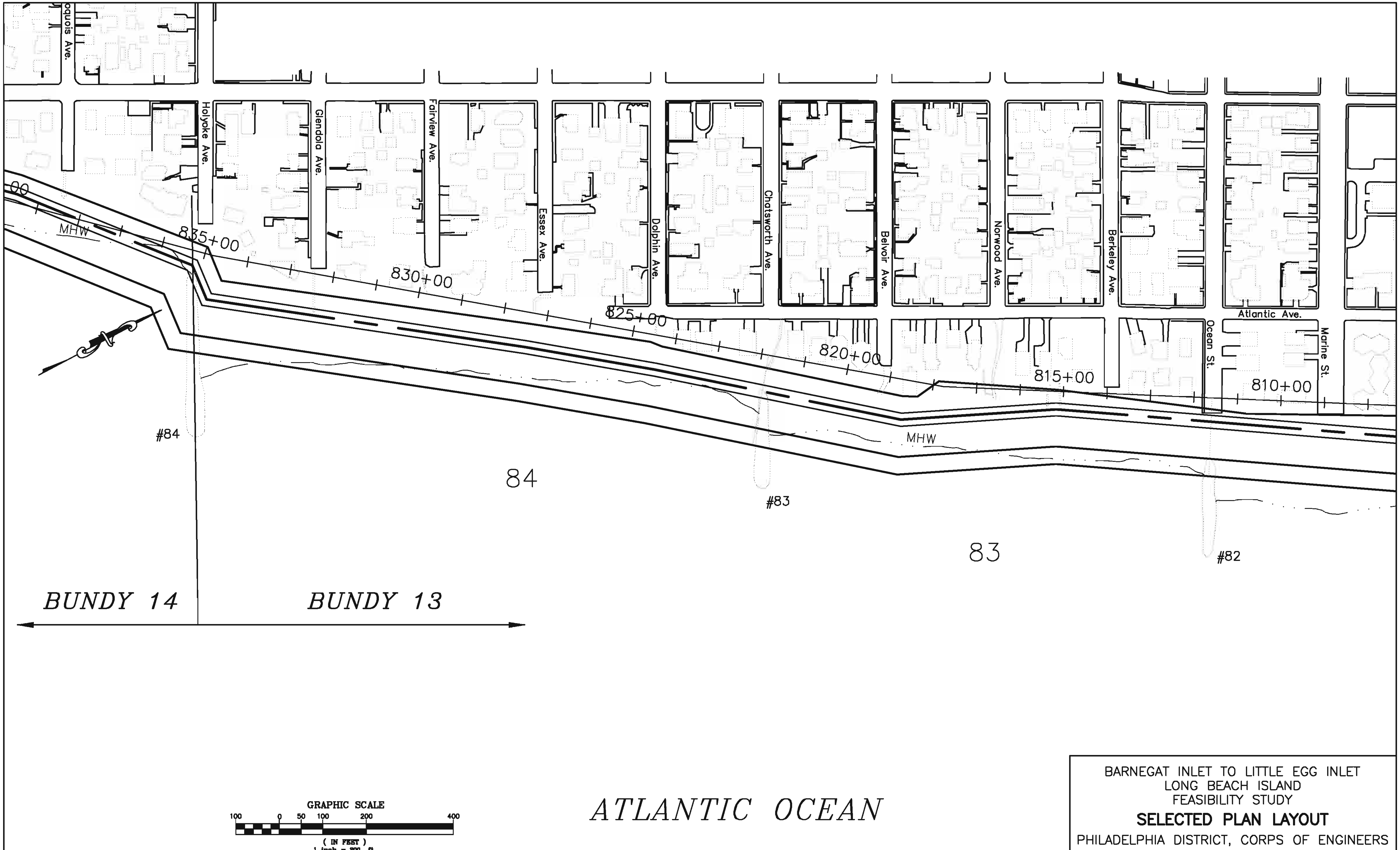
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 3 of 30

Figure 5 – 3



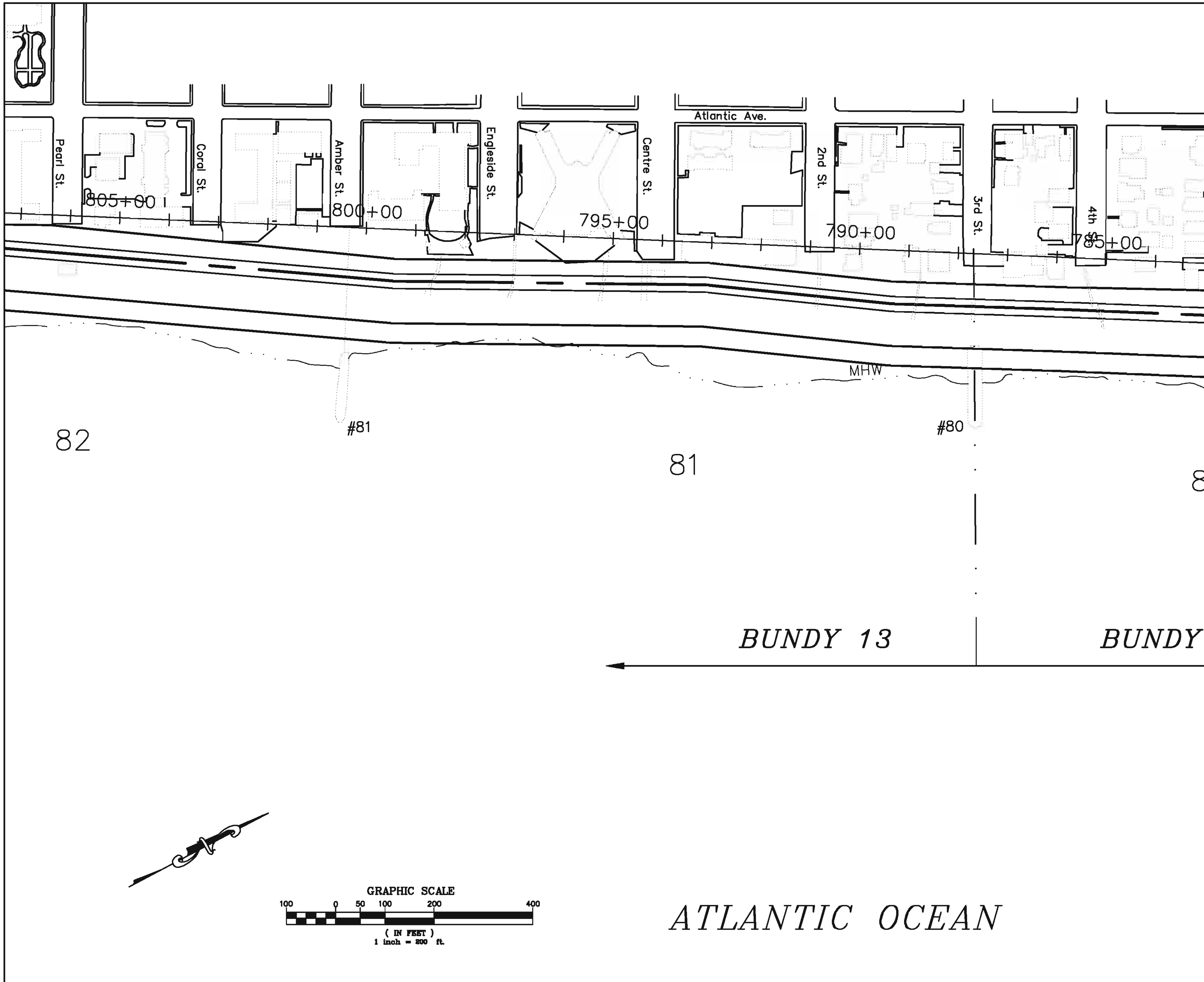
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 4 of 30

Figure 5 – 4



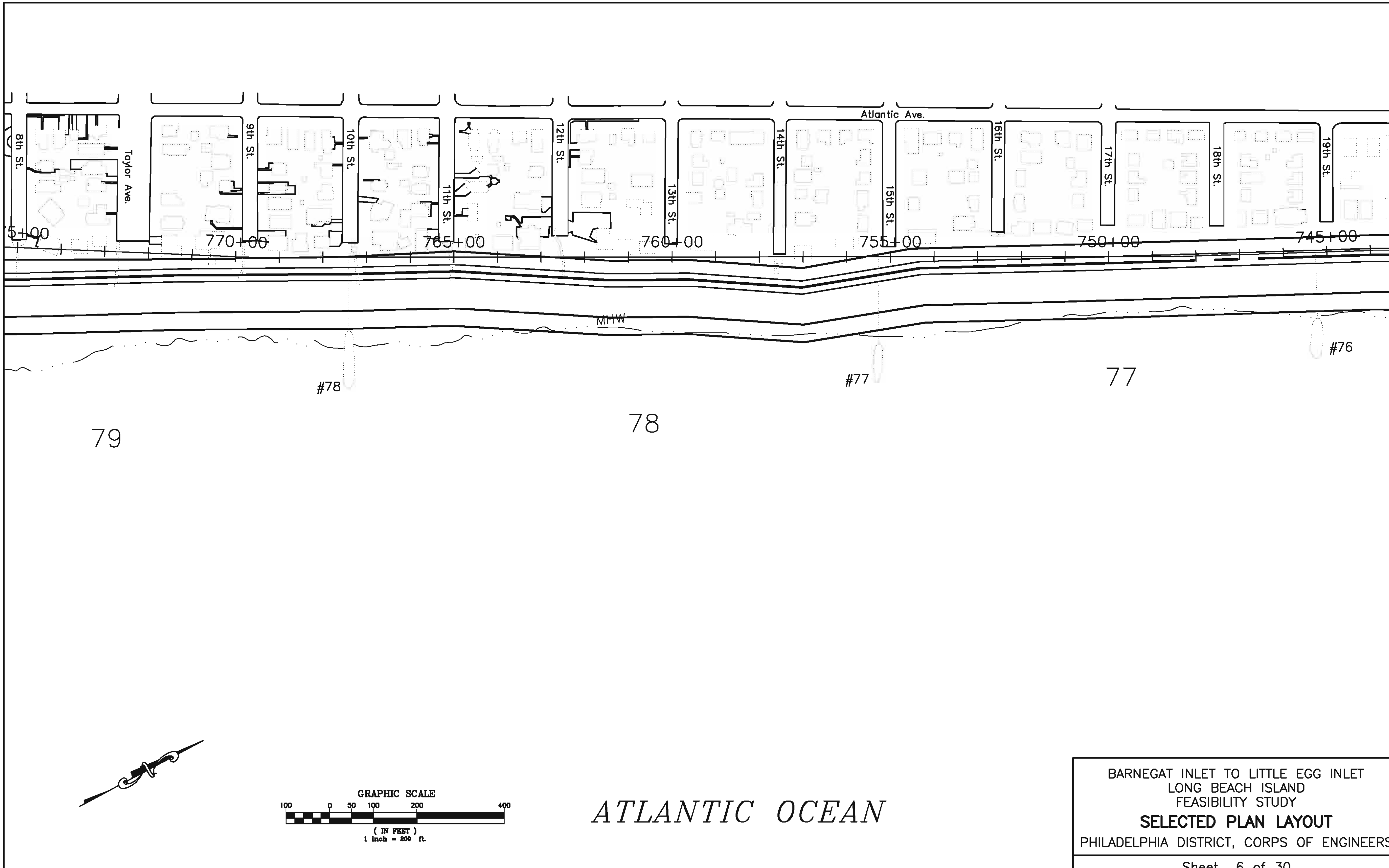
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 5 of 30

Figure 5 – 5



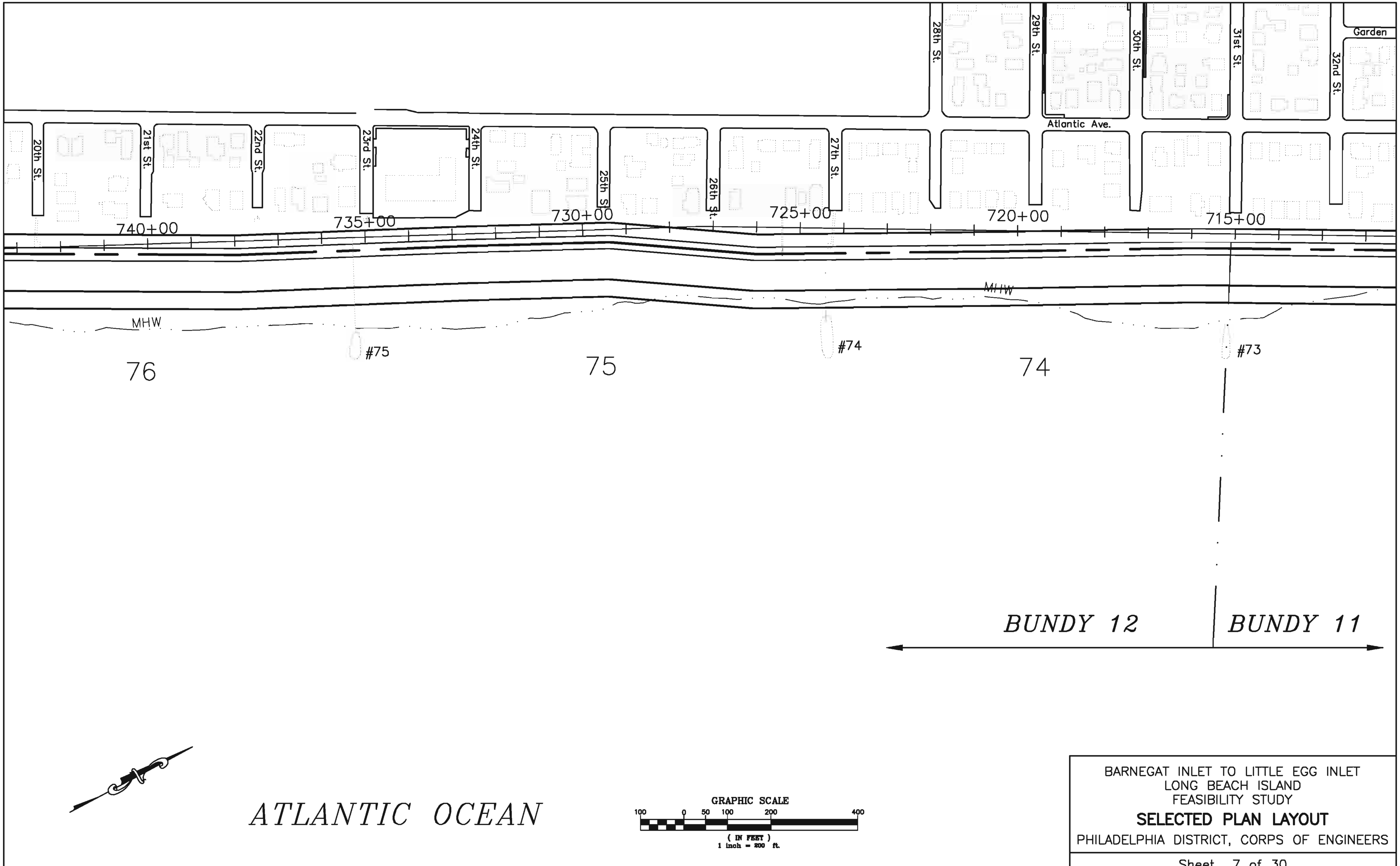
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 6 of 30

Figure 5 – 6



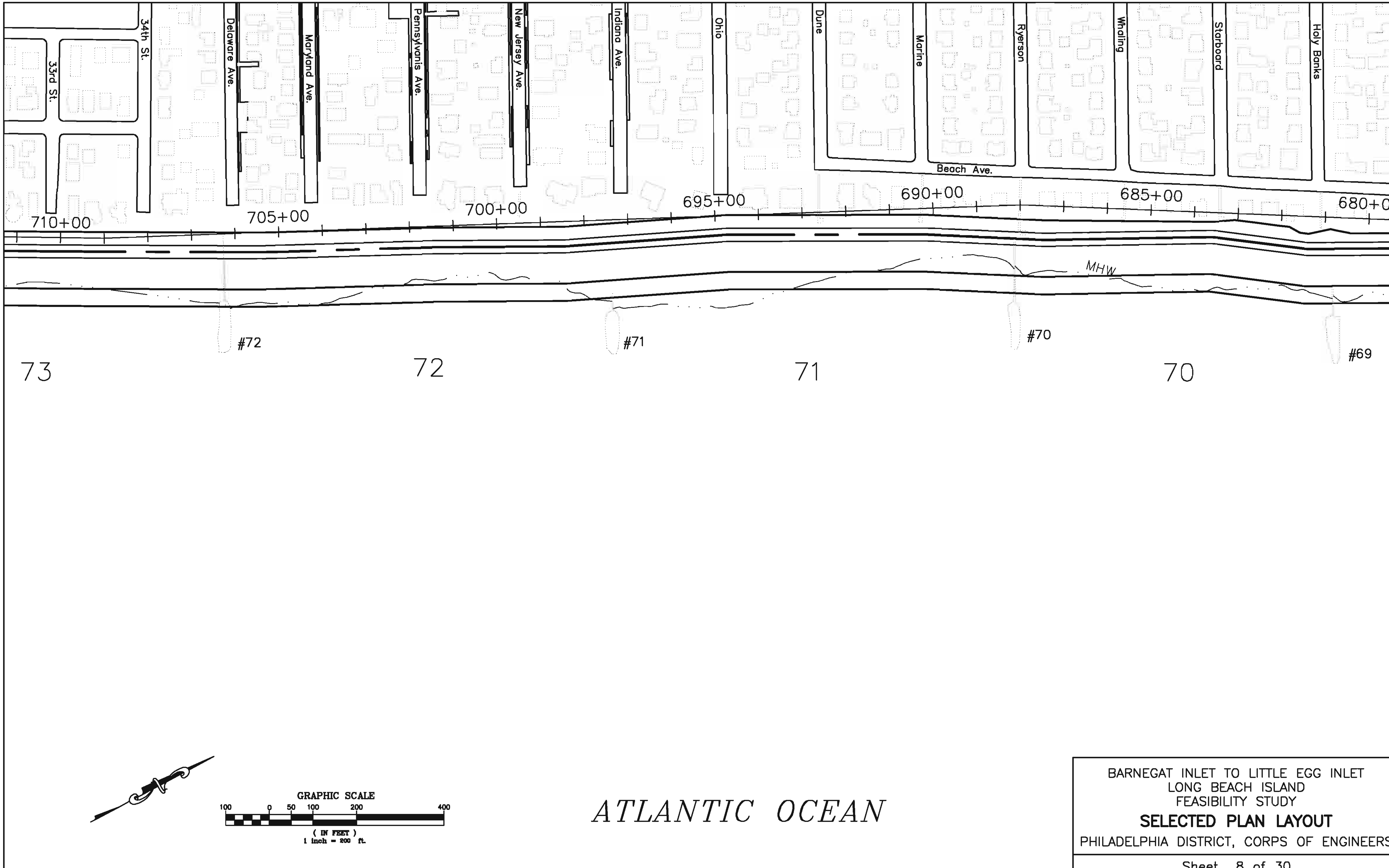
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 7 of 30

Figure 5 – 7



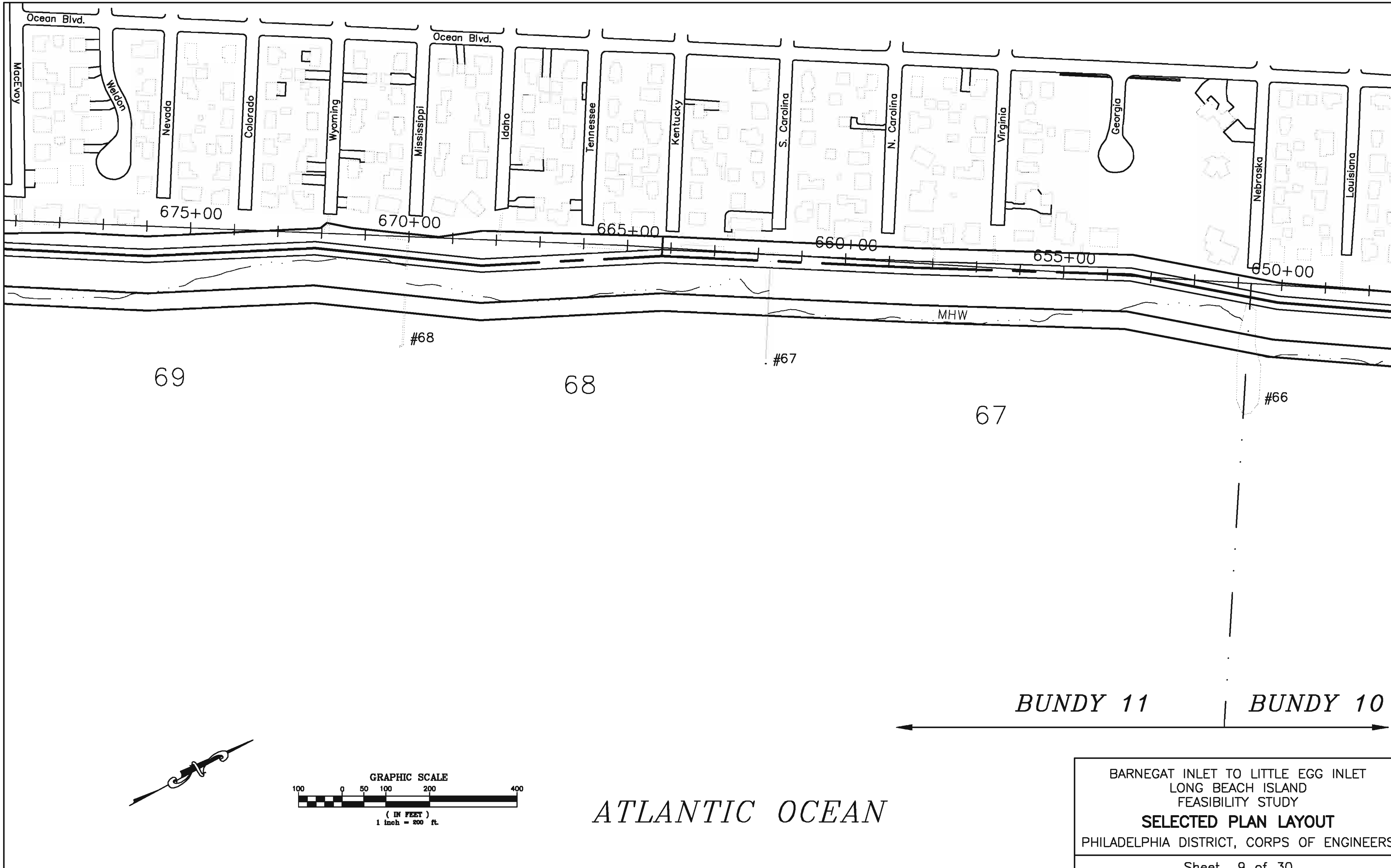
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 8 of 30

Figure 5 – 8

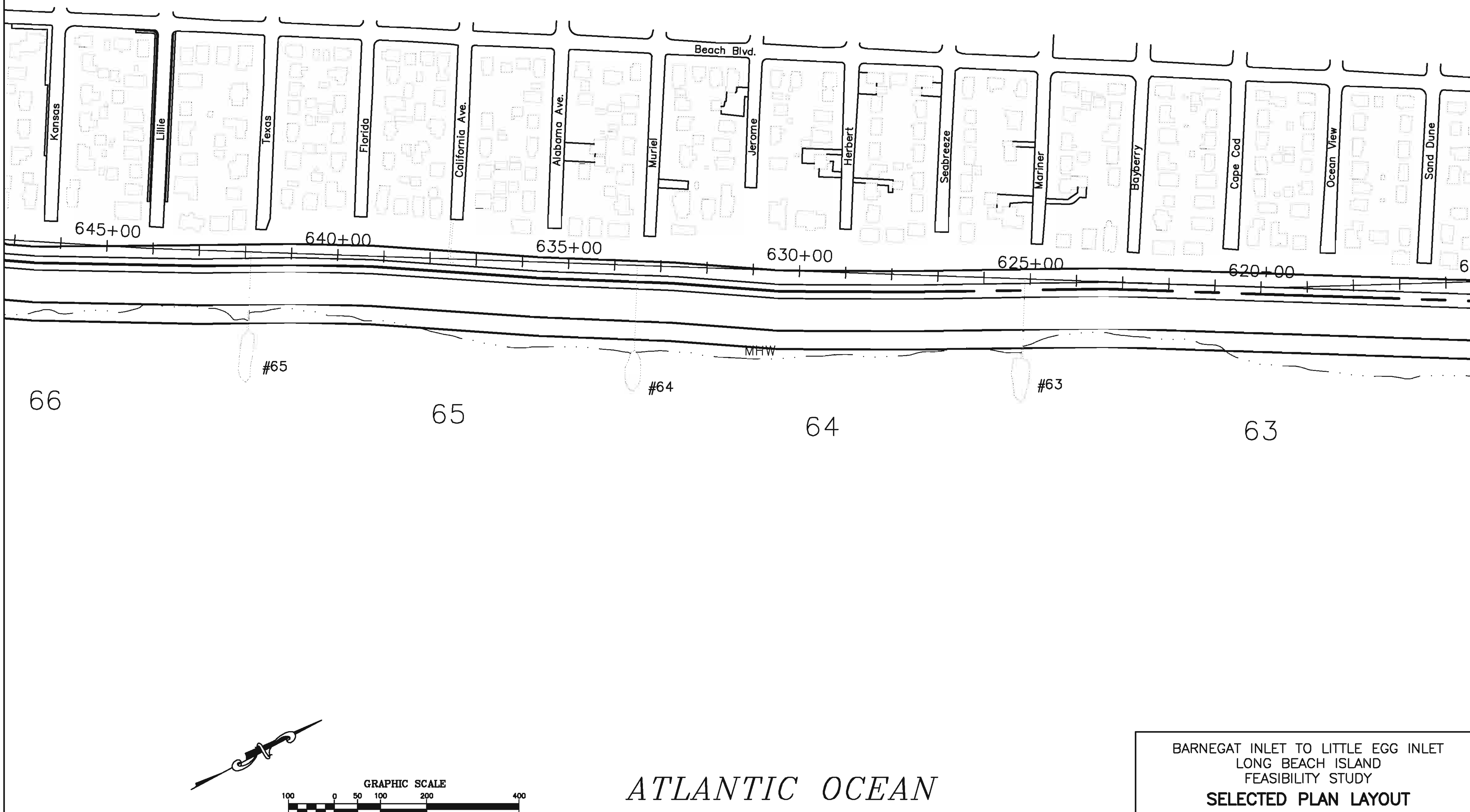


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 9 of 30

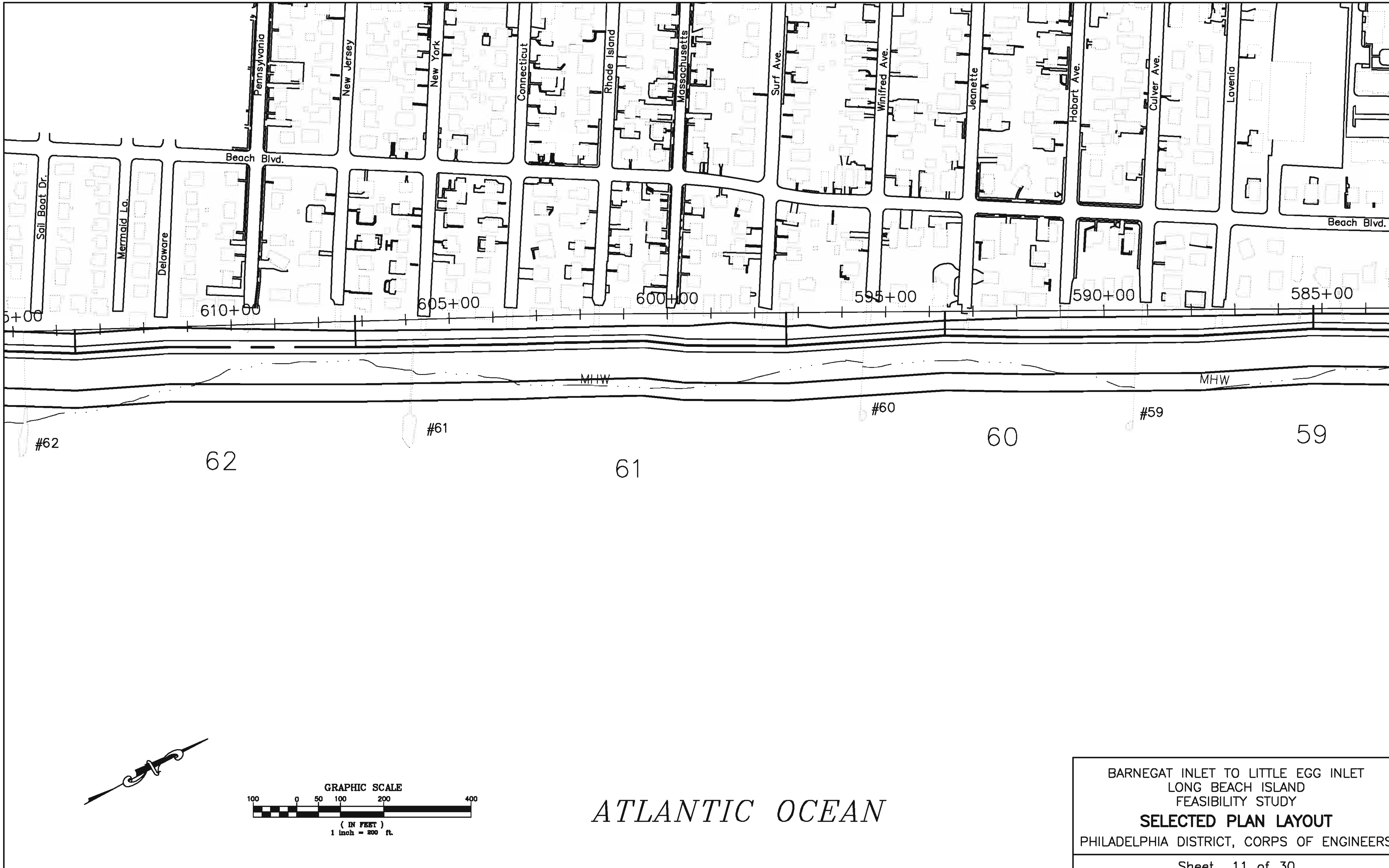


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 10 of 30

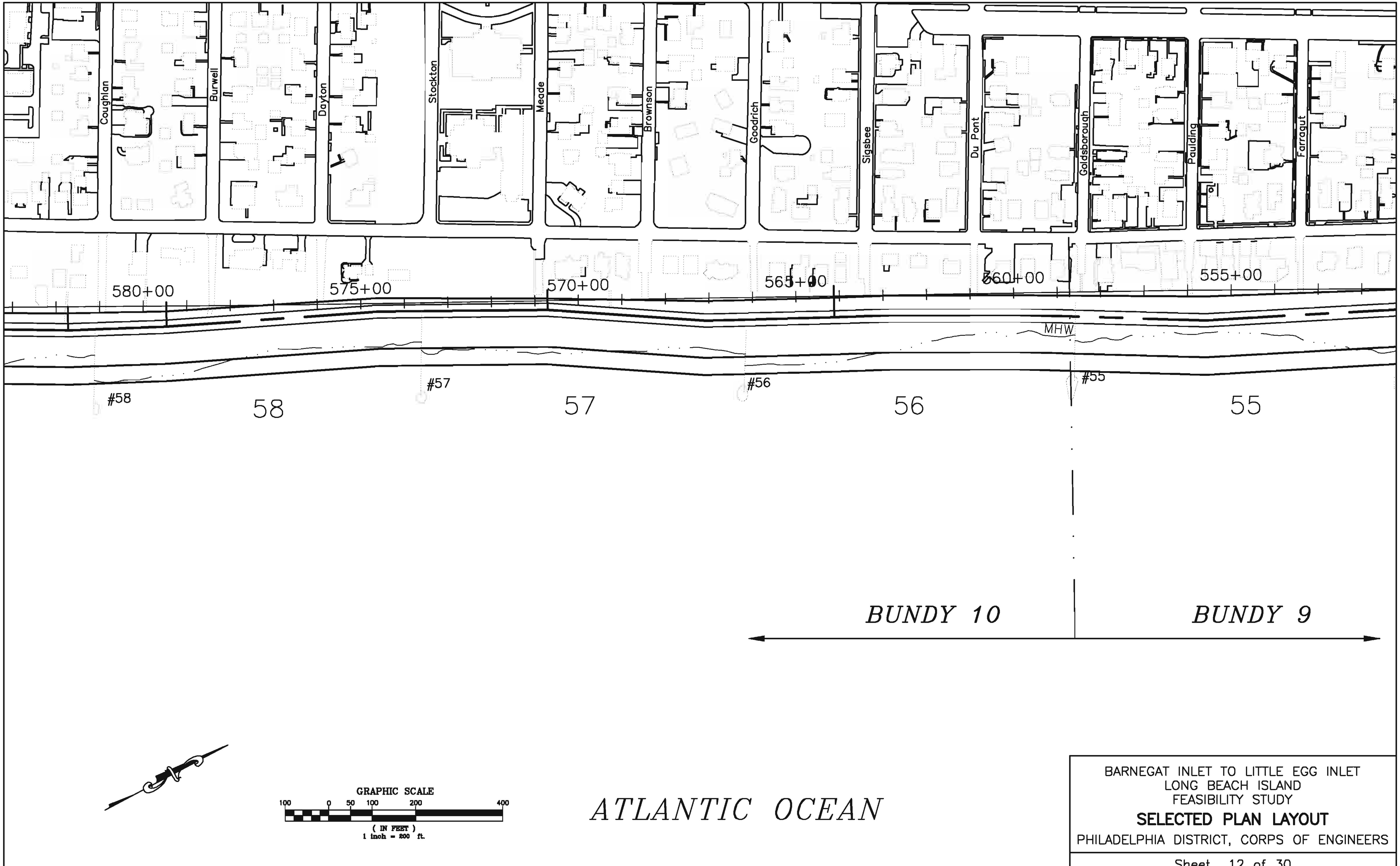


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 11 of 30

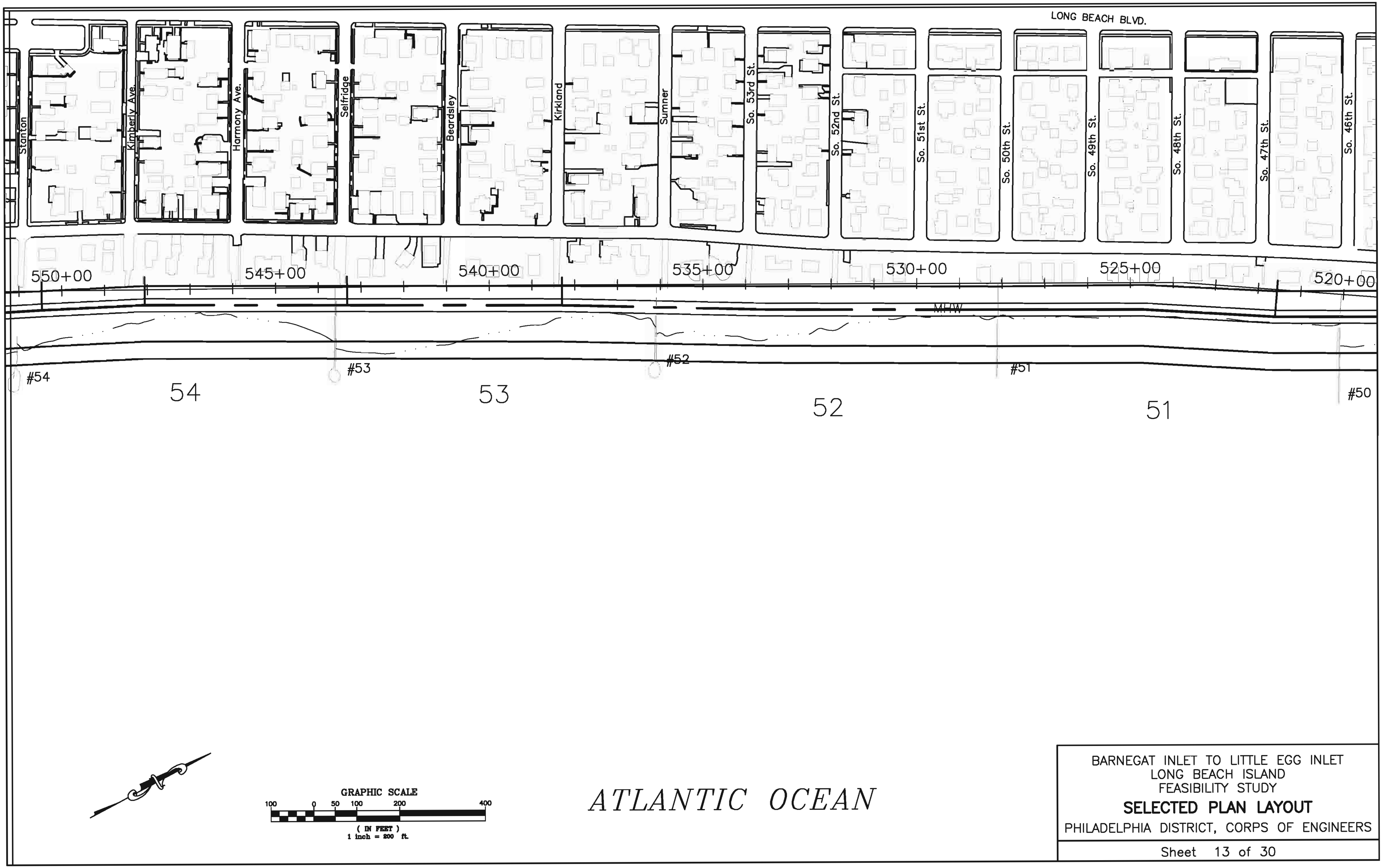


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 12 of 30

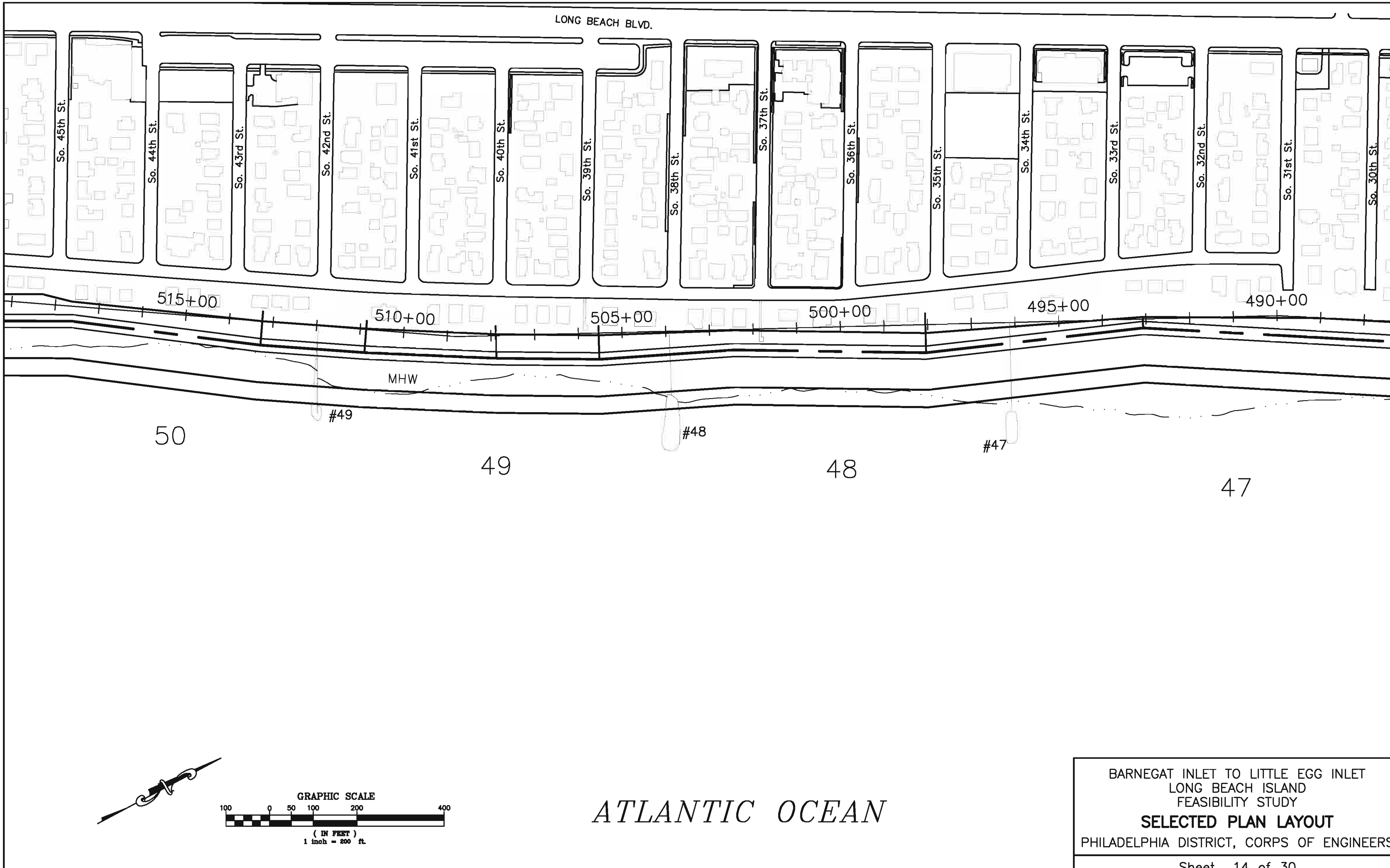


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 13 of 30

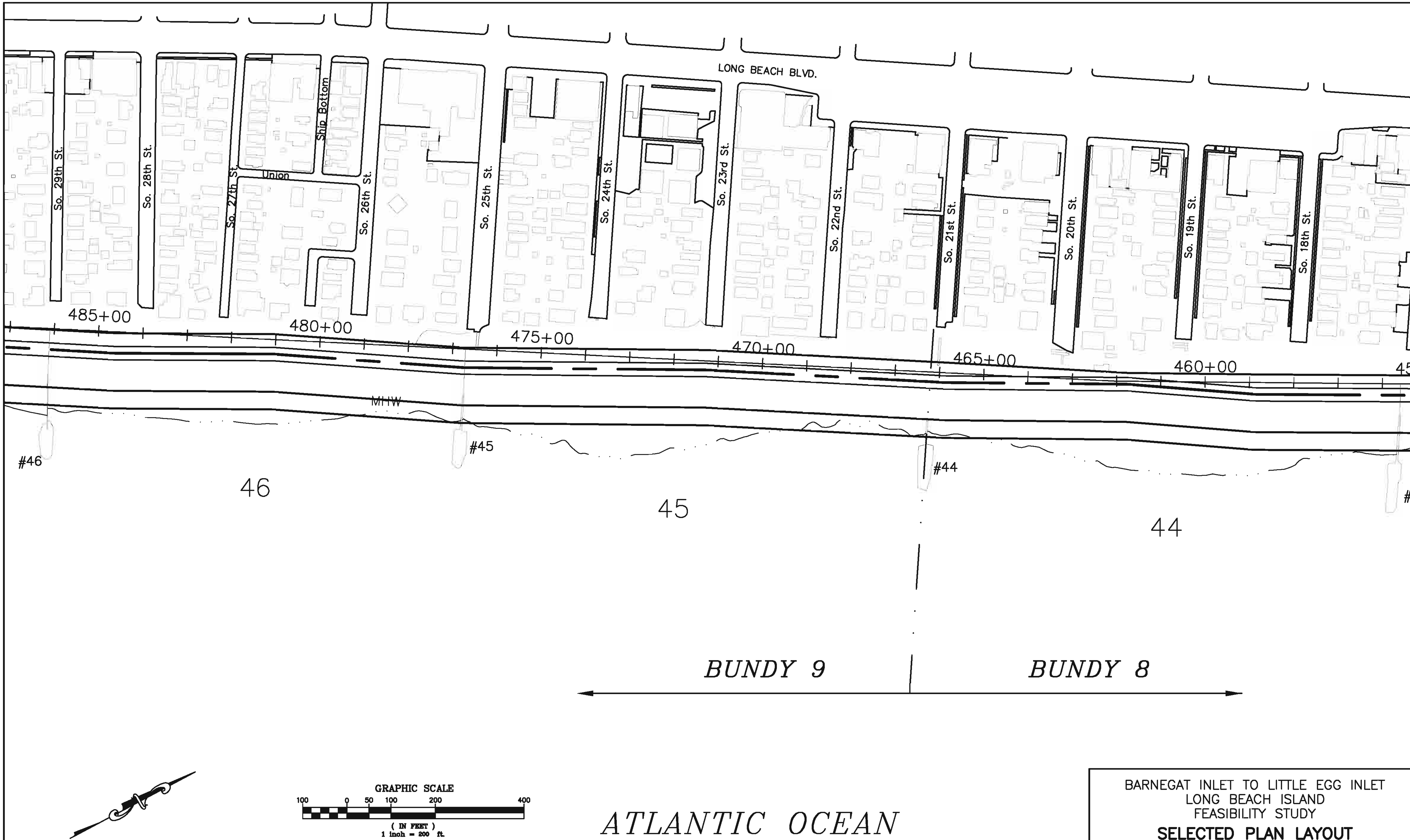


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 14 of 30

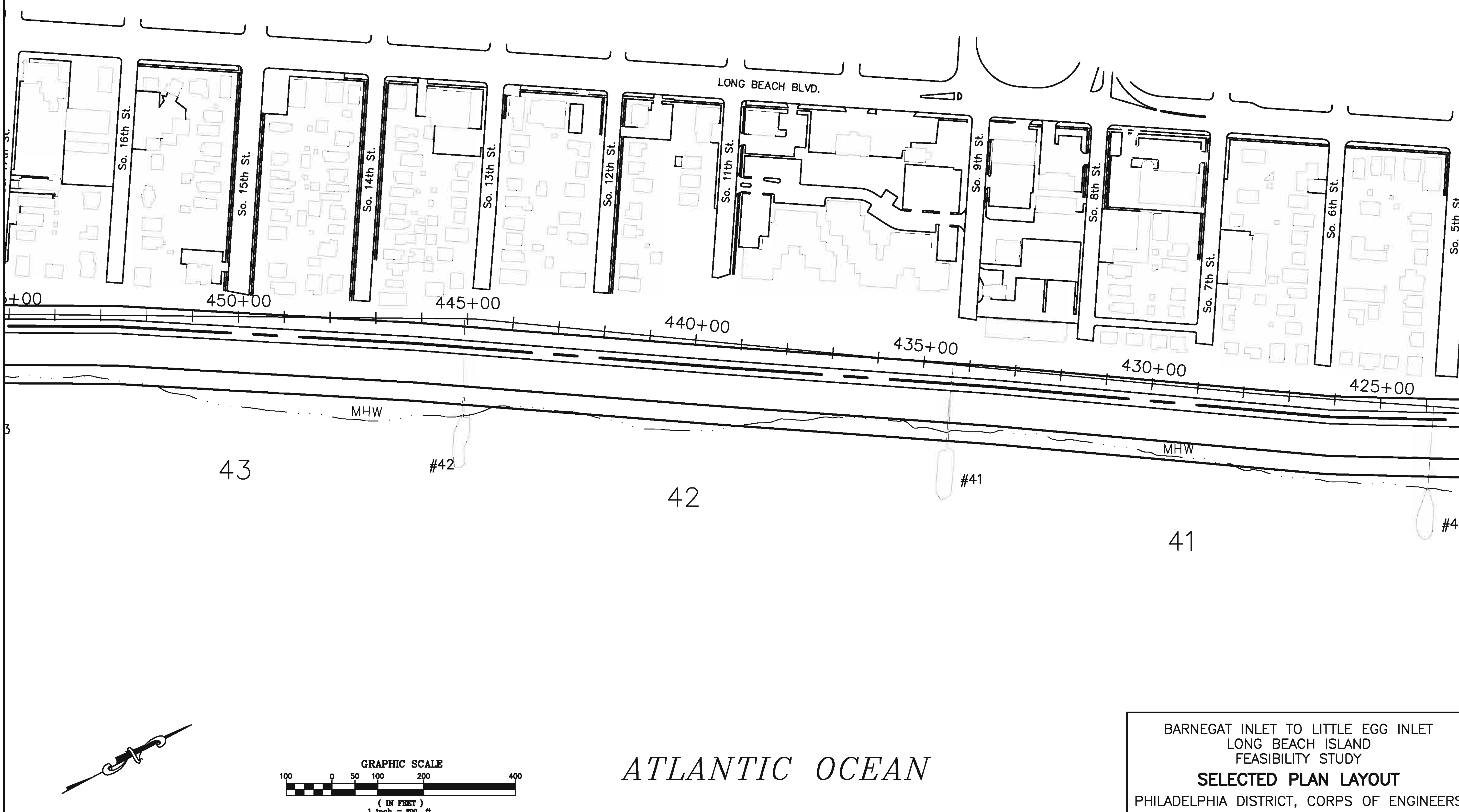


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 15 of 30



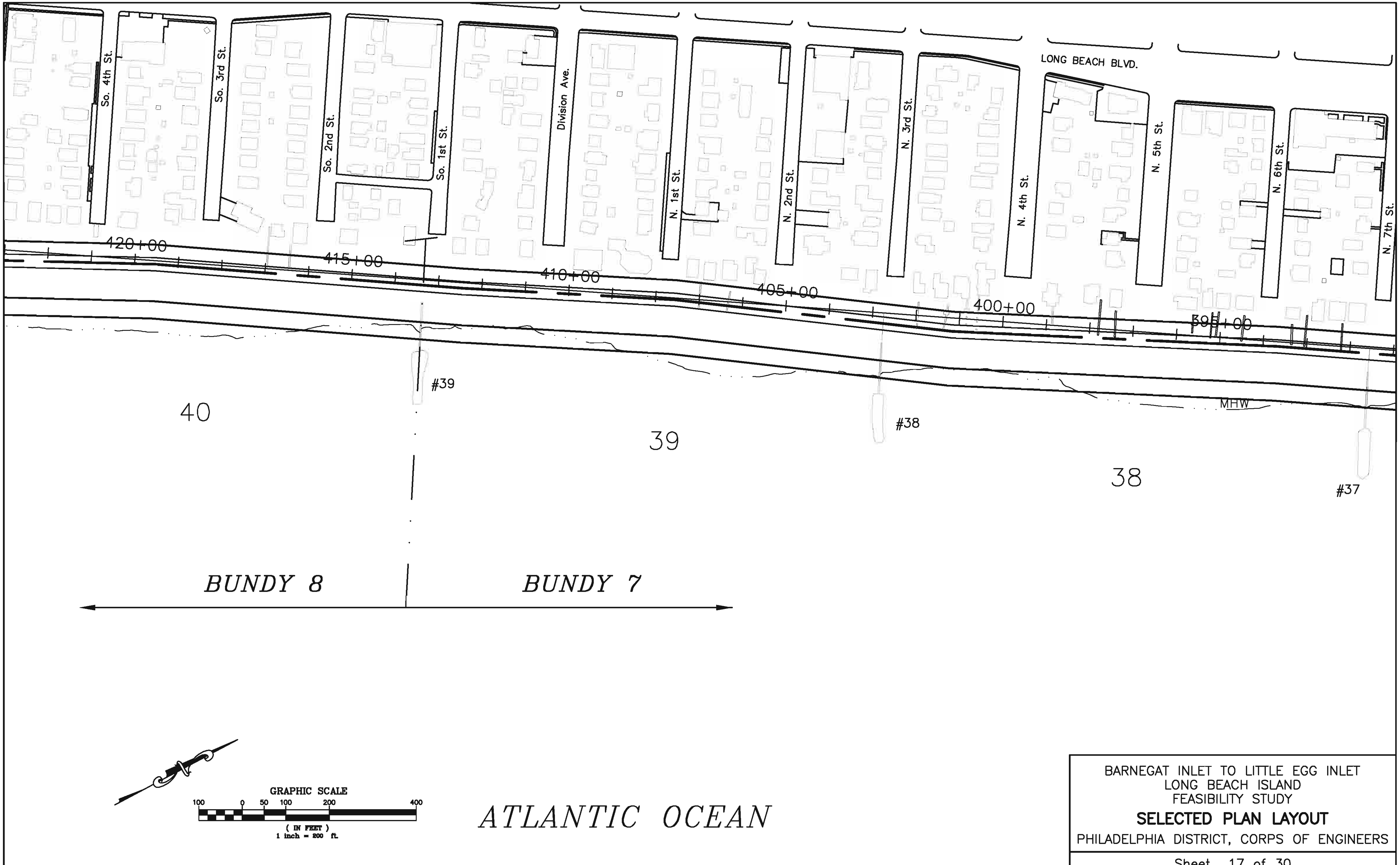
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 16 of 30

Figure 5 – 16

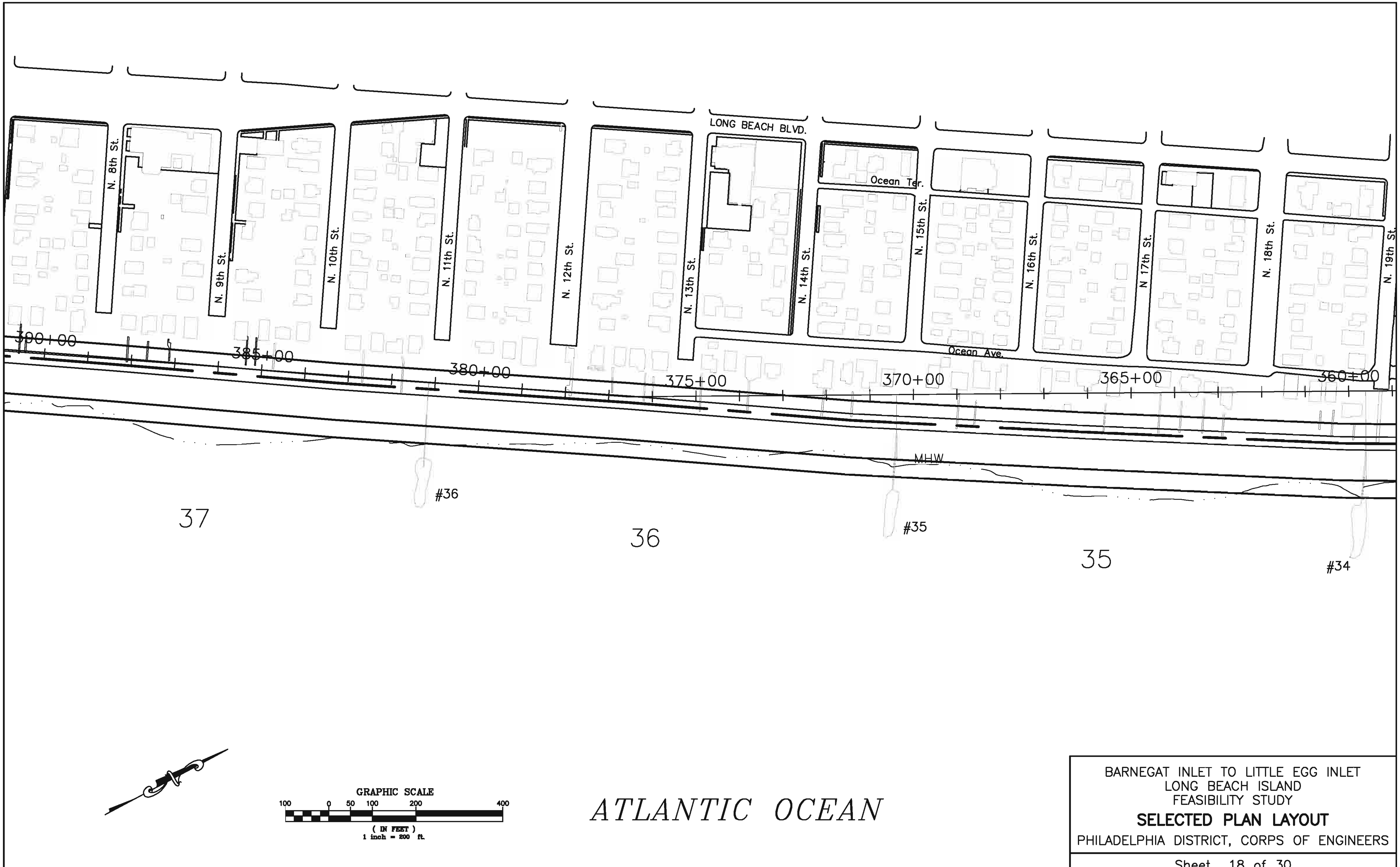


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 17 of 30



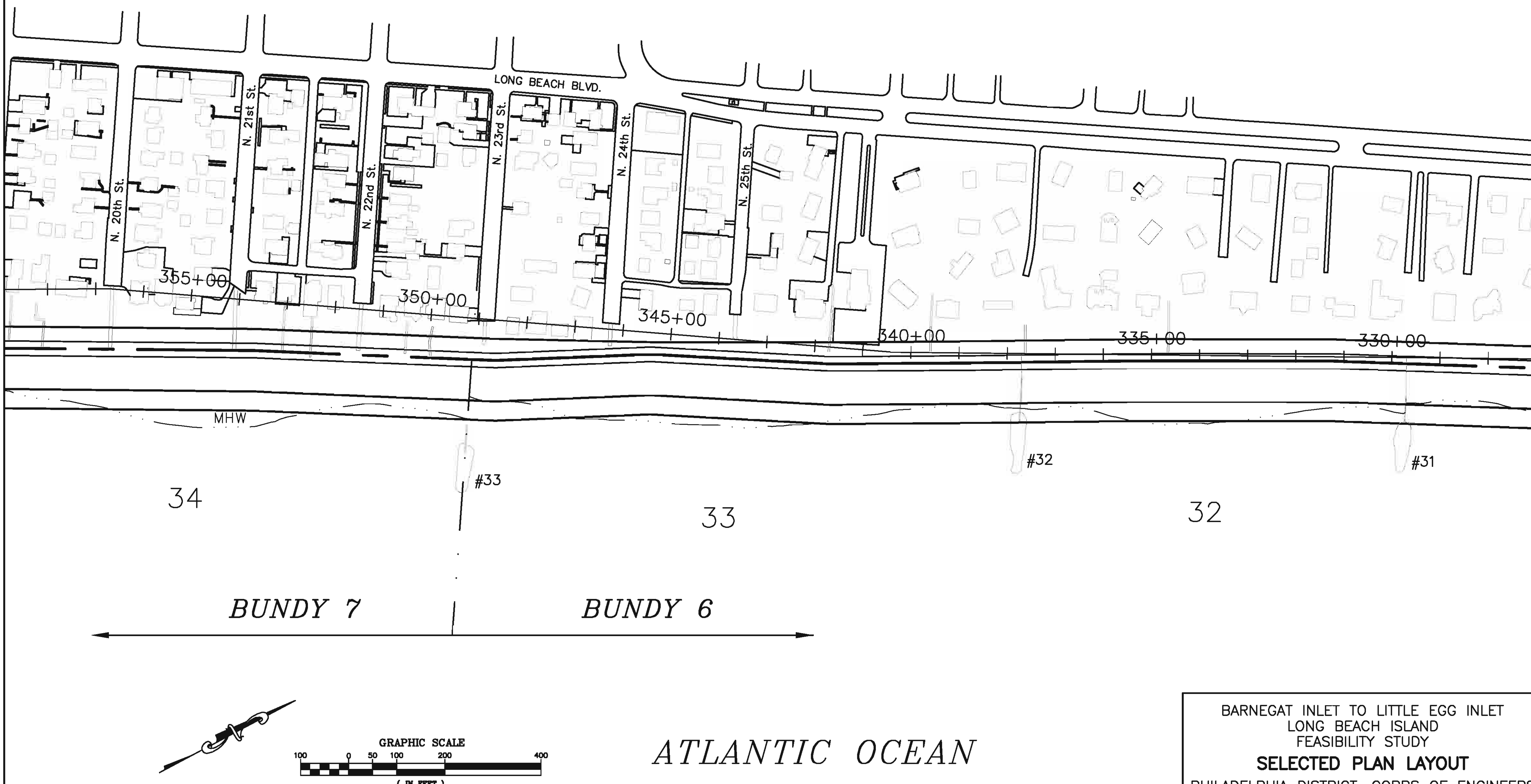
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 18 of 30

Figure 5 – 18

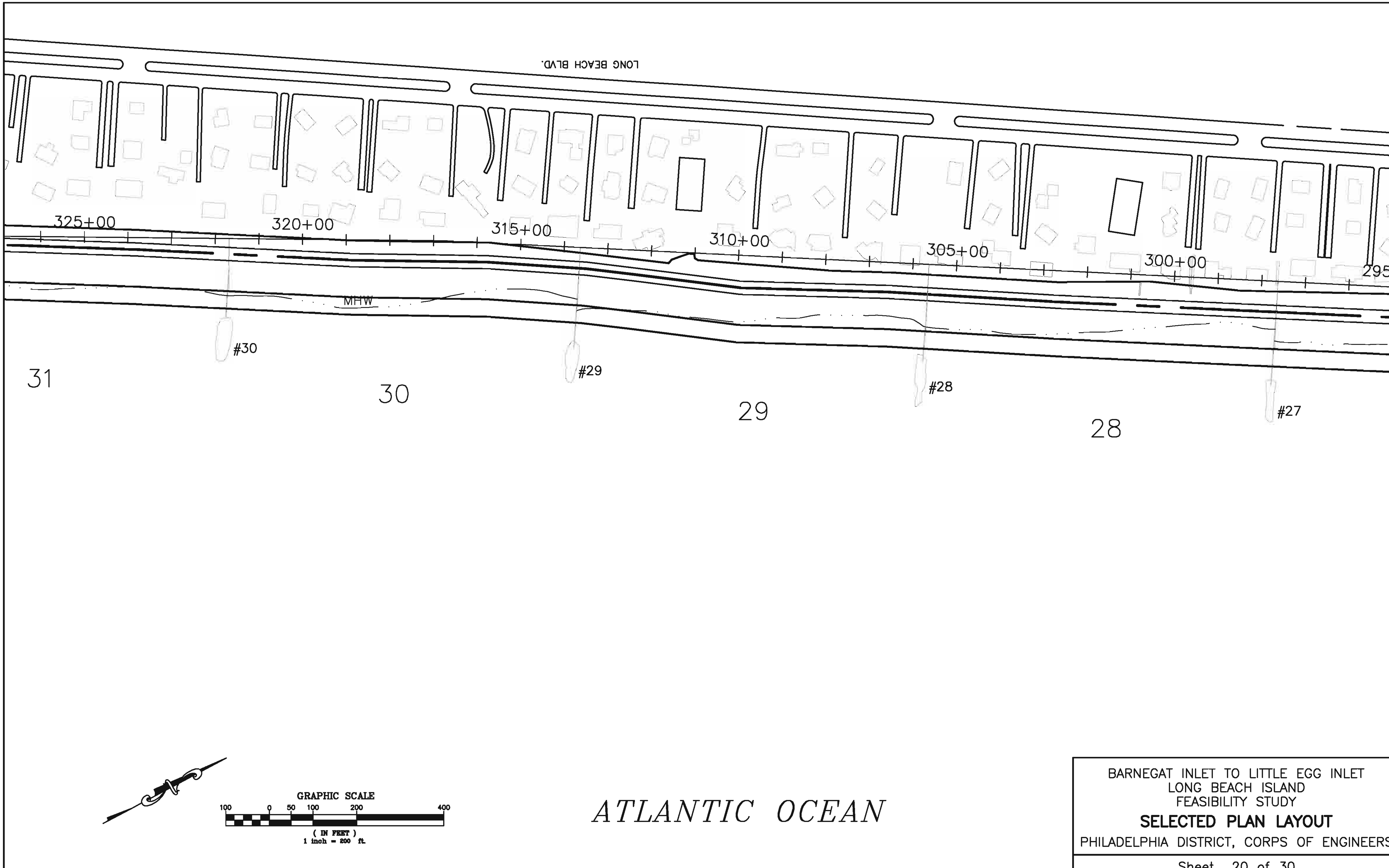


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 19 of 30

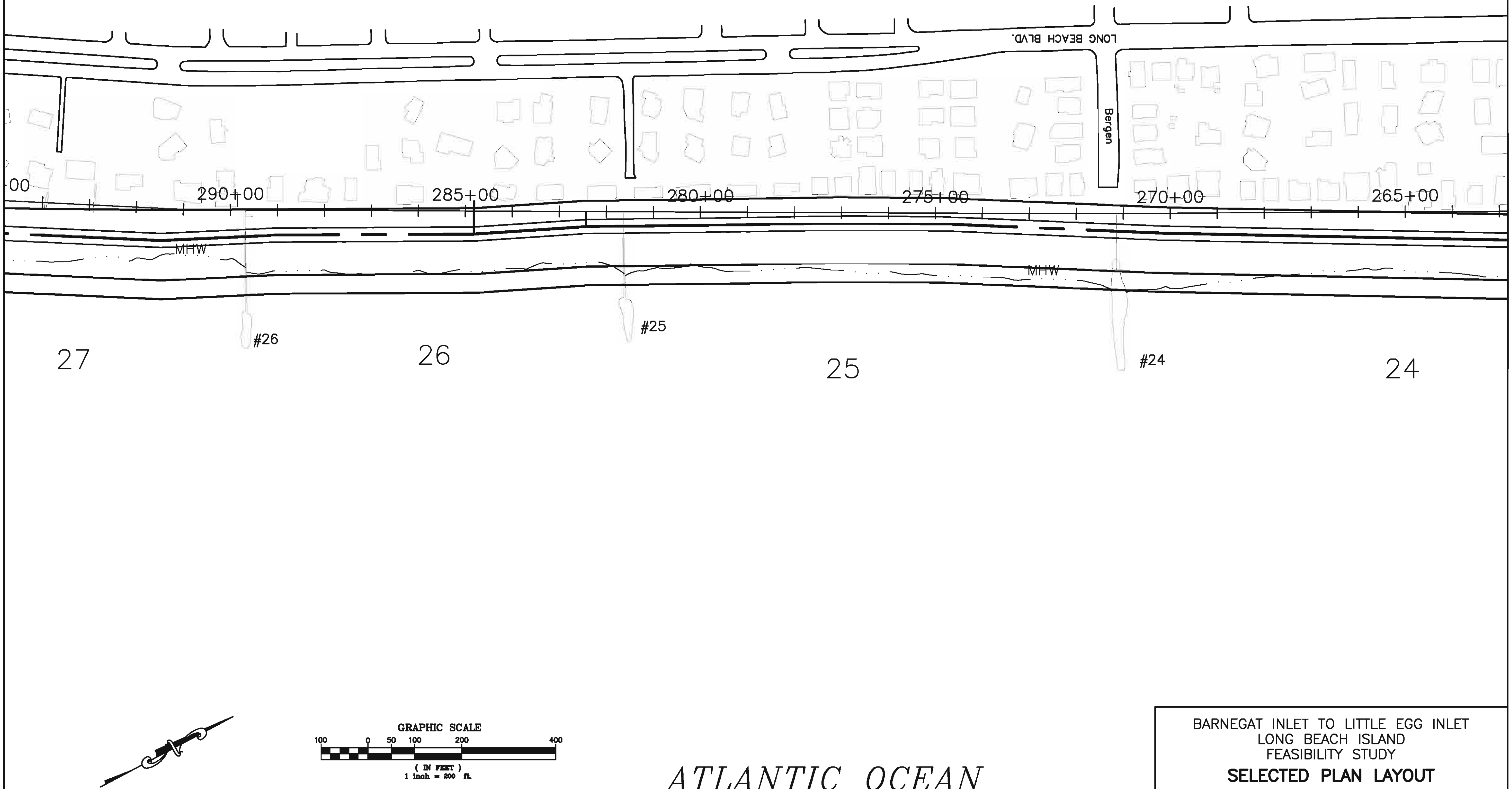


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 20 of 30



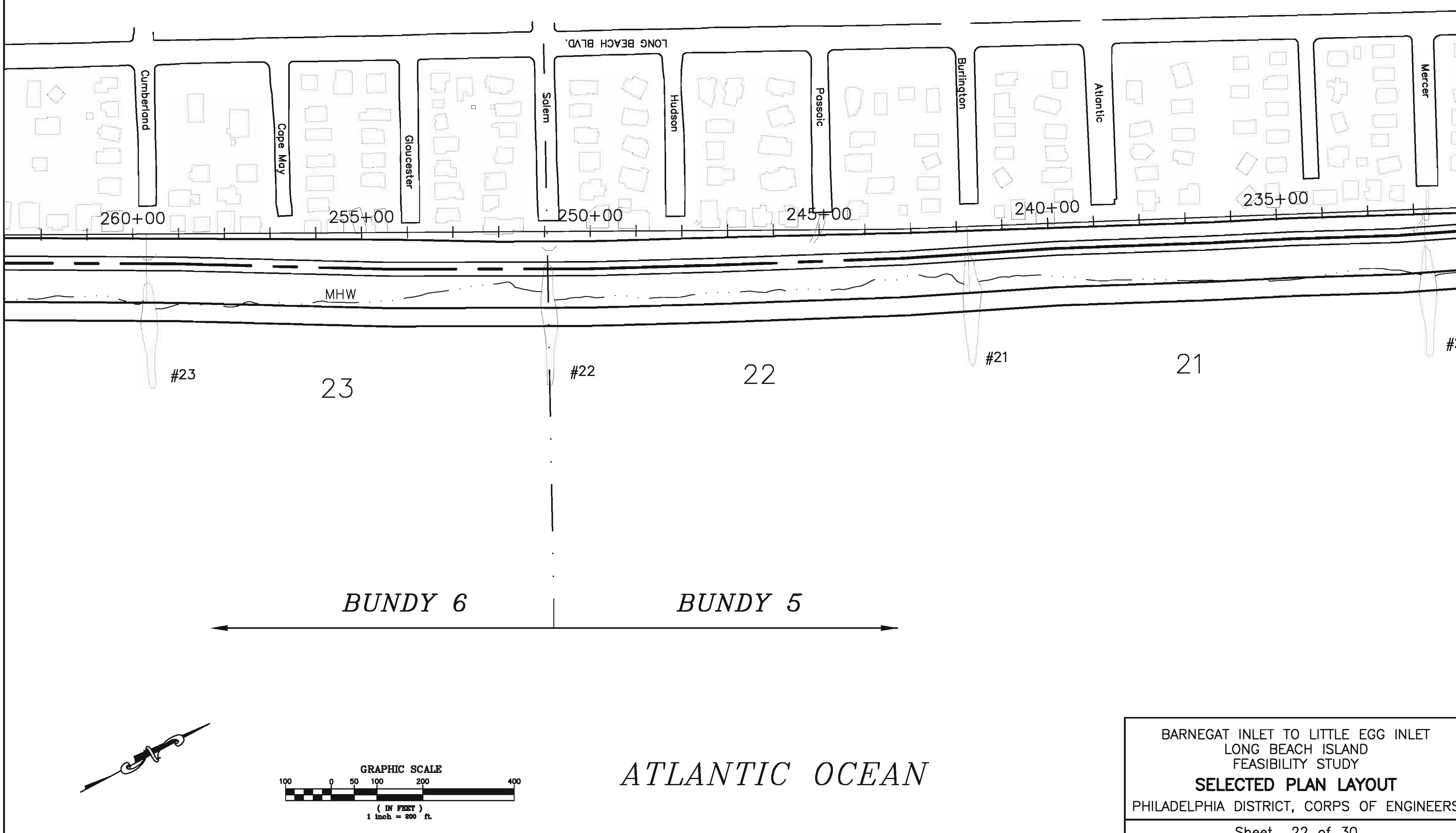
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 21 of 30

Figure 5 – 21



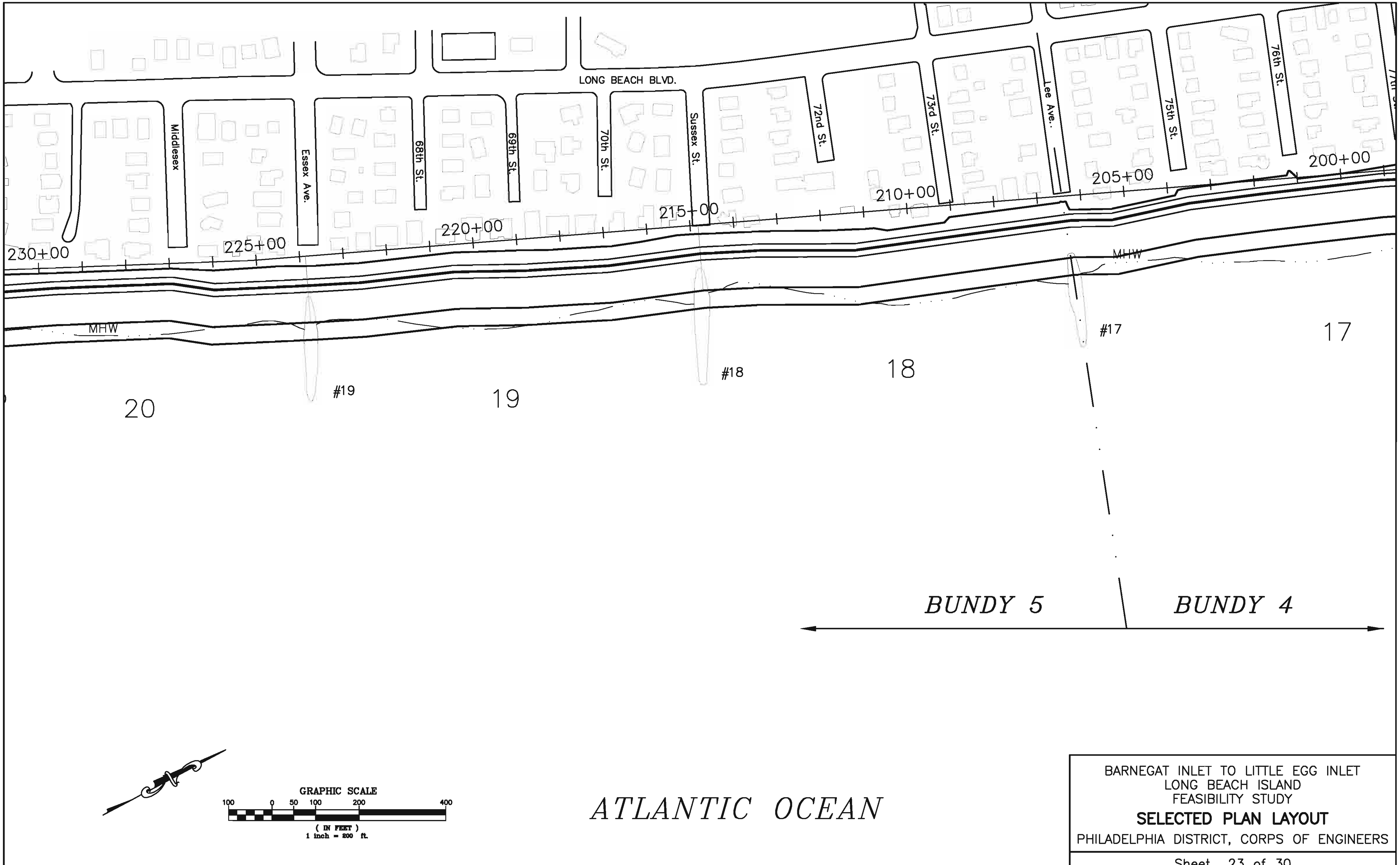
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 22 of 30

Figure 5 – 22

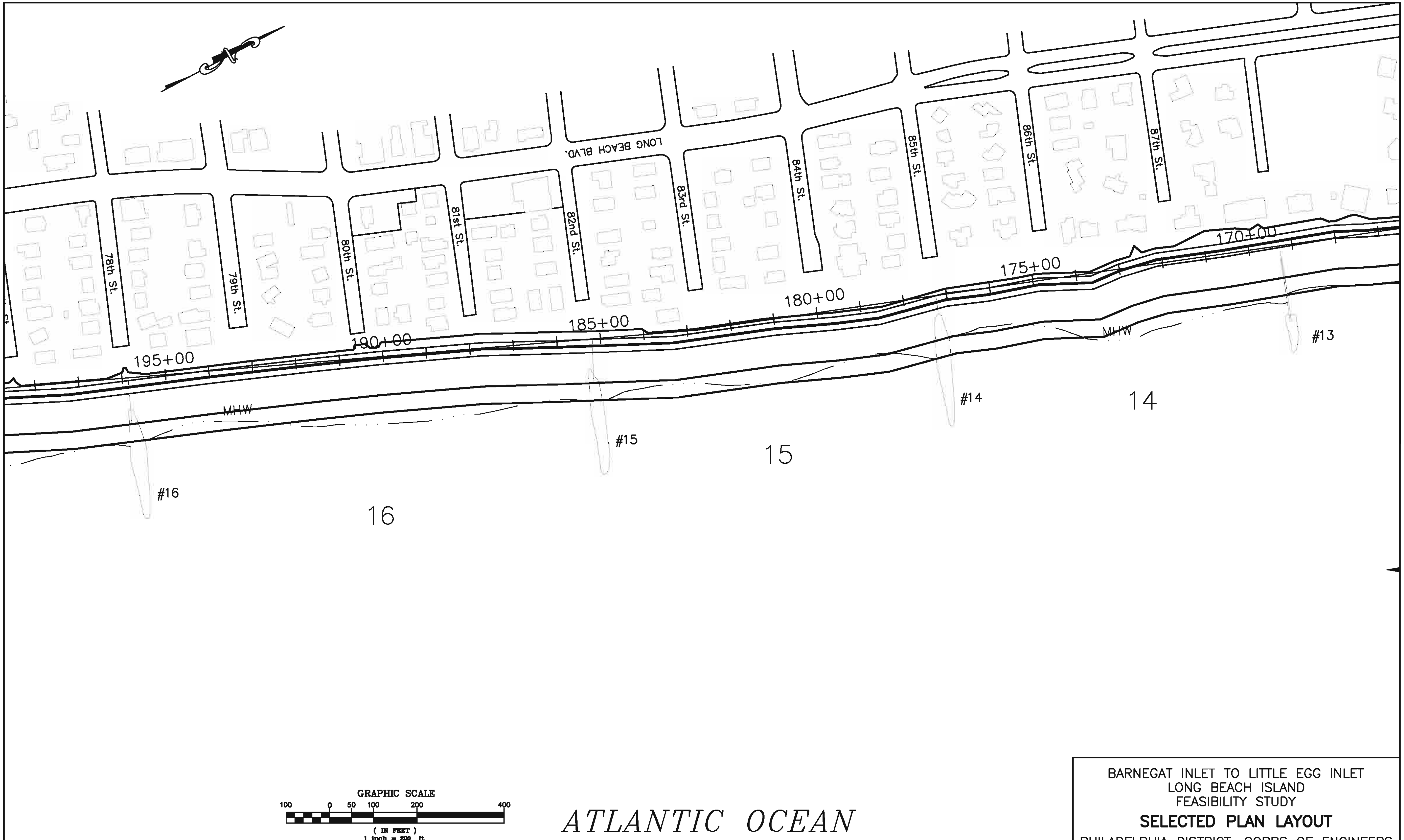


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 23 of 30

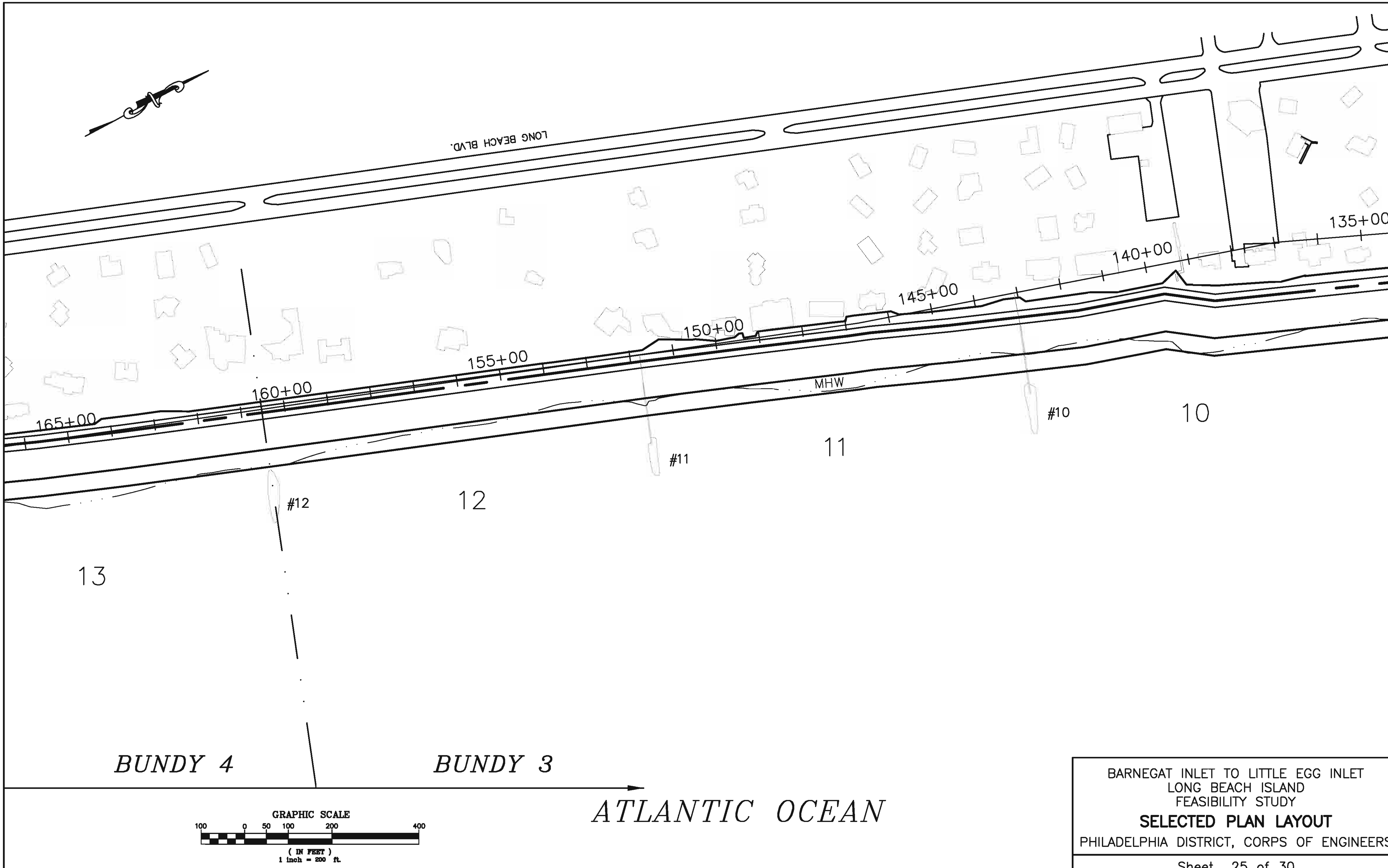


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 24 of 30

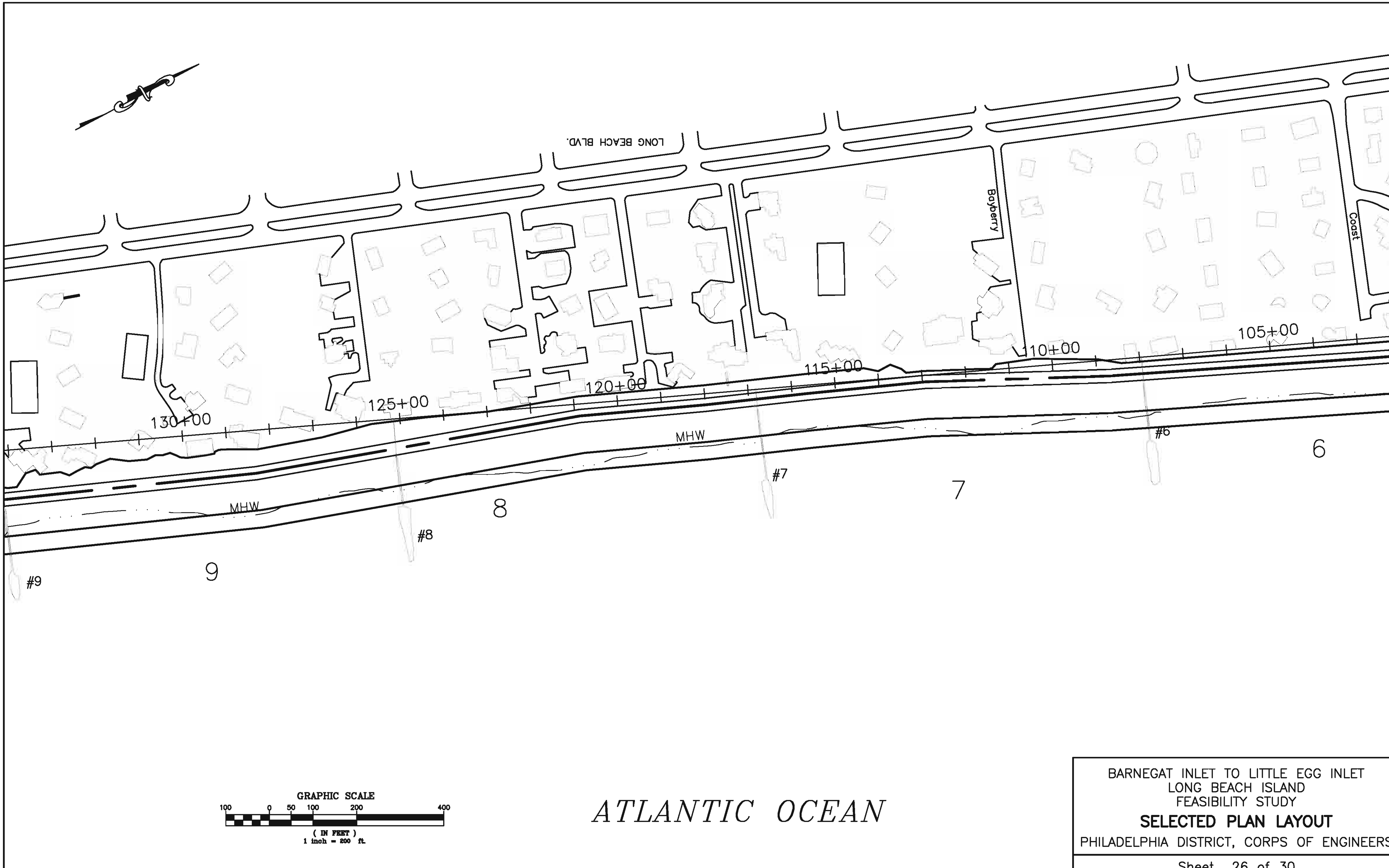


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 25 of 30

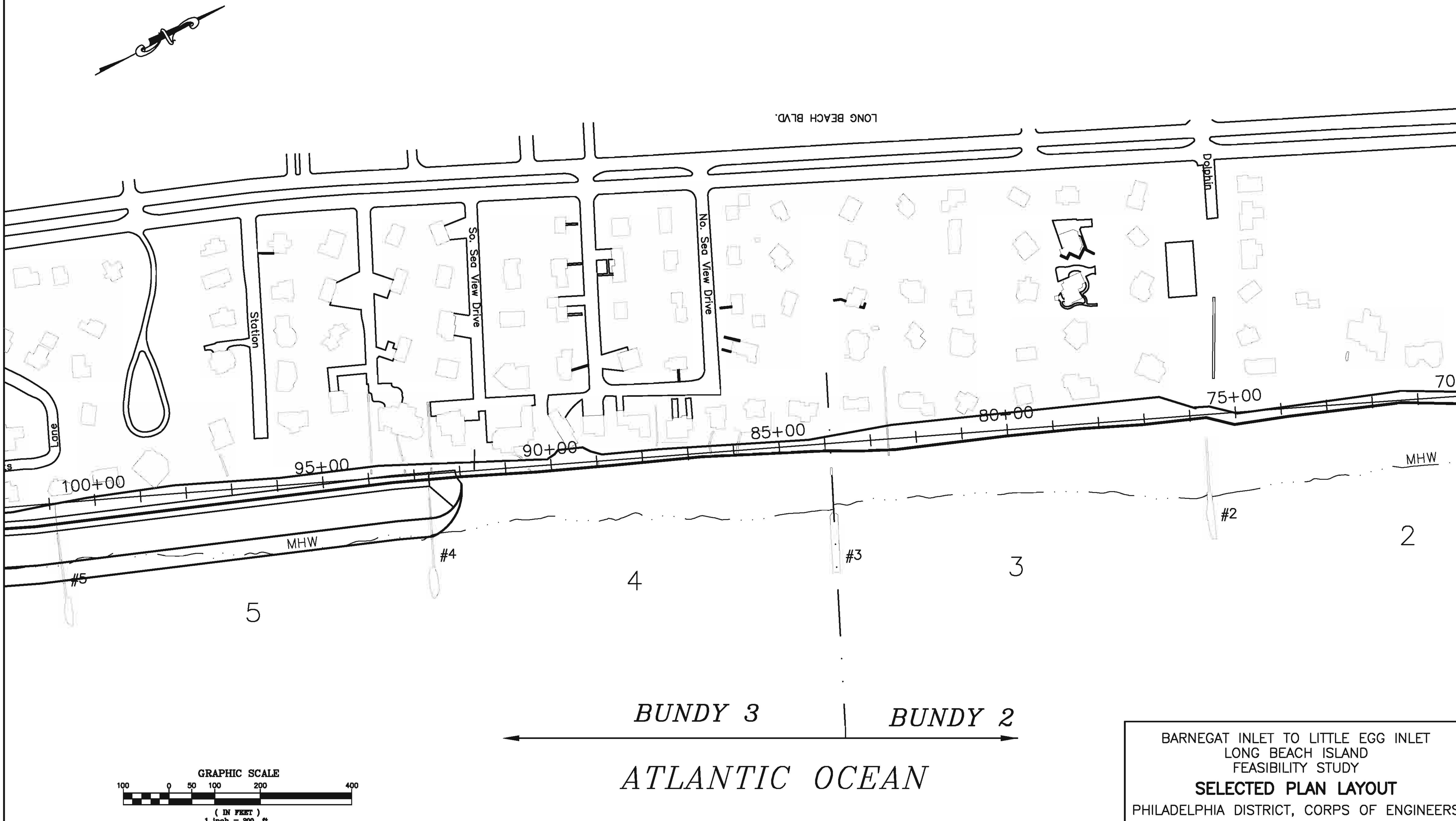


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 26 of 30

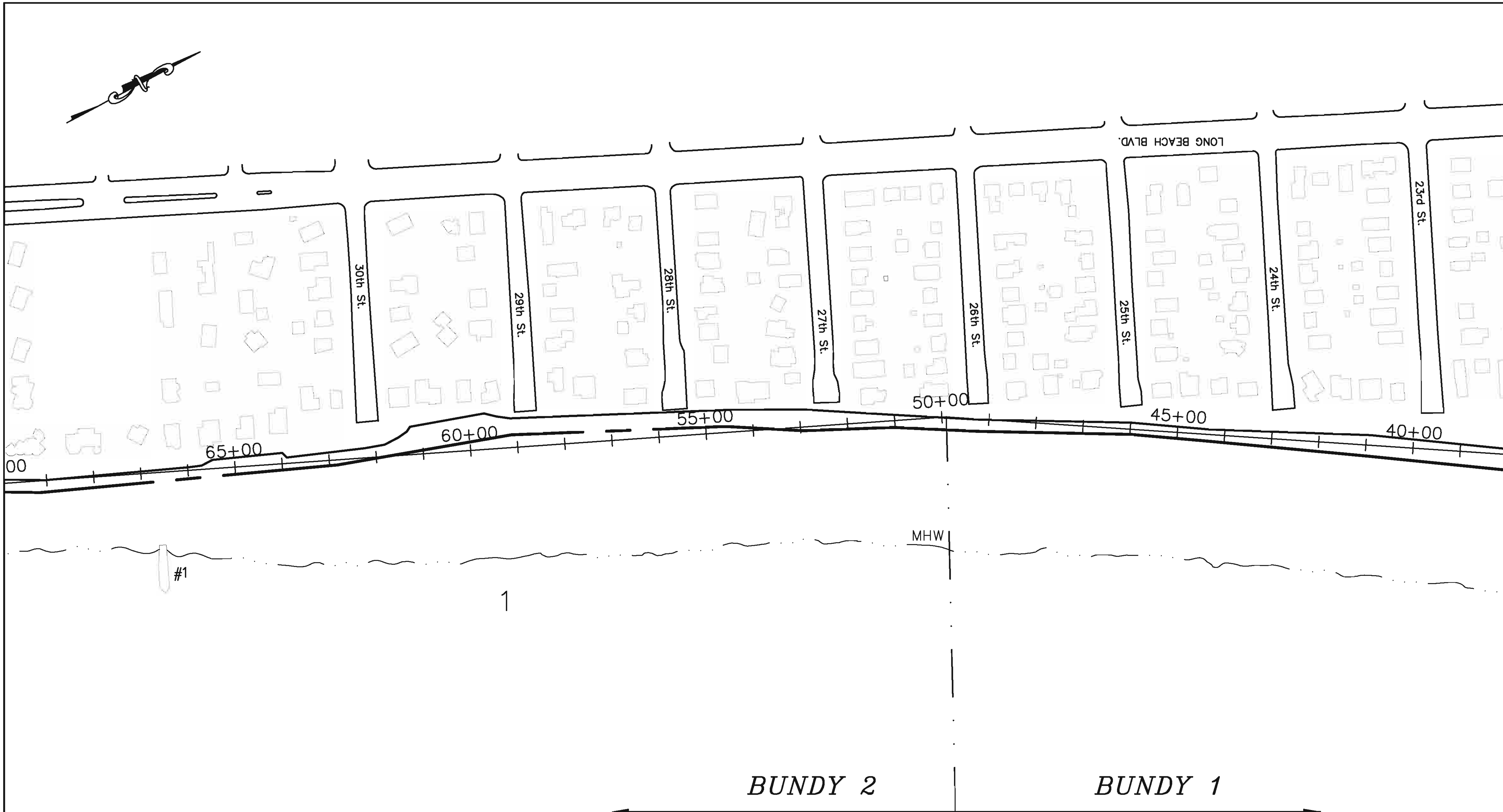


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 27 of 30



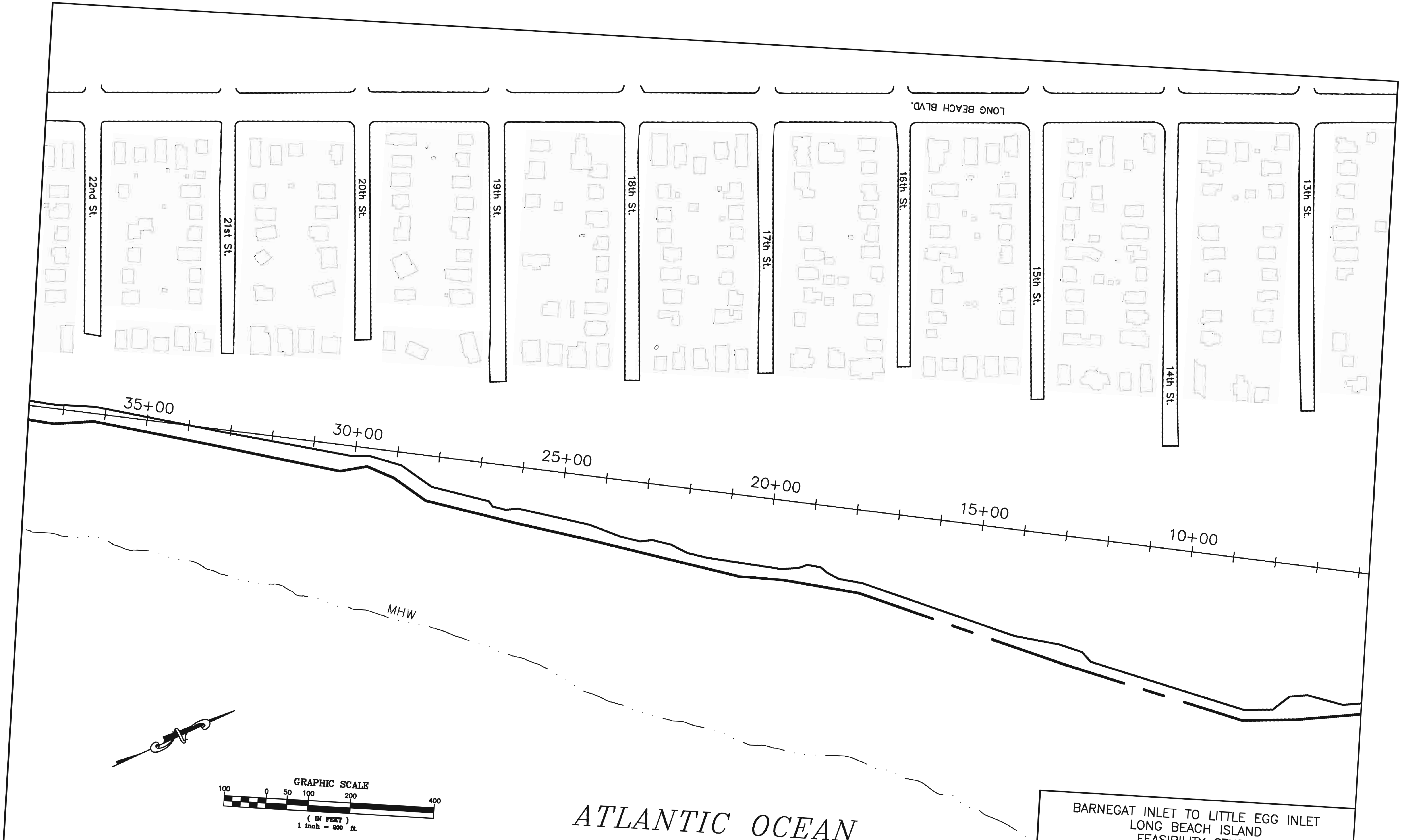
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 28 of 30

Figure 5 – 28

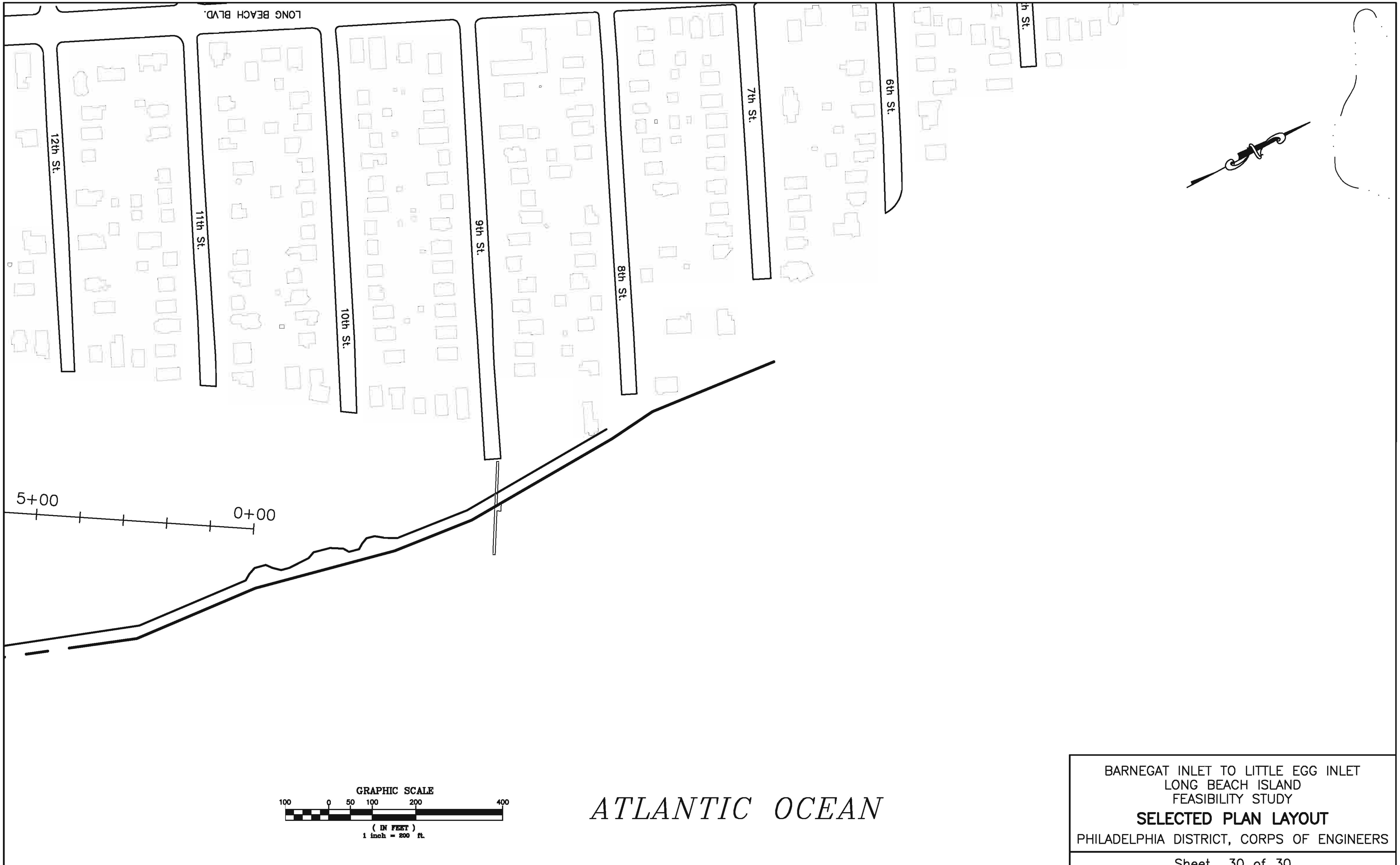


BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 29 of 30



BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY

SELECTED PLAN LAYOUT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

Sheet 30 of 30

Figure 5 – 30

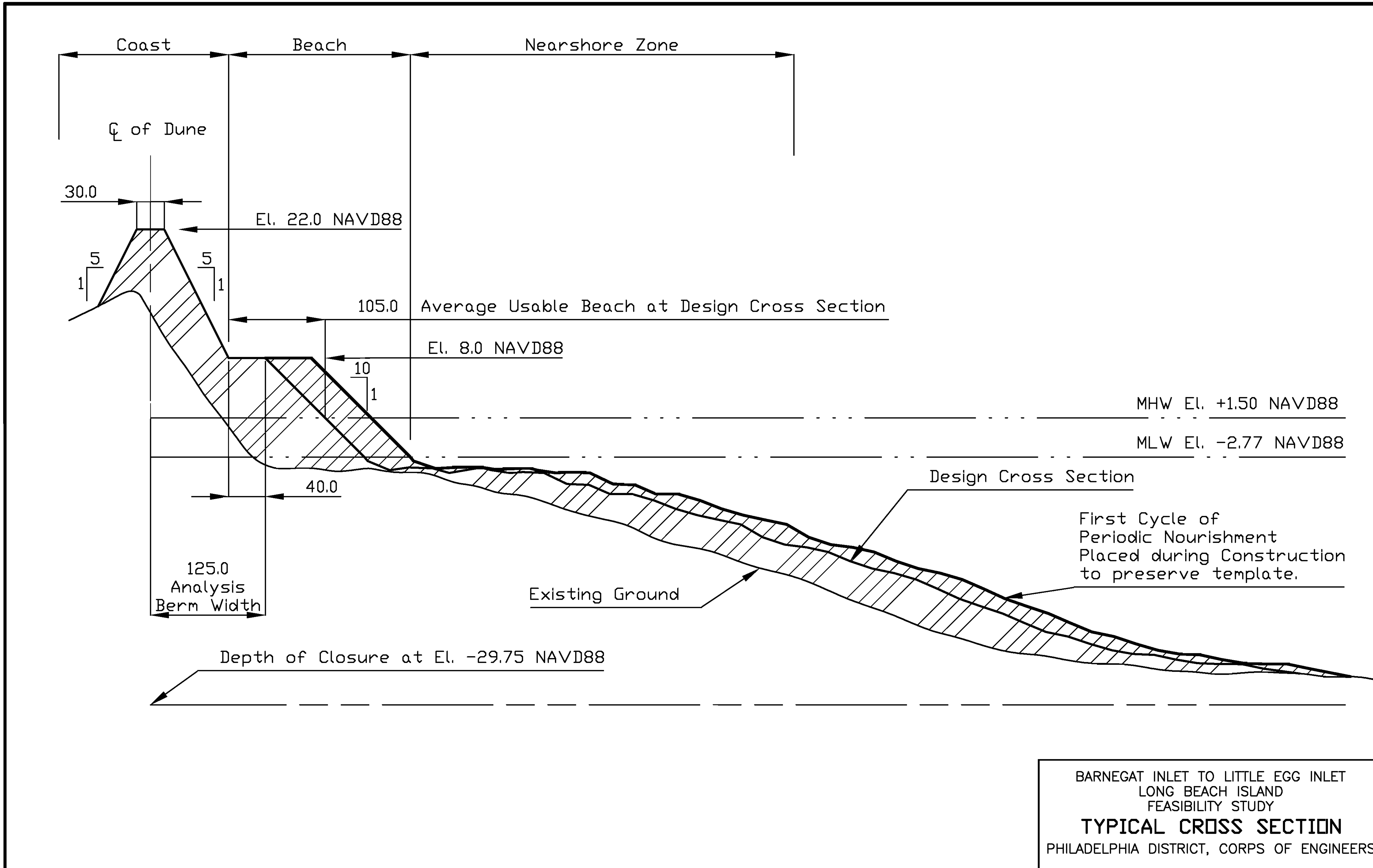
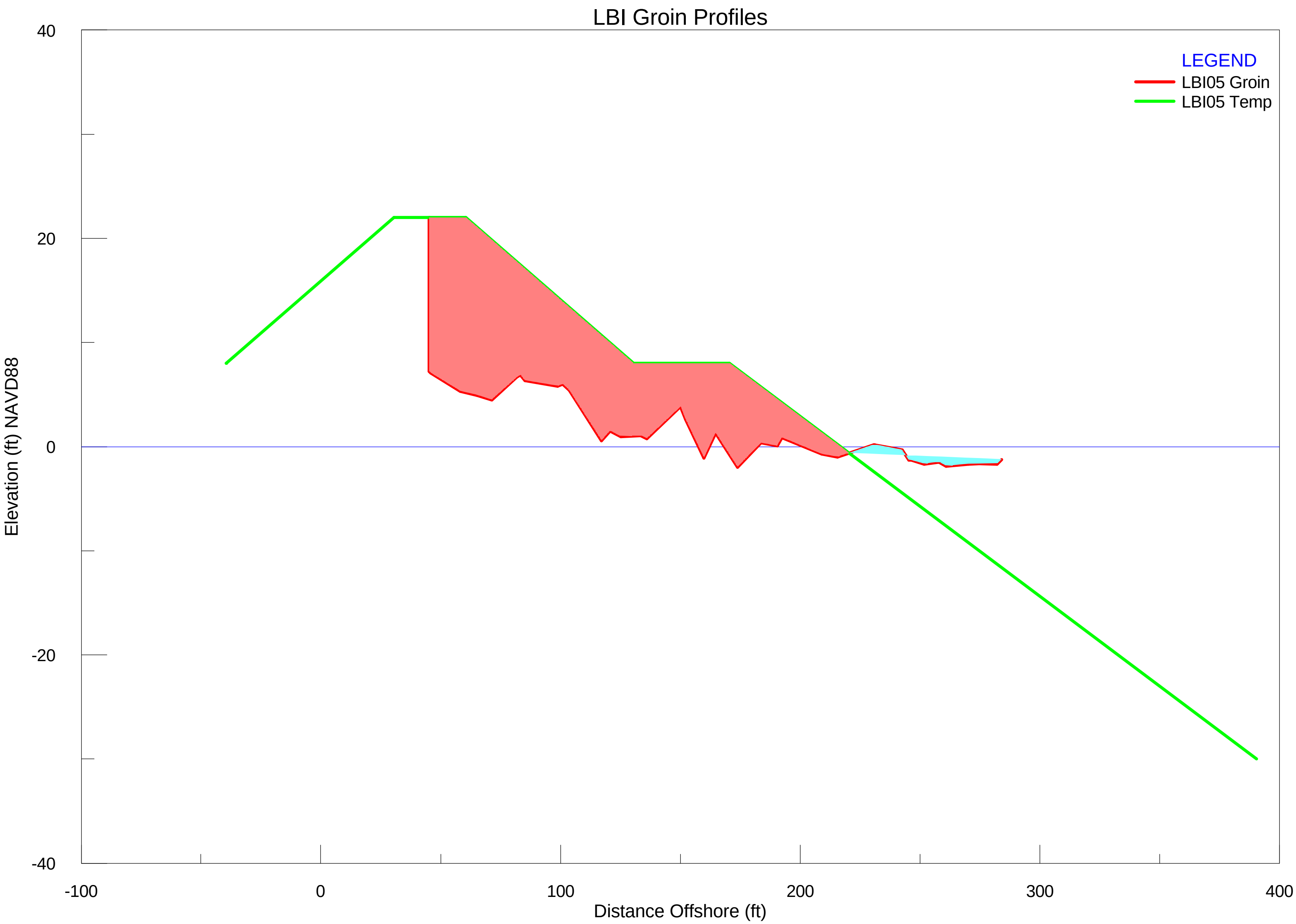
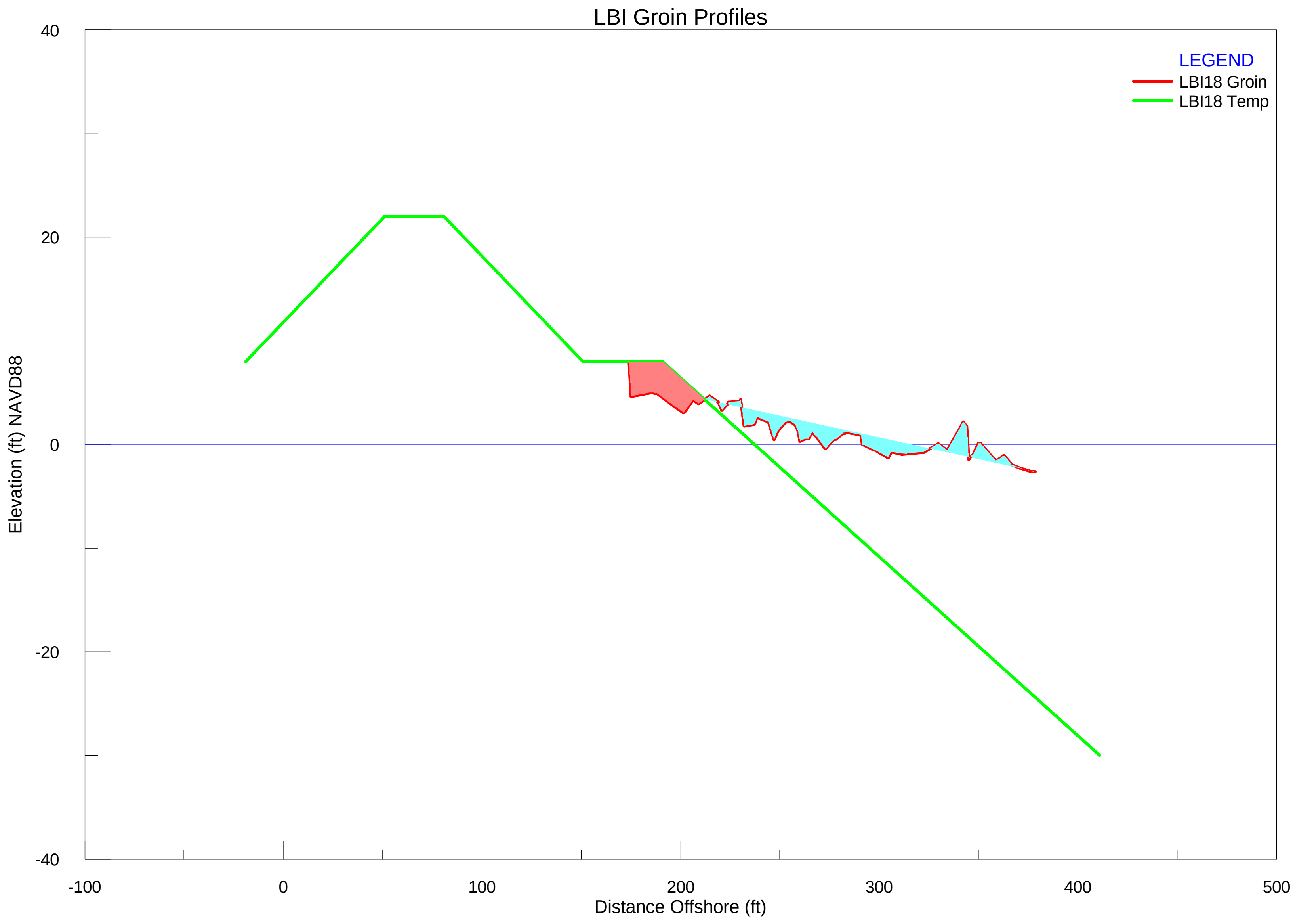

Coast
Beach
Nearshore Zone
℄ of Dune
30.0
El. 22.0 NAVD88
5
1
5
1
105.0
Average Usable Beach at Design Cross Section
El. 8.0 NAVD88
10
1
MHW El. +1.50 NAVD88
MLW El. -2.77 NAVD88
Design Cross Section
40.0
First Cycle of
Periodic Nourishment
Placed during Construction
to preserve template.
125.0
Analysis
Berm Width
Existing Ground
Depth of Closure at El. -29.75 NAVD88
BARNEGAT INLET TO LITTLE EGG INLET
LONG BEACH ISLAND
FEASIBILITY STUDY
TYPICAL CROSS SECTION
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

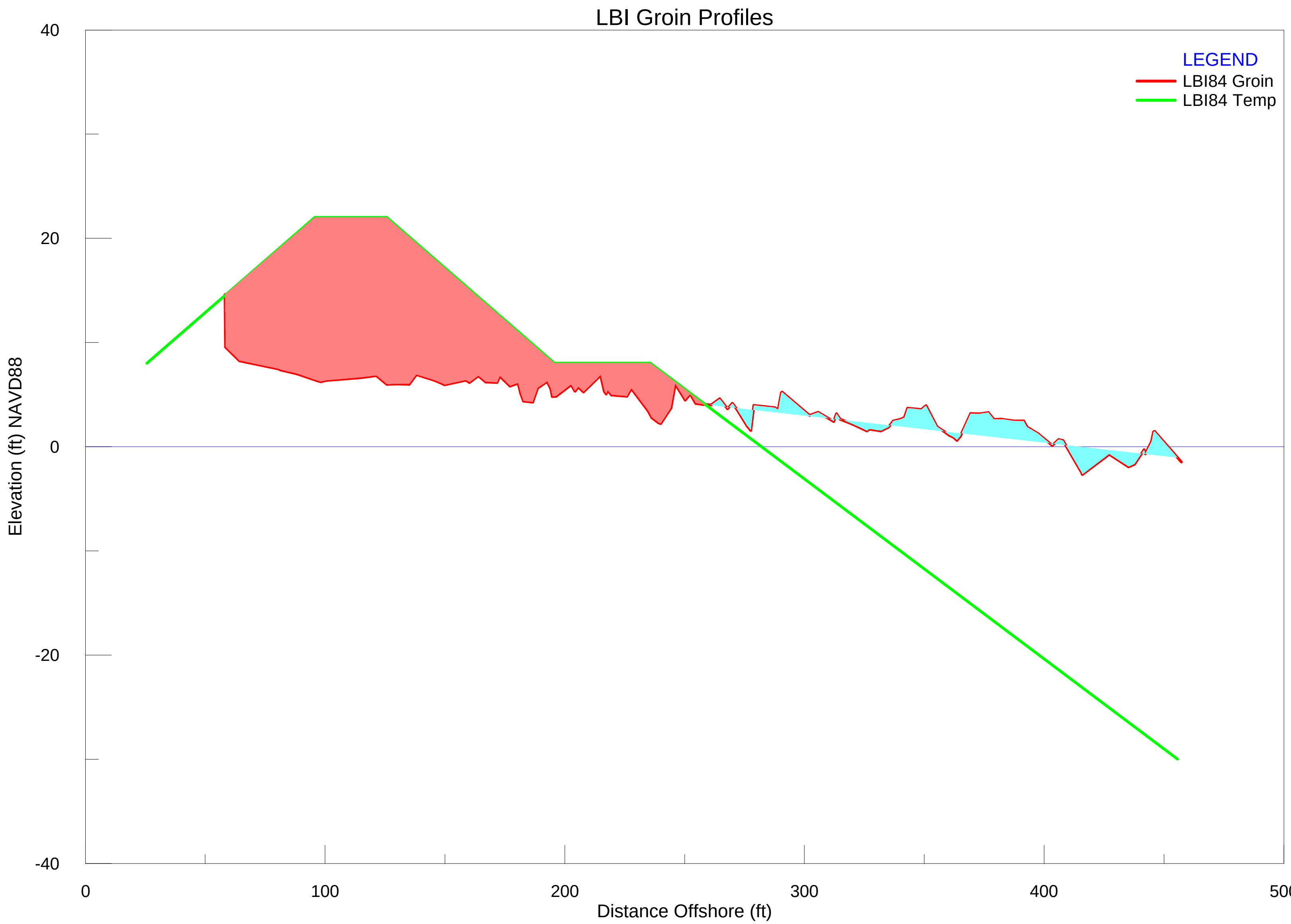
Figure 5-31



LBI Groin Profiles
LEGEND
LBI05 Groin
LBI05 Temp
40
20
0
-20
-40
Elevation (ft) NAVD88
-100
0
100
200
300
400
Distance Offshore (ft)



LBI Groin Profiles
LEGEND
LBI18 Groin
LBI18 Temp
Elevation (ft) NAVD88
40
20
0
-20
-40
-100
0
100
200
300
400
500
Distance Offshore (ft)



LBI Groin Profiles
LEGEND
LBI84 Groin
LBI84 Temp
Elevation (ft) NAVD88
40
20
0
-20
-40
0
100
200
300
400
500
Distance Offshore (ft)

5.3 PROJECT IMPACTS TO ENVIRONMENTAL RESOURCES

SUMMARY OF ENVIRONMENTAL EFFECTS OF THE SELECTED PLAN AND PLAN ALTERNATIVES

Environmental Consequences: The alternatives that were considered for further investigation as part of Cycle 3 (Table 4-2) plus the No-Action alternative, (Section 4.1 through 4.9) were examined for their environmental consequences. These alternatives are berm only, berm and reinforced dune, bulkheads, groin modifications, nearshore feeder berm, submerged reef structures, sand recycle system, and the selected plan-berm and dune restoration. As part of the berm and dune restoration approximately 1,030.85 acres would be covered, of these, approximately 365.10 acres would be above mean high water (MHW) and 665.75 acres would be below MHW. The elevation of MHW is 1.5 ft in NAVD datum. The above surface areas extend from the inland toe of dune to MHW and from MHW to depth of closure of -29.0 ft NAVD.

Water Quality:

No-Action: The No-Action alternative should not have an effect on water quality in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. With the eventual failure of these structures would come an increased contact with non-point source pollution from the surrounding areas. These sources would allow heavy metals, pesticides, fertilizers, discarded oils, detergents, yard wastes, petroleum products, animal wastes, and debris to enter the water.

Berm Only: The berm only alternative might have a short-term effect on turbidity levels, during both excavation of borrow sites, and the placement of sand along the shore. Elevated levels of particulate concentrations at the discharge location might also result from a washout after beachfill is placed. The high energy of the ocean should carry the limited turbidity out of the area in a short time period. High turbidity levels can stress aquatic organisms by clogging respiratory organs. The turbidity might also decrease hunting capacity of visual predators. Reilly *et al.* 1983 determined that high turbidity could inhibit recruitment by pelagic larval stocks. In addition, midwater nekton like finfish and mobile benthic invertebrates might migrate outside the area where turbidity and deposition occurs.

Short-term adverse impacts to water quality in the immediate vicinity of dredging can occur. Aquatic ecosystems concentrate biological and chemical substances such as organic matter, nutrients, heavy metals, and toxic chemical compounds in bottom sediments. When introduced to the water column, these substances tend to bind with suspended particulate matter and eventually settle to the bottom. Dredging operations typically elevate levels of suspended particulate in the water column through excessive agitation of the sediment. Adverse impact to the water quality might include oxygen depletion and the release of chemical substances, making them biologically available to aquatic organisms through ingestion or respiration.

The borrow material is not expected to be chemically contaminated. The use of sand, coupled with the absence of nearby dumping activities, industrial outfalls, or contaminated water infer the low probability that borrow material is contaminated by pollutants. The amount of turbidity and its associated plume is mainly dependent on the grain size of the material. Generally, the larger the grain sizes the smaller the area of impact. The period of turbidity is also less with larger grain sized materials. The proposed borrow areas contain medium to fine sands. Turbidity resulting from the re-suspension of these sediments is expected to be localized and temporary in nature. Utilization of a hydraulic dredge with a pipeline delivery system would help minimize the impact.

This alternative should have limited or no impact on pH, nutrient levels, bacteria, or DO. It also should not change the New Jersey classification of the water as approved for the harvest of oysters, clams, and mussels.

Berm and Reinforced Dune: The effects of this alternative are the same as the berm only alternative.

Bulkheads: Bulkhead placement should have no effect on turbidity levels during the limited excavation and the placement of timbers. Any bulkhead that would be constructed would be placed above the high tide line. The use of a proper erosion and sediment control plan during the construction phase would prevent any runoff from the site.

Groin Modifications: Groin modification might have a short-term effect on turbidity levels during the limited excavation and placement of timbers and rocks. The high energy of the ocean should carry the limited turbidity out of the area in a short time period. High turbidity levels can stress aquatic organisms by clogging respiratory organs. The turbidity might also decrease hunting capacity of visual predators. If groins are notched, the removal of the material should be done during low tide to limit the amount of disturbance to the water column. This alternative should have limited or no impact on pH, nutrient levels, bacteria, or DO. It also should not change the New Jersey classification of the water as approved for the harvest of oysters, clams, and mussels.

Nearshore Berm: The effects of this alternative are similar to those of the berm only alternative. Since the placement of sand is completely below low tide there would be a greater amount of "washout". Also since this is a source of sand for the beach there would be a continued increased turbidity level as the nearshore berm is eroded down.

Submerged Reef Structures: This alternative would have a limited and short-term effect on water quality. Placement of the reef would stir up bottom sediments. The high energy of the ocean should carry the limited turbidity out of the area in a short time period. It also should not change the New Jersey classification of the water as approved for the harvest of oysters, clams, and mussels.

Sand Recycle System: This alternative would have a prolonged but minimal effect on water quality. The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. The system moves sand by combining sand with water to form a slurry for pumping. A constant input of particles to the water column would occur during the pumping time. Nourishment requirements of the area served by the system are estimated between 300,000 and 750,000 cu/yd per 7-year cycle. Since this is a high-energy beach there is already a significant amount of sand in the water column. The additional sand should not be noticeable. The use of sand, coupled with the absence of nearby dumping activities, industrial outfalls, or contaminated water infer the low probability that borrow material would be contaminated by pollutants. It also should not change the New Jersey classification of the water as approved for the harvest of oysters, clams, and mussels.

Selected Plan - Berm and Dune Restoration: Berm and dune restoration might have a short-term effect on turbidity levels during both excavation of borrow sites and placement of sand along the shore. Elevated levels of particulate concentrations at the discharge location might also result from "washout" after beachfill is placed. The high energy of the ocean should carry the limited turbidity out of the area in a short time period. High turbidity levels can stress aquatic organisms by clogging respiratory organs. The turbidity might also decrease hunting capacity of visual predators. Reilly *et al*. 1983 determined that high turbidity could inhibit recruitment by pelagic larval stocks. In addition, mid-water nekton like finfish and mobile benthic invertebrates might migrate outside the area where turbidity and deposition occurs.

Short-term adverse impacts to water quality in the immediate vicinity of dredging can occur. Aquatic ecosystems concentrate biological and chemical substances such as organic matter, nutrients, heavy metals, and toxic chemical compounds in bottom sediments. When introduced to the water column, these substances tend to bind with suspended particulate matter and eventually settle to the bottom. Dredging operations typically elevate levels of suspended particulates in the water column through excessive agitation of the sediment. Adverse impact to water quality might include oxygen depletion and the release of chemical substances, making them biologically available to aquatic organisms through ingestion or respiration.

The borrow material is not expected to be chemically contaminated. The use of sand, coupled with the absence of nearby dumping activities, industrial outfalls, or contaminated water infer the low probability that borrow material is contaminated by pollutants.

This alternative should have limited or no impact on pH, nutrient levels, bacteria, or DO. It also should not change the New Jersey classification of the water as approved for the harvest of oysters, clams, and mussels.

Beach and Dune Habitat:

No-Action: The No-Action alternative would result in continued erosion and loss of the beach and dune environment. There would be a loss of habitat for some plant species.

Berm Only: The placement of sand on the berm might bury some plants. The berm is naturally a non-stable area. The few plant species that exist there are not found in large numbers. Recovery of plants would occur from wind blown seeds from nearby beaches, and would be no different from their recovery after a storm event.

Berm and Reinforced Dune: The placement of sand on the berm would bury some plants. The berm is naturally a non-stable area. The few plant species that exist there are not found in large numbers. The dunes are transient in nature also, but are stabilized by the plants that grow on them. The planting of beach grass and dune fencing would help stabilize the new dune. Recovery of other plants would occur from wind blown seeds from nearby beaches, and would be no different from their recovery after a storm event. The reinforced core of the dune would help prevent the loss of the whole dune and protect the plants that exist on the backside of those dunes.

Bulkheads: Bulkheads should have limited impact on the beach and dune habitat of the area. The bulkheads would only be placed in hot spot areas, which for the most part have all ready lost their dunes. The bulkhead would be used in combination with the overall dune and berm restoration plan.

Groin Modifications: This alternative should benefit the beach part of the beach and dune habitat. The modifications to the groins should limit the loss of sand from the system. This alternative would provide a more stable beach habitat.

Nearshore Berm: This alternative should benefit the beach part of the beach and dune habitat. The nearshore berm should provide sand to the system. This would provide a more stable beach habitat.

Submerged Reef Structures: This alternative should benefit the beach part of the beach and dune habitat. The submerged reef should lower the wave energy and the removal of sand from the system. This would provide a more stable beach habitat.

Sand Recycle System: The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. This alternative should benefit the beach part of the beach and dune habitat. The sand by-pass would provide sand to the system. This would provide a more stable beach habitat.

Selected Plan - Berm and Dune Restoration: The placement of sand on the berm would bury some plants. The berm is naturally a non-stable area. The few plant species that exist there are not found in large numbers. The dunes are transient in nature also, but are stabilized by the plants that grow on them. The planting of beach grass and dune fencing would help stabilize the new dune. Recovery of other plants would occur from wind blown seeds from nearby beaches, and would be no different from their recovery after a storm event.

<u>Intertidal and Nearshore Zone</u>:

No-Action: The no-action alternative should not have an effect on the intertidal zone in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur and create more intertidal area. This would eventually erode the shoreline back to man made structures. With the eventual failure of these structures would come an increased contact with non-point source pollution from the surrounding areas. These pollutants might adversely effect the invertebrate communities of the intertidal zone. Some contaminants may bioaccumulate up the food chain.

Berm Only: The berm only alternative and subsequent renourishment would bury infaunal organisms and might result in mortality within the intertidal and nearshore zones. The burial of the benthic community during placement activities in the intertidal and nearshore zone would cause a short-term impact. Most of the organisms inhabiting these dynamic zones are highly mobile and respond to stress by displaying large diurnal, tidal, and seasonal fluctuations in population density (Reilly *et al.,* 1983). Despite the resiliency of intertidal benthic fauna, the initial effect of beachfill would be the smothering and mortality of some of the existing benthic organisms in the intertidal zone. This would initially reduce species diversity and number of animals. The ability of a nourished area to recover depends heavily on grain size compatibility of material pumped on the beach (Parr *et al.,* 1978). Reilly *et al.,* (1983*)* concludes that nourishment initially destroys existing macrofauna. The recovery is usually rapid after pumping operations cease. Recovery of the macrofaunal component may occur within one or two seasons if borrow material grain sizes are compatible with the natural beach sediments. Results obtained from the intertidal and surf zone of Folly Beach, South Carolina indicated that beach nourishment had a very brief effect on the infaunal abundance and number of species in the benthic communities (Lynch, 1994). Recolonizing infauna was observed in substantial numbers one day after nourishment. The abundance and species assemblages were generally not different from pre-nourishment samples after three months. Recolonization depends on the availability of larvae, suitable conditions for settlement, mobile organisms from nearby beaches, vertical migration of organisms through the placement material, and mortality. However, the benthic community may be somewhat different from the original community. The seven-year nourishment cycle should allow recovery time for the intertidal areas. Geomorphological studies on the sediments within the proposed borrow sites indicate that there would be relatively low levels of fine sediments placed on the beaches of Long Beach Island, so the potential for recovery of the area is great.

Berm and Reinforced Dune: This alternative is similar in impact to the berm only alternative.

Bulkheads: This alternative should have no impact on the intertidal zone. The placement of bulkheads in hotspot areas would be above the high tide line.

Groin Modifications: Depending on the method of modification there may be an impact to the benthic community of the intertidal zone. The placement of stone at the seaward end of groins would eliminate the present sandy bottom habitat. The bottom topography would be changed and unrecoverable. A new type of benthic habitat would be created. Rocky intertidal habitat is rare in New Jersey waters. This new habitat would attract a different assemblage of benthic organisms. The notching of groins should not have any impact on the intertidal benthic community.

Nearshore Berm: This alternative is similar in impact to the berm only alternative. There would be a change in the offshore topography, but no change in the material that makes up the bottom. As with the berm only alternative, the recovery of a benthic community is expected to be rapid, but might be different due to the change in topography. Mounds are known to attract a variety of organisms and are known to concentrate larvae settlement.

Submerged Reef Structures: This alternative is similar in impact to the nearshore berm. Since the material is different than the existing material there would be an unrecoverable loss of sandy bottom habitat. A new type of benthic habitat would be created. Rocky intertidal habitat is rare in New Jersey waters. This new habitat would attract a different assemblage of benthic organisms.

Sand Recycle System: This alternative is similar in impact to the berm only alternative. The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. There would be a long-term impact of burial and disturbance since there would only be a short recovery time between pumping operations.

Selected Plan - Berm and Dune Restoration: This alternative is similar in impact to the berm only alternative.

Offshore Sand Habitat:

No-Action: This alternative would have no effect on the sand habitat of borrow areas, since these areas would not be disturbed.

Berm Only: The primary ecological impacts of dredging the sand borrow site would be the complete removal of the existing benthic community through entrapment into the dredge. Mortality of the benthic and epibenthic organisms would occur as they pass through the dredge and/or because of being transplanted into an unsuitable habitat.

Dredging of sediments from an offshore borrow area can have immediate localized effects on the benthic macroinvertebrate community and clam populations of the area. The most direct effect is the removal of the existing natural, established communities. Survival of organisms during dredging varies widely. Mechanical disturbance of the substrate may generate suspended sediments and increase turbidity near the dredging operation. Reduced penetration of light through the water can effect settlement of larvae by delaying their final descent and subjecting them to increased predation. Depth and tidal currents influence the spread of sediments and turbidity.

Another potential effect is habitat modification through alteration of the sediment substrate. Removal of the original substrate by dredging might uncover sediments that are different in composition and potentially unsuitable for the existing benthic community. Dredging could also alter the hydrodynamics of the area, which could effect sediment accumulation or scouring rates. Changing from coarse sand sediment to muddy sediment, for example, would significantly change the composition of the benthic assemblage at a site (Maurer *et al.*, 1978). The effect of changing from a muddy-sand to a sandy-mud would be less severe (Maurer *et al., 1978*).

Additional habitat modification could occur if the dredging design allows for creations of deep borrow pits. Dredging of these pits in some locales might create areas of summer hypoxia, which currently do not exist in the area. These pockets of low DO waters could have an adverse impact on the macroinvertebrate community. This could be avoided by designing an adequate dredging plan that avoids the creation of deep borrow pits. The intended design for dredging all the proposed borrow areas is to reduce existing elevations to surrounding bathymetry. No deep borrow pits will be created.

Besides the physically disruptive effects of dredging, a long-term environmental concern is the recolonization and resettling of the dredged area. The benthic community is decimated initially but resettling and recolonization can be fairly rapid, typically taking from three months to a few years for complete recovery (Saloman *et al.*, 1982; Van Dolah *et al*., 1984; Hirsch *et al*., 1978). Highly mobile organisms such as amphipods can escape to the water column and can directly resettle after dredging operations are complete (Conner and Simon, 1979). Mobile polychaetes are intermediate of amphipods and bivalves in their capacity to resettle directly after dredging. The least mobile organisms, such as bivalves, may initially be the most affected by dredging operations, although pelagic larvae of these species can cause high recruitment peaks, depending on the timing of dredging operations.

Larval recruitment and horizontal migration from adjacent, unaffected areas (Van Dolah *et al*., 1984, Oliver *et al*., 1977) initially recolonize the disturbed area. Initial recolonization is dominated by opportunistic taxa whose reproductive capacity are large, and flexible environmental requirements allow them to occupy disturbed areas (Boesch and Rosenberg, 1981; McCall, 1977). Recruitment of organisms with pelagic larvae that have one spring spawn a year can also be rapid, but is dependant on the timing of the dredging activity. With time (several months to several years), and if environmental conditions permit, the initial surface-dwelling opportunistic species would be replaced by benthic species that represent a more mature community (Bonsdorff, 1983).

Most of the dominant taxa of the four LBI borrow areas were smaller organisms such as the polychaetes, (*Polygordius* spp., *Mediomastus ambiseta*, and *Parapionosyllis longicirrata),* a small tanaid, (*Tanaissus psammophilus)*, and the small bivalves, (*Donax variabilis*, *Petricola pholadiformis*, and *Tellina agilis).* These species could easily recolonize after dredging operations (Scott and Kelly, 1988a). The mean number of large organisms within each LBI borrow area was not significantly higher that the reference areas, indicating that each site has good potential for reaching conditions similar to those occurring before dredging operations.

Additionally, the four LBI borrow areas do not appear to contain a unique or rare macroinvertebrate community that would preclude its use as a sand borrow source for beach nourishment and replenishment activities along the Long Beach Island coastline. The community composition of the borrow areas were similar to the surrounding reference area so recruitment after dredging activities should result in similar community patterns. Additionally, though diversity at the four borrow areas was relatively high compared to the more southerly located reference areas, the community diversity in the borrow areas was not significantly different than the nearby LBI reference area.

The direct effect of dredging operations on the commercial shellfish of the region is of great concern to natural resource managers. The Atlantic surf clam (*Spisula solidissima*) harvest along New Jersey's coastal waters account for more than 80% of the total Mid-Atlantic catch (NJDEP 1995). Annual commercial surf clam surveys conducted by the New Jersey Division of Fish, Game, and Wildlife, indicate that the vast majority of commercial surf clam beds in New Jersey waters are located between Atlantic City and Shrewsbury Rocks including the Long Beach Island area. Dredging sand for beach replenishment has potential environmental effects on these resources. An immediate effect is the removal of the existing shellfish communities. Furthermore, potential alteration of the substrate composition may effect important nursery habitats, which could hinder surf clam recruitment success.

The surf clam community of the four LBI borrow areas contained a mix of juvenile, small adult, and adult surf clams. The mean abundance of juvenile and small adult clams ranged between 183/m^2 (Borrow D) and 568/m^2 (Borrow A), while the density estimates for adults averaged between 0.4 clams/100 sq. ft. (0.04 clams/m^2; Borrow B) to 64 clams /100 sq. ft. (6.9 clams/m^2; Borrow E). These numbers suggest that the borrow areas contain conditions conducive to good clam recruitment and subsequent growth to maturity and marketable size.

It is unknown whether dredging operations would alter the substrate composition of the borrow areas to preclude surf clam recolonization after dredging. Evidence from a dredged area near Ocean City, NJ, seems to indicate that the surf clam populations are resilient and would be able to successfully recruit even after multiple dredging operations (Scott and Kelley, 1998b). Data from that study indicated that good clam recruitment is occurring and that the clams in the area are reaching mature and harvestable sizes. Since surveys of the surrounding areas of Long Beach Island indicated good populations of mature adults, it can be assumed that these clams would provide a strong recruitment base for clams if dredging occurs.

Based on the benthic community composition and surf clam populations of the four LBI borrow areas, there is no reason to believe that these areas would not fully recover from dredging operations in time. Other borrow areas along New Jersey have been used as a sand source for beach nourishment and replenishment activities, the study of one has displayed the ability to rapidly recover (i.e., within 2 years) even after multiple dredging operations (Scott and Kelley, 1998b). The data from this study suggest that the benthic communities of the four borrow sites are typical of the New Jersey coastline. Also, the surf clam populations within the borrow areas have a good potential for recruitment and growth that would most likely continue after dredging is complete.

Berm and Reinforced Dune: This alternative would have the same impact as the berm only alternative, except that there would be a greater disturbance to the borrow areas due to the need for more sand.

Bulkheads: This alternative would have no effect on the sand habitat of borrow areas, since these areas would not be disturbed.

Groin Modifications: This alternative would have no effect on the sand habitat of borrow areas, since these area would not be disturbed.

Nearshore Berm: This alternative would have the same impact as the berm only alternative, except that there would be a less disturbance to the borrow areas due to the need for less sand.

Submerged Reef Structures: This alternative would have no effect on the sand habitat of borrow areas, since these areas would not be disturbed.

Sand Recycle System: This alternative would have no effect on the sand habitat of borrow areas, since these areas would not be disturbed.

Selected Plan - Berm and Dune Restoration: This alternative would have the same impact as the berm only alternative, except that there would be a greater disturbance to the borrow areas due to the need for more sand.

Wetlands: None of the alternatives would impact wetlands. The project limits do not extend into any areas that have wetlands. The Barnegat Light section of Long Beach Island has been removed from the project area.

Finfish: No-Action: The no-action alternative should not have an effect on finfish in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. With the eventual failure of these structures would come an increased contact with non-point source pollution from the surrounding areas. These pollutants may adversely impact the invertebrate communities of the intertidal zone. Some contaminants may bioaccumulate up the food chain. This could have an impact on the reproductive capability, and survivability of finfish. The turbidity might also decrease hunting capacity of visual predators.

Berm Only: This alternative would have limited and short-term impact on finfish. With the exception of some small finfish, most bottom dwelling and pelagic fishes are highly mobile and should be capable of avoiding turbidity impacts due to placement and dredging operations. Due to the suspension of food particles in the water column, it is anticipated that some finfish might become attracted to the turbidity plume. The primary impact to fisheries would be felt from the disturbances of benthic and epibenthic communities. The loss of benthos and epibenthos smothered during berm construction and removed during borrow activity would temporarily disrupt the food chain in the impact area. This effect is expected to be temporary as pioneering species rapidly recolonizes these areas. Coordination with appropriate resource agencies would occur to prevent construction during critical spawning and over wintering periods.

Berm and Reinforced Dune: This alternative would have the same impact as the berm only alternative, except that there would be a greater disturbance to the borrow areas due to the need for more sand.

Bulkheads: This alternative should have no impacts to finfish, since the bulkheads if placed would be placed above the high tide line.

Groin Modifications: This alternative would have limited and short-term impact on finfish. There might be some turbidity increase. The turbidity may decrease hunting capacity of visual predators. Fish are transient and mobile by nature; this would lead to them avoiding the construction area. The placement of stones at the seaward end of the groins would change the offshore topography and may attract finfish. The small fish would use the gaps in the rocks as hiding places. There might also be an increase of food items attracted to the area.

Nearshore Berm: This alternative would have limited and but long term impact on finfish. While the berm feeds the beach with sand, there would be some turbidity increase. This would also occur during sand placement. The increased turbidity should be minimal compared to what is present due to the high-energy nature of the area. The turbidity might decrease hunting capacity of visual predators. Fish are transient and mobile by nature; this would lead to them avoiding the construction area. . The berm would change the offshore topography and may attract finfish. There may also be an increase of food items concentrated in the area.

Submerged Reef Structures: This alternative would have limited and short-term impact on finfish. There may be some turbidity increase. The turbidity might decrease hunting capacity of visual predators. Fish are transient and mobile by nature; this would lead to them avoiding the construction area. The placement of a hardened reef would change the offshore topography and might attract finfish. The small fish would use the gaps in the rocks as hiding places. There may also be an increase of food items concentrated in the area.

Sand Recycle System: This alternative would have limited but long term impact on finfish. The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. There would be some turbidity increase during the sand pumping operation. The increased turbidity should be minimal compared to what is present due to the high-energy nature of the area. The turbidity may decrease hunting capacity of visual predators. Fish are transient and mobile by nature; this would lead to them avoiding the output area. Pumping during spawning periods would be avoided.

Selected Plan - Berm and Dune Restoration: This alternative would have limited and short-term impact on finfish. With the exception of some small finfish, most bottom dwelling and pelagic fishes are highly mobile and should be capable of avoiding turbidity impacts due to placement and dredging operations. Most fish would also be able to avoid entrainment into the dredge. Due to the suspension of food particles in the water column, it is anticipated that some finfish may become attracted to the turbidity plume. The primary impact to fisheries would be felt from the disturbances of benthic and epibenthic communities. The loss of benthos and epibenthos smothered during berm construction and removal during borrow activity would temporarily disrupt the food chain in the impact area. This effect is expected to be temporary as pioneering species rapidly recolonizes these areas. Coordination with appropriate resource agencies would occur to prevent construction during critical spawning and over wintering periods.

Wildlife:

No-Action: The no-action alternative should have little or no effect on wildlife in the short term, but might in the long term. This is because the area is already highly disturbed. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. The continued loss of habitat due to erosion would limit the areas for wildlife. Also the exposure to contaminants would increase for wildlife if the man-made objects where destroyed by erosion forces.

Berm Only: There would be a short-term impact to wildlife during construction. Most wildlife in the area is either transient in nature or very adaptable. Most wildlife would avoid the construction area due to the noise of construction activity, but would return after construction ends. Not many wildlife species use the berm part of the beach on a regular basis. The increased berm would attract more nesting birds, hence more predatory animals.

Berm and Reinforced Dune: There would be a short-term impact to wildlife during construction. Most wildlife in the area is either transient in nature or very adaptable. Most wildlife would avoid the construction area due to the noise of construction activity, but would return after construction ends. Not many wildlife species use the berm part of the beach on a regular basis. The increased berm would attract more nesting birds, hence more predatory animals. The dunes would provide protected areas and food sources for many wildlife species.

Bulkheads: The bulkhead alternative would have only short-term effects on wildlife. Most of the wildlife would avoid the construction area due to the noise of construction activity. Wildlife would return to the area quickly after completion of work. The dune would cover the bulkhead. Since the bulkhead would be placed only in hotspot areas, with degraded habitats already, this should not cause a major impact to wildlife resources. Wildlife should be able to move around these limited bulkheads.

Groin Modifications: This alternative would have only short-term effects on wildlife. Most of the wildlife would avoid the construction area due to the noise of construction activity. The wildlife would return to the area quickly after completion of work.

Nearshore Berm: This alternative should have no negative impact on wildlife since construction would be offshore. There may be some positive impact due to the nearshore berm's stabilizing effect on the shoreline and maintenance of the beach width.

Submerged Reef Structures: This alternative should have no negative impact on wildlife since construction would be offshore. There may be some positive impact due to the reef's stabilizing effect on the shoreline and maintenance of the beach width.

Sand Recycle System: This alternative would have limited but long term impact on wildlife. The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. Wildlife in the area is either transient in nature or very adaptable. Most of the wildlife would avoid the construction area due to the noise of construction activity, but would return after construction ends.

Selected Plan - Berm and Dune Restoration: There would be a short-term impact to wildlife during construction. Most wildlife in the area is either transient in nature or very adaptable. Most of the wildlife would avoid the construction area due to the noise of construction activity, but would return after construction ends. Not many wildlife species use the berm part of the beach on a regular basis. The increased berm would attract more nesting birds, hence more predatory animals. The dunes would provide protected areas and food sources for many wildlife species.

Birds:

No-Action: The no-action alternative should not have an effect on birds in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. There would be a loss of habitat for nesting and feeding activities. Contamination from man made materials may have an effect on the reproductive success of birds in the area.

Berm Only: There would be a short-term impact to birds during construction. This impact should be limited to avoidance of the area, with the birds returning after placement of sand ends. Construction of the berm may create additional suitable nesting habitat for shorebirds and colonial nesting water birds.

Berm and Reinforced Dune: This alternative would have similar impacts to the berm only alternative. Enhancement of dunes would provide nesting and feeding habitat for a variety of bird species.

Bulkheads: The bulkhead alternative would have only short-term effects on birds. Most of the birds would avoid the construction area due to the noise of construction activity. The birds would return to the area quickly after completion of work. The dune would cover the bulkhead. Since the bulkhead would be placed only in hotspot areas, with degraded habitats already, this should not cause a major impact to avian resources.

Groin Modifications: This alternative would have only short-term effects on birds. Most of the birds would avoid the construction area due to the noise of construction activity. The birds would return to the area quickly after completion of work. Notching the groins would allow shorebirds easier access between each segment of the beach. The placement of stone at the seaward end of the groin may attract prey, which can be utilized by certain avian species.

Nearshore Berm: This alternative should have no negative impact on birds since construction would be offshore. There may be some positive impact due to the nearshore berm's stabilizing effect on the shoreline and maintenance of the beach width. Also there may be a concentration of prey, which can be fed upon by certain avian species.

Submerged Reef Structures: This alternative should have no negative impact on wildlife since construction would be offshore. There may be some positive impact due to the reef's stabilizing effect on the shoreline and maintenance of the beach width. The placement of hardened structure may attract fish and invertebrate species, which can be utilized by avian species.

Sand Recycle System: This alternative would have limited but long term impact on birds. The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. Most of the birds would avoid the construction area due to the noise of construction activity, but would return after construction ends. When the system is pumping sand, birds would be expected to avoid the area. Pumping during nesting and migratory cycles would be avoided.

Selected Plan - Berm and Dune Restoration: This alternative would have similar impacts to the berm only alternative. Enhancement of dunes would provide nesting and feeding habitat for a variety of bird species.

Threatened and Endangered Species:

No-Action: The no-action alternative should not have an effect on threatened and endangered species in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. There would be a loss of habitat for nesting and feeding activities. Contamination from man made materials may have an effect on species that utilize the beach. Bioaccumulation of some contaminants has been linked with reproductive failure in several threatened and endangered species, especially raptors.

Berm Only: There could be a short-term impact to threatened and endangered species during construction. This impact would be limited to avoidance of the area, with the individuals returning after placement of sand ends.

Piping plovers presently nest at three locations within the study area (Barnegat Light, between Harvey Cedars and Loveladies, and within the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge). Both the Barnegat Light area and the Holgate Unit have been removed from the project area. Coordination with the US Fish and Wildlife Service and the NJ Department of Environmental Protection would occur before any construction in the Harvey Cedars/Loveladies area. To minimize impacts to piping plovers associated with beach nourishment, the USFWS suggests seasonal restrictions, further consultation prior to initial nourishment and all subsequent renourishment activities. In accordance with Section 7 of the Endangered Species Act (87 Stat. 884 as amended, 16 U.S.C. 1531 et seq.) the Philadelphia District is currently preparing a Biological Assessment for piping plovers. The recommendations developed in the B.A. will be followed for this project. The District will comply with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act", dated April 15, 1994.

Peregrine falcons and bald eagles can be found in the vicinity of the project area. Several state-listed species of birds are found in the vicinity also. They may be temporally displaced from the construction area and have to find alternate feeding sites. The black skimmer, roseate tern and least tern occur along beaches in the project area. Birds are transient in nature and construction activities should have limited impact on them. However, use of seasonal dredging restrictions and implementation of a comprehensive beach nesting bird management plan coordinated with USFWS and NJDEP Endangered and Non-Game Species Program will minimize impacts to nesting least terns and black skimmers.

Between June and November, New Jersey's Coastal waters may be inhabited by transient sea turtles, especially the loggerhead, green, leatherback, and the Kemp's ridley. Sea turtles can be adversely impacted during hopper dredging operations. Coordination with the National Marine Fisheries Service (NMFS) in accordance with Section 7 of the Endangered Species Act has been undertaken on all Philadelphia District Corps of Engineers dredging projects. A Biological Assessment that discusses Philadelphia

District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles was prepared and formally submitted to the NMFS. A Biological Opinion was provided by the NMFS in November of 1996. As a term and condition of the incidental take statement included in this Opinion, the NMFS is requiring monitoring of all hopper dredge operations in areas where sea turtles are present between June and November by trained endangered species observers. Adherence to the findings of the Biological Opinion would insure compliance with Section 7 of the Endangered Species Act. Other measures that may be taken to reduce the impact to sea turtles include the use of rigid dragarm deflectors and pre-dredging trawling when hopper dredges are employed.

Marine mammals would be expected to avoid the dredging operation. The impact to them should be minimal and should not impact migratory pathways. There might be a reduction of prey species in the area.

The diamondback terrapin inhabits marshes, tidal flats, and beaches associated with saltmarsh systems. The terrapin breeds in sandy substrate above the levels of normal high tides. It is expected that this species would not directly benefit from a berm restoration project, however, efforts to minimize erosion of beach habitat in areas where terrapin' breed can be considered an indirect benefit to the species. Berm restoration would not adversely impact the diamondback terrapin.

To minimize impacts to seabeach amaranth associated with beach nourishment and renourishment activities, the Service suggests conduction surveys for seabeach amaranth prior to initiation of construction activities. If seabeach amaranth is identified in the project area, a protective zone should be established around the plants.

Construction of the proposed project could create additional suitable nesting habitat for the piping plover and additional habitat for the seabeach amaranth (Arroyo, 1994).

Berm and Reinforced Dune: This alternative would have similar impacts to the berm only alternative. Enhancement of the dunes would provide nesting and feeding habitat for a variety of species, especially raptors.

Bulkheads: The bulkhead alternative would have only short-term effects on threatened and endangered species. Birds would avoid the construction area due to the noise of construction activity. Individuals would return to the area quickly after completion of work.

Piping plovers presently nest on Long Beach Island, but do not nest in the hotspot areas where bulkheads would be placed. Therefore, construction should have no impact on them. This alternative would not provide additional nesting habitat.

Peregrine falcons and bald eagles can be found in the vicinity of the project area. Several state-listed species of birds are found in the vicinity also. They may be temporally displaced from the construction area and have to find alternate feeding sites. The black skimmer, roseate tern and least tern occur along beaches in the project area. Birds are transient in nature and construction activities should have limited impact on them. The bulkhead might be an impediment to the movement and nesting of some species. Since the bulkhead would be placed only in hotspot areas, with degraded habitats already, this should not cause a major impact to these species.

There would be no impact on sea turtles or marine mammals since placement of bulkheads would be above the high tide line and because no dredging is involved. The diamondback terrapin occurs primarily in emergent wetlands and shallow water habitat. It is expected that this species would not benefit from a bulkhead alternative, neither would it be adversely impacted by the project.

Groin Modifications: This alternative would have only short-term effects on threatened and endangered species. Birds would avoid the construction area due to the noise of construction activity. Individuals would return to the area quickly after completion of work.

Notching the groins would allow shorebirds (piping plovers) easier access between each segment of the beach. The placement of stone at the seaward end of a groin may attract prey, which can be utilized by shorebirds such as the piping plover, black skimmer, roseate tern and least tern.

There would be no impact on sea turtles or marine mammals since modification of groins would impact areas that are traditionally used by local species, and because no dredging is involved. The diamondback terrapin occurs primarily in emergent wetlands and shallow water habitat. It is expected that this species would not benefit from this alternative, neither would it be adversely impacted by the project.

Nearshore Berm: This alternative would have only short-term effects on threatened and endangered species. Most of these species would avoid the construction area due to the noise of construction activity. Any threatened and endangered species would return to the area quickly after completion of work.

There may be some positive impact due to the nearshore berm's stabilizing effect on the shoreline and maintenance of beach width. This may provide additional habitat for nesting shorebirds (piping plover).

Peregrine falcons and bald eagles can be found in the vicinity of the project area. Several state-listed species of birds are found in the vicinity also. They may be temporally displaced from the construction area and have to find alternative feeding sites

The black skimmer, roseate tern and least tern occur along beaches in the project area. Birds are transient in nature and construction activities should have limited impact on them. An underwater berm can attract and concentrate fish and larvae, which could be a food source for some bird species.

Between June and November, New Jersey's Coastal waters may be inhabited by transient sea turtles, especially the loggerhead, green, leatherback, and the Kemp's ridley. Sea turtles can be adversely impacted during hopper dredging operations. Coordination with the National Marine Fisheries Service (NMFS) in accordance with Section 7 of the Endangered Species Act has been undertaken on all Philadelphia District Corps of Engineers dredging projects. A Biological Assessment that discusses Philadelphia District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles was prepared and formally submitted to the NMFS. A Biological Opinion was provided by the NMFS in November of 1996. As a term and condition of the incidental take statement included in this Opinion, the NMFS is requiring monitoring of all hopper dredge operations in areas where sea turtles are present between June and November by trained endangered species observers. Adherence to the findings of the Biological Opinion would insure compliance with Section 7 of the Endangered Species Act. Other measures that may be taken to reduce impact to sea turtles include use of rigid drag arm deflectors and pre-dredge trawling when hopper dredges are employed.

Marine mammals would be expected to avoid the dredging and placement operations. The impact to them should be minimal and should not impact migratory pathways. There might be a reduction of prey species in the area.

The diamondback terrapin inhabits marshes, tidal flats, and beaches associated with saltmarsh systems. The terrapin breeds in sandy substrate above the levels of normal high tides. It is expected that this species would not directly benefit from a berm restoration project, however, efforts to minimize erosion of beach habitat in areas where terrapins breed can be considered an indirect benefit to the species. Berm restoration would not adversely impact the diamondback terrapin.

Submerged Reef Structures: This alternative would have similar impacts as the nearshore berm alternative. Since there would be no dredging involved the impacts to marine mammals and sea turtles would be reduced. Since the reef structure would be different from the existing bottom material, there would be and unrecoverable loss of sandy bottom habitat. Loss of habitat would reduce existing benthic food sources. However, a new type of benthic habitat would be created. This new habitat would attract a different assemblage of benthic organisms. The placement of a hardened structure would attract fish and invertebrate species, which could be utilized by threatened and endangered species (sea turtles).

Sand Recycle System: Construction and operation of a sand by-pass plant would be a disturbance to shorebirds due to the noise and general activity that would result. The plant would be operated more frequently than a traditional beach nourishment project, which would make the disturbance more long-term. While species such as the piping plover, black skimmer, least tern and roseate tern would be expected to avoid the area during periods of construction and operation, they would likely return after activity ceases. Avoiding disturbance during critical periods such as the nesting season would minimize project impacts. There may be a temporary reduction in piping plover habitat as the area below MHW is reduced in size, making the berm subject to further erosion from storms. But the impact is temporary as the area has a high accretion rate and is expected to replace the losses within the year.

There should be no impact on sea turtles or marine mammals since the by-pass system would not impact areas that are traditionally used by these species, and because hopper dredging is not involved. The diamond back terrapin occurs primarily in emergent wetlands and shallow water habitat. It is expected that this species would not benefit from this alternative, neither would it be adversely impacted by the project.

Selected Plan - Berm and Dune Restoration: This alternative would have similar impacts as the berm only alternative. Enhancement of dunes would provide nesting and feeding habitat for a variety of shorebirds, including piping plovers, black skimmer, least tern and roseate tern. Raptors would also benefit from the increase in foraging area.

Visual:

No-Action: The no-action alternative should have no effect on the pleasing visual quality of the shoreline in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man-made structures. With the eventual failure of these structures, the visual appeal of the shoreline would be disrupted.

Berm Only: The berm only alternative should not have an effect on the visual quality of the shoreline. This alternative would provide wider beaches, which would only enhance the view. There would be a short term displeasing view of construction equipment and pipes on the beach.

Berm and Reinforced Dune: This alternative should have similar effects as the berm only alternative. Construction would result in wider beaches and higher dunes.

Bulkheads: The dune would cover the bulkhead. The bulkheads would be placed in hotspot areas only, this would limit their visual disturbance. There would be a short term displeasing view of construction equipment.

Groin Modifications: There would be a short term displeasing view of construction equipment. After construction, there should be no long-term visual disturbance. No new groins would be built. Some of the present groins might be notched or shortened. The notched groins would be smaller then they are presently. This would provide a benefit to the view of the beach by reducing visual obstruction. Any extension of the groins would be to the seaward toe of the groin. The stones in this area would be covered by water and not seen at most tide levels.

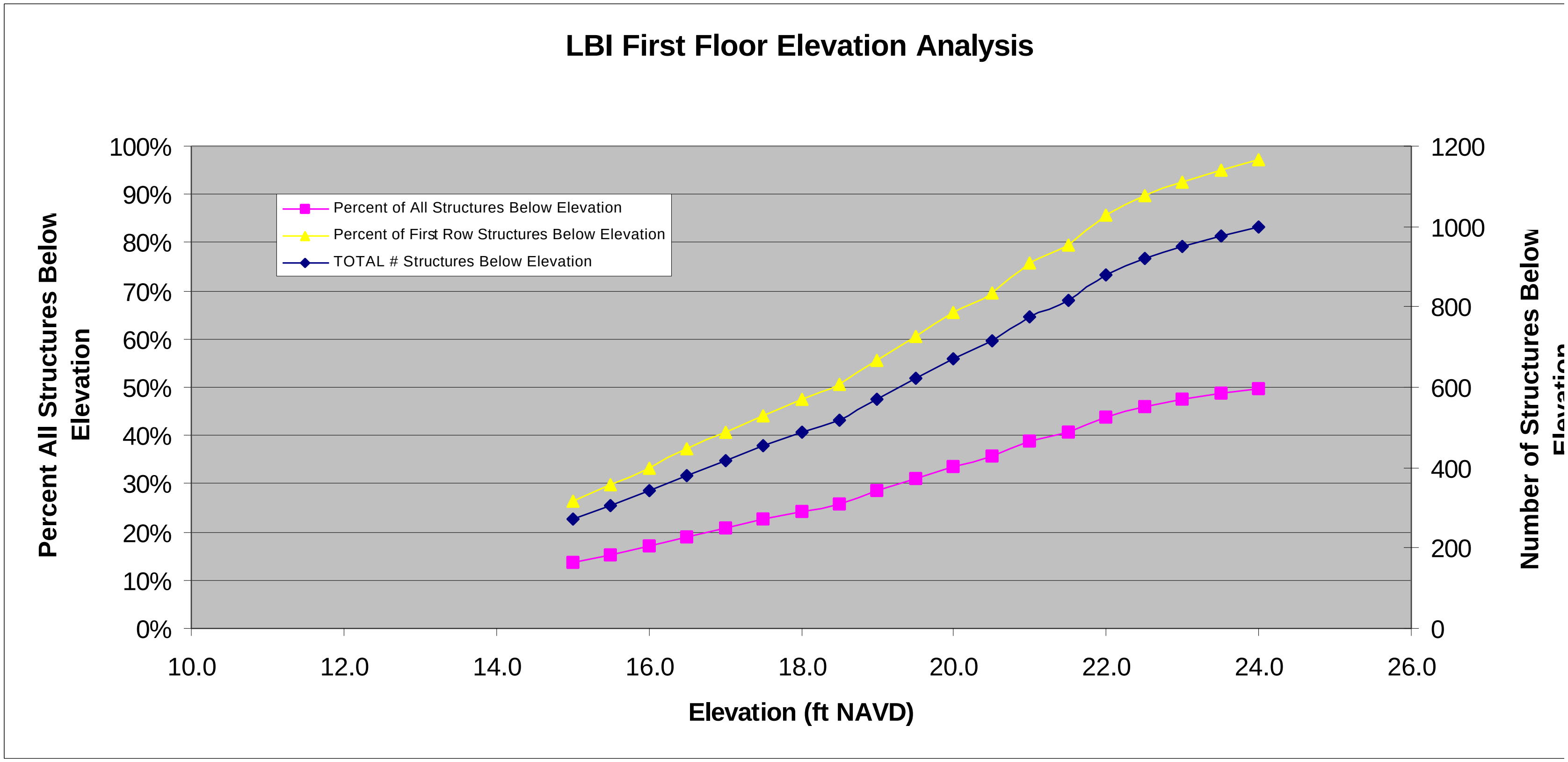
Nearshore Berm: There would be a short term displeasing view of construction equipment and a barge. The berm itself would not be visible above the water level.

Submerged Reef Structures: There would be a short term displeasing view of construction equipment and a barge. The reef itself would not be visible above the water level.

Sand Recycle System: The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. There would be short term displeasing views of construction equipment and pipes on the beach during periods of operation. Placement of a permanent pump house on the beach would cause a long-term disturbance of the view.

Selected Plan - Berm and Dune Restoration: This alternative should have similar effects as the berm only alternative. Construction would result in wider beaches and higher dunes. Higher dunes may impact the view from the front row structures. **Figure 5-35** gives a general breakdown of how the proposed alternatives and selected plan will affect the structures in the structure inventory. **Table 5-1** depicts more specifically first row structures at varying first floor elevations. The first floor elevations of structures generally represent the point of entry for inundation into the living area of a structure. A typical visual impact may involve homeowners who are use to viewing the beach area while sitting at a picture window. If the first floor elevation they are sitting on is 17-feet, plus the additional height of the chair (standard is 18 inches) and upper body height (average 30 inches) their visual line of sight, in this example, is at 21-feet NAVD. A 22-feet NAVD high dune would partially impact their view.

Figure 5-35



LBI First Floor Elevation Analysis
Percent of All Structures Below Elevation
Percent of First Row Structures Below Elevation
TOTAL # Structures Below Elevation
Percent All Structures Below Elevation
Number of Structures Below
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1200
1000
800
600
400
200
0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
Elevation (ft NAVD)

LBI First Floor Elevations Below Select Elevations **Table 5-1**

Analyzed First Row of Structures (1026 Strucutes out of 2003 Structures Surveyed for Economic Analysis)

Number Of Structures within Bundy below Selected Elevation

	BUNDYS															
El (NAVD)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**TOTAL**
15.0	19	3	13	8	4	34	24	11	35	37	19	15	16	16	17	**271**
15.5	19	3	16	10	8	37	30	11	38	41	22	17	17	18	19	**306**
16.0	22	3	17	11	8	42	35	12	42	49	23	20	17	20	20	**341**
16.5	26	3	17	13	10	48	39	14	49	52	24	24	19	21	22	**381**
17.0	27	4	17	13	10	52	46	18	52	53	25	28	23	23	25	**416**
17.5	31	4	18	14	11	58	50	20	55	56	27	33	24	26	27	**454**
18.0	34	4	19	16	13	60	53	21	59	59	29	36	26	29	30	**488**
18.5	37	4	21	16	14	63	58	21	64	64	31	37	28	30	31	**519**
19.0	41	4	24	17	15	70	61	24	68	74	38	39	30	32	34	**571**
19.5	45	6	27	19	16	72	63	25	72	80	43	47	31	33	42	**621**
20.0	49	6	28	19	18	75	66	25	78	84	54	52	31	35	51	**671**
20.5	50	6	34	20	20	80	68	27	86	89	59	54	31	36	54	**714**
21.0	53	7	35	23	23	86	74	28	92	98	62	63	36	36	60	**776**
21.5	55	7	38	26	27	90	74	32	96	100	66	66	38	36	66	**817**
22.0	57	9	42	28	36	94	78	37	107	102	69	73	39	36	73	**880**
22.5	61	9	44	32	41	96	82	41	111	105	70	76	41	36	76	**921**
23.0	64	9	45	32	47	98	83	44	112	110	72	76	41	37	79	**949**
23.5	65	10	50	34	47	101	86	47	114	111	73	77	41	37	82	**975**
24.0	65	10	57	36	50	104	88	47	115	114	73	77	42	37	83	**998**

Air Quality and Noise Level:

No-Action: The No-Action alternative would have no impact on the air and noise quality of the project area.

Berm Only: Minor short-term impacts to air quality and noise levels would result from the construction phase of the berm only alternative. Dredging activities and grading equipment would produce noise levels in the 70 to 90 dBA (50 feet from the source) ranges. These noises would dissipate with distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. The noise levels and air quality impact would be limited to those produced by heavy construction equipment. No long-term significant impacts to the local air quality are anticipated.

Berm and Reinforced Dune: This alternative would have similar impacts to air quality and noise levels as the berm only alternative. Houses along the dunes would experience higher noise levels due to the closeness to the construction activities.

Bulkheads: Minor short-term impacts to air quality and noise levels would result from the construction phase of the bulkhead alternative. Grading and pile driving equipment would produce noise levels in the 70 to 90 dBA (50 feet from the source) ranges. These noises would dissipate with distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. The noise levels and air quality impact would be limited to those produced by heavy construction equipment. No long-term significant impacts to the local air quality are anticipated.

Groin Modifications: Minor short-term impacts to air quality and noise levels would result from the construction phase of the groin modification alternative. Removal or placement of stone, and pile driving equipment would produce noise levels in the 70 to 90 dBA (50 feet from the source) ranges. These noises would dissipate with distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. The noise level and air quality impact would be limited to those produced by heavy construction equipment. No long-term significant impacts to the local air quality are anticipated.

Nearshore Berm: Minor short-term impacts to air quality and noise levels would result from the construction phase of the nearshore berm. Dredging and pumping equipment would produce noise levels in the 70 to 90 dBA (50 feet from the source) ranges. These noises would dissipate with distance. Since this would be done off the beach, the sound heard by the homes along the dune would be minimal. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. The noise level and air quality impact would be limited to those produced by heavy construction equipment. No long-term significant impacts to the local air quality are anticipated.

Submerged Reef Structures: Minor short-term impacts to air quality and noise levels would result from the construction phase of the submerged reef alternative. Crane and barge equipment would produce noise levels in the 70 to 90 dBA (50 feet from the source) ranges. These noises would dissipate with distance. Since this would be done off the beach, the sound heard by the homes along the dune would be minimal. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. The noise level and air quality impact would be limited to those produced by heavy construction equipment. No long-term significant impacts to the local air quality are anticipated.

Sand Recycle System: A by-pass system would be run at various times dependent on need and environmental issues. The system would not be run during critical times when the sound would disturb nesting birds. The system is a contained unit that buffers the high decibel levels on the inside. Outside the sound level would be low. Ambient air quality would also be temporarily degraded during the pumping cycle, but emission controls and limited duration aid in minimizing the effects. The air quality impact would be limited to those produced by the pumps. Long-term minimal impacts to the local air quality are anticipated.

Selected Plan - Berm and Dune Restoration: This alternative would have similar impacts to air quality and noise levels as the berm only alternative. Houses along the dunes would experience higher noise levels due to the closeness to the construction activities.

Recreation:

No-Action: The no-action alternative should have no effect on the recreational use of the shoreline in the short term, but might in the long term. If the natural geomorphic conditions continue, shoreline retreat would occur. This would eventually erode the shoreline back to man made structures. The loss of beach area would crowd beachgoers into denser crowds. The change in beach slope might change wave characteristics, which could effect use of the waves by swimmers and surfers. The loss of beach would also reduce the available area for surf fishermen. The loss of habitat for shorebirds would effect the number of bird watchers that use the area.

Berm Only: The berm only alternative should have a beneficial impact on the recreational use of the area. The increased beach width would provide more room for beachgoers. The placement of sand on the beach would mirror the slope of the existing beach; therefore, there should be little impact on wave characteristics and use of the water by swimmers and surfers. The increased habitat for shorebirds would benefit bird watchers in the area. There would be a short-term negative impact to recreation during placement of sand on the berm.

Alternatives that include berm restoration will have the height and width of the berm translated into the nearshore zone. Fill is placed to a point known as the depth of closure, which extends seaward to a point as far as –29 ft NAVD. The minimal size of the berm and the minimal amount of fill that constitutes the depth of closure should have limited impacts on surfing conditions.

Berm and Reinforced Dune: This alternative would have similar beneficial impacts to recreational use of the area as the berm only alternative. The dune would provide additional habitat to attract wildlife and birds to the area, hence benefiting wildlife observation. There would be a short-term negative impact to recreation during placement of sand on the berm and dune.

Bulkheads: Bulkheads would have little or no effect on the recreational use of the area. Bulkheads would only be placed in hotspot areas, which by their nature already have a lowered recreational use. There would be a short-term negative impact to recreation during placement of bulkheads.

Groin Modifications: Groin modifications should have a beneficial impact on the recreational use of the area. The extension of groins might increase fishery resources in the area, which would benefit recreational fishermen. Notching of groins should stabilize the beach and provide more habitats for birds, which would benefit bird watchers. A wider, more stable beach would also benefit beachgoers. There would be a short-term negative impact to recreation during actual construction.

Nearshore Berm: The nearshore berm should stabilize the beach and provide more habitat for birds and bird watchers, while also providing less dense beaches for beachgoers. The change in the off shore slope might change wave characteristics, which could effect use of the waves by swimmers and surfers. The berm might also be a navigational or swimming hazard. The berm would change the offshore topography and might attract fishery resources, thus recreational fishermen to the area.

Submerged Reef Structures: The submerged reef should stabilize the beach and provide more habitat for birds and bird watchers, while also providing less dense beaches for beachgoers. The placement of a hardened structure offshore might change wave characteristics, which could effect use of the waves by swimmers and surfers. The reef might also be a navigational or swimming hazard. The reef would change the offshore topography and might attract fishery resources, thus recreational fishermen to the area.

Sand Recycle System: The sand recycle system would run optimally once every 2.5 years dependent on need and environmental issues. There would be a long-term benefit from the Sand Recycle System to recreation. The stabilization of the beach would provide more habitat for birds, which would benefit bird watchers. A wider, more stable beach would also benefit beachgoers. There would be a short-term negative impact to recreation during construction of the recycle system; also there would be an impact during periodic pumping operations.

Selected Plan - Berm and Dune Restoration: This alternative would have similar beneficial impacts to recreational use of the area as the berm only alternative. The dune would provide additional habitat to attract wildlife and birds to the area, hence benefiting wildlife observation. There would be a short-term impact to recreation during placement of sand on the berm and dune. The slope of berm would extend beyond the seaward edge of groins, however the restoration of the dune and berm is placed upon the existing dune and berm. Additionally a protective template is placed to maintain the project design template. This “advanced” nourishment material settles naturally overtime to form the berm slope and toe after which the beach reaches a point of equilibrium. Physically no material is placed below the mean low water line, naturally the material erodes overtime or is moved by storm events. The increase in bottom depth would vary –1 ft. to – 2 ft., along the entire project area. Only temporary impacts to recreational fishing would occur during the placement of material. Little or no disturbance to fish and other aquatic wildlife would occur due to the nature of the placement of material.

5.4 CULTURAL RESOURCES

Impacts on Cultural Resources: Proposed project construction has the potential to impact cultural resources in two areas. These are the existing beach areas, the underwater near-shore sand placement areas and the underwater offshore borrow areas. In the beach and near-shore sand placement areas, potential impacts to cultural resources could be associated with the placement and compaction of sand during berm and dune construction. Dredging activities in offshore borrow areas could impact submerged cultural resources.

A recent cultural resources investigation in the project area identified nine remote sensing targets that could possibly exhibit shipwreck characteristics (Hunter Research, Inc. et al, 1998). These include five targets identified during the hand-held magnetometer survey along the shoreline, three targets identified in underwater near-shore sand placement areas, and one target recorded in offshore Borrow Area D. The following recommendations are provided in the above referenced report.

First, a program of controlled, periodic archeological monitoring is recommended during and immediately following the beach replenishment operation to check for archeological materials originating in the offshore sand borrow material. The Corps recognizes that prehistoric cultural material may on occasion be dredged up from offshore borrow deposits and re-deposited along the shore during the course of beach nourishment.

Second, no further study of the eight targets located in the shoreline and near-shore project areas is recommended (Targets MA-1, MA-3, MA-4, MA-7, MD-4 and Targets 4:735, 4:816 and 4:1009). It is unclear how many of these targets derive from shipwrecks or other features of historic interest. However, the careful placement of sand along the shoreline in these locations will protect the source of these magnetic anomalies. It is suggested that these target locations be clearly marked in the field prior to sand nourishment so heavy machinery and other construction activities can avoid them.

Third, ground truthing of Target 7:614 at the Phase I level is recommended. This target was identified in offshore Borrow Area D and may represent a significant underwater resource such as a historic shipwreck. Additional underwater work should involve reacquisition and more focused analysis of the target's remote sensing signature, diving, visual inspection, probing and recording. If this work shows this target to be a potentially significant underwater resource, such as a shipwreck, consideration should be given to avoiding this location during sand borrowing activities. The Philadelphia District concurs with the report recommendations.

Section 106 consultation with the New Jersey State Historic Preservation Office is continuing. Underwater work at Target 7:614 will be conducted and the results coordinated with the NJ SHPO. In addition, cultural resources investigations may be required for project areas that were not previously investigated and the Philadelphia District, if necessary, will conduct this work, and the results coordinated with the NJ SHPO. All Section 106 consultation with the NJ SHPO will be concluded prior to any project construction activity.

Supplemental cultural resources investigations are continuing in the project area and should be concluded by the end of September 1999. Additional remote sensing of Borrow Area "D2" will be conducted during PED. The results of the initial Phase I investigation, supplemental investigation, and remote-sensing investigation of Borrow Area "D2" will be coordinated closely with the NJ SHPO. The level of additional work required to investigate remote sensing targets not previously investigated will also be coordinated with the NJ SHPO and completed prior to construction. Underwater operations were conducted at Target 7:614 in June 1999. The results of those investigations showed that the target is a navigational Bell-Bouy that is not eligible for listing in the National Register of Historic Places. A construction monitoring program and magnetic anomaly protection program will be prepared by the District, in consultation with the NJ SHPO, and implemented prior to and during construction. Section 106 coordination with concluded prior to any project construction activity.

5.5 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS:

The unavoidable adverse impact of the no-action alternative would be continued erosion of the existing beach, which would result in loss of habitat and eventually damage to structures. Increased flooding would occur as beach loss continues. As the risk of storm damage increases, property values would decrease. The unavoidable adverse impact of the berm and dune alternative would be decreased benthic community standing stocks, which would be effected during dredging and placement operations. It is anticipated that these communities would recover in time.

5.6 SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY:

The no-action alternative does not involve short-term uses, but would effect the long-term biological productivity and the economy of the project area. The berm and dune alternative would protect and restore shoreline habitat over the 50-year period of analysis.

5.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES:

The no-action alternative does not involve a commitment of resources. The berm and dune restoration would involve the utilization of time and fossil fuels, which are irreversible and irretrievable. Impacts to the benthic community would not be irreversible, as benthic communities would reestablish with cessation of placement activities.

5.8 CUMULATIVE EFFECTS:

Cumulative impacts, as defined by CEQ regulations, is the "impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Before 1930, the Federal government's involvement in shore erosion was limited to protection of public property. With the enactment of the River and Harbor Act of 1930 (Public Law 71-520, Section 2) the Chief of Engineers was authorized to make studies of the erosion problem in cooperation with municipal and state governments in efforts to prevent further erosion. Until 1946, the Federal aid was limited to studies and technical advice. In 1946 and 1956, the law was amended to provide Federal participation in the cost of a project and allowed limited contribution to the protection of privately owned shores which would benefit the public.

In New Jersey, the Federal navigation project at Absecon Inlet provides for an entrance channel with a turning basin in Clam Creek to be maintained. Two early beach erosion control projects included the Atlantic City, NJ project and the Ventnor, Margate and Longport, NJ project. The Atlantic City project (1954) included widening of the inlet channel, nourishing the beaches along the inlet frontage (10 years), replacement of a damaged concrete seawall, construction and extension of groins, and replacing revetment on a bulkhead. The project was partially completed to include 3727 feet of the Brigantine Jetty, some groin and bulkhead work, and beachfill. The project was deauthorized January 1990. The Ventnor, Margate, Longport, NJ project consisted of widening beach, maintenance of an existing groin and periodic nourishment. The project was deferred in November 1971 due to consideration of the Absecon Island project in the Comprehensive New Jersey Coastal Inlets and Beaches Study. The project was also deauthorized in January 1990.

Projects of a restorative nature using beachfill were becoming increasingly common in coastal areas of high development as they become more susceptible to erosive forces. Numerous beach nourishment projects have been studied along the Atlantic Ocean coast of New Jersey since the 1960s by local, state, and Federal interests. Depending on site-specific circumstances, such as the methods utilized to alleviate coastal erosion and ensuing storm damages and the existing ecological and socioeconomic conditions, it is difficult to gauge the net cumulative effects of these actions. The scientific literature generally supports beachfill projects over structural alternatives, if properly planned, are short-term, and have minor ecological effects.

In the 1960s and 1970s, the Corps of Engineers conducted several beach erosion control and navigation studies under the New Jersey Coastal Inlets and Beaches Study, which included Barnegat Inlet, Long Beach Island, Brigantine Island, and Absecon Island. These projects were authorized for Phase I Design Memorandum Stage of Advanced Engineering and Design by Section 101a of WRDA 1976. The projects on Brigantine Island and Absecon Island were re-authorized pursuant to the provision of Section 605 of the Water Resources Development Act of 1986. The project for Brigantine includes beachfill, dunes, groins, and periodic nourishment. The Absecon project included the same provisions but also a weir breakwater. Neither of these projects has been constructed however, because of the large cost associated with structural shore protection measures. All four projects had a predominance of recreation benefits in the original formulation and thus, PED was never initiated. The Barnegat Inlet project modification was constructed as a design deficiency under the authority of the Supplemental Appropriations Act of 1985. The projects for Barnegat Inlet to Longport, NJ are considered deauthorized as of November 1991.

A beach nourishment project *Great Egg Harbor and Peck Beach, Ocean City, New Jersey* GDM was completed in April 1989. The project proposed to place 4.1 mcy of initial beachfill and 1.0 mcy of subsequent renourishment every 3 years for the 50-year life of the project. The borrow area (Borrow Area 9) is an ebb shoal area 5,000 feet offshore of Great Egg Harbor Inlet. The depth in the borrow area is no great than -16 feet MLW. At this depth, the annual shoaling rate and annual borrow rate are essentially the same and therefore would be self-maintaining for navigation/shoaling purposes. Actual initial and nourishment quantities are as follows:

CYCLE	QUANTITY (CY)
Initial Construction	6.2 million
1st Cycle	2 million
2nd Cycle	800,000

The New Jersey Shore Protection Study was initiated to investigate shoreline protection and water quality problems that exist along the entire coast. The Limited Reconnaissance Phase of this study was completed in September 1990 and prioritized those coastal reaches which have potential Federal interest based on shore protection and water quality problems. Funds were allocated in 1991 to conduct a reconnaissance study of the Brigantine Inlet to Great Egg Harbor Inlet reach. The Reconnaissance Study was completed in 1992. The Feasibility Report (*Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island Interim Feasibility Study*) was completed in August 1996. The selected plan proposes beach and dune restoration on 9.2 miles of beach along Atlantic City's Absecon Inlet frontage and the ocean coast of Absecon Island for the purpose of hurricane and storm damage reduction. Approximately 6.1 million cubic yards (MCY) of initial fill would be required with 1.6 MCY of sand for subsequent renourishment every 3 years for a 50-year period. Three offshore borrow areas were selected for analysis. The Absecon Inlet borrow area was identified for use in the initial quantity of sand and the first few nourishment cycles to lessen impacts to benthic and surf clam resources identified in greater quantities in alternative borrow sites. This project has not been constructed to date. The 345 acre borrow site contains approximately 8.5 million cubic yards of sand which is currently dredged to approximately 15 feet below the sediment surface. The site replenishes over time through in-filling.

The *Townsends Inlet to Cape May Inlet Feasibility Study* was completed in March 1997 to address storm damage reduction for the communities of Avalon, Stone Harbor, North Wildwood, New Jersey and included an ecosystem restoration project for Stone Harbor Point. The selected plan included an initial beachfill of 3.1 million cubic yards and subsequent renourishment every 3 years of 746,000 cy for a project life of 50 years. Three borrow areas were identified in the study as being suitable: 1) offshore of Seven Mile Island-limited to just 245 acres in 25 to 45 feet of water; 2) Hereford Inlet Borrow Area-limited to 145 acres which would maintain an ebb shoal complex to minimize impacts to the hydrodynamics of the shoal area and minimize impacts to the benthic environment; and 3) Townsends Inlet Borrow Area-248 acres offshore of Avalon, to also maintain an ebb shoal with water depths of 3-10 feet. This project has also not been constructed to date.

NJDEP has records regarding state and local community dredging projects. The most recent dredging projects included Borough of Avalon, dredging at Townsends Inlet; Borough of Stone Harbor, dredging off of Hereford Inlet.

Cumulative adverse impacts of past and proposed future coastal erosion control projects typically result from the effect these projects have on the borrow areas: 1) the benthic resource community and 2) the creation of hypoxic conditions by dredging deep holes. Impacts to the nourishment sites themselves are temporary displacement of benthic resources in the short-term and positive impacts to the beach ecosystem in the long-term (enhanced storm protection and increased habitat). Since the current project was designed to minimize adverse environmental effects of all types the project should not culminate in adverse cumulative impacts on ecological and socio-economic resources, and should result in an overall improvement of the beach environment.

5.9 ESSENTIAL FISH HABITAT:

Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" and covers all habitat types utilized by a species throughout its life cycle. The Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-267) requires all Federal agencies to consult with National Marine Fisheries

Service (NMFS) on all actions, or proposed actions, permitted, funded, or undertaken by the agency, that may adversely affect EFH.

The no action alternative should not have any effect on EFH as defined by the 1996 Magnuson-Stevens Act. The selected plan was revised during the draft report comment period to eliminate borrow areas B and subsequently, E to avoid impacts to EFH, as recommended by the state of New Jersey, USFWS, and NMFS. Modification of the selected plan conforms to Corps policy that states that damages to fish and wildlife resources will be prevented to the extent practicable through thorough planning and design, incorporation CEQ mitigation principles (ER 1165-2-1 and ER 1105-2-100). The modified selected plan proposes to utilize borrow areas A, D1 and D2 in accordance with the resource agencies recommendations to avoid essential fish habitat identified in borrow areas B and E.

Essential Fish Habitat. Under provisions of the Magnuson-Stevens Act, areas along the New Jersey Atlantic coast, including the proposed borrow areas are designated as Essential Fish Habitat (EFH) for species with Fishery Management Plans (FMP's). The National Marine Fisheries Service has identified EFH within 10' X 10' square coordinates. The study area contains EFH for various life stages for 30 species of managed fish and shellfish. Tables 5-2, 5-3, 5-4 present the managed species and their life stage that EFH is identified for within three 10' x 10' squares (#26, #34, and #35) that cover the project area and proposed borrow areas. The habitat requirements for identified EFH species and their representative live stages are provided in Table 5-5.

The selected plan for the Barnegat Inlet to Little Egg Inlet study for hurricane and storm damage protection entails berm and dune restoration utilizing sand obtained from offshore borrow sources. The plan requires 4.95 million cubic yards of sand for initial berm placement and 2.45 million cubic yards for dune placement. Approximately 1.9 million cubic yards would be needed for periodic nourishment every 7 years for the 50-year period of analysis. The berm and dune restoration plan extends from groin 4 (Seaview Drive, Loveladies) to the terminal groin (groin 98) in Holgate, Long Beach Township, approximately 17 miles. The Barnegat Light area (northern end of the study area) is not included in the plan due to low background erosion and ample shore protection. In accordance with the U.S. Fish and Wildlife Service recommendations, the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge (the southern end of the study area) was also not included in the project.

TABLE 5-2. SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10' x 10' SQUARE (#26 at 39 50.0'N 74 00.0'W; 39 40.0' N 74 10.0') (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Atlantic cod *(Gadus morhua)*				X
Red hake *(Urophycis chuss)*	X	X	X	
Windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*			X	X
Monkfish *(Lophius americanus)*	X	X		
Bluefish *(Pomatomus saltatrix)*			X	X
Witch Flounder (*Glyptocephalus cynoglossus)*	X			
Winter Flounder (*Pleuronectes americanus*)	X	X	X	X
Yellowtail Flounder (*Pleuronectes ferruginea*)	X	X		
Atlantic butterfish *(Peprilus tricanthus)*			X	
Summer flounder *(Paralicthys dentatus)*		X	X	X
Scup *(Stenotomus chrysops)*	n/a	n/a	X	X
Black sea bass *(Centropristus striata)*	n/a		X	X
Surfclam *(Spisula solidissima)*	n/a	n/a	X	
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Cobia *(Rachycentron canadum)*	X	X	X	X
Tiger shark *(Galeocerdo cuvieri)*		X		
Dusky shark *(Charcharinus obscurus)*		X		
Sandbar shark *(Charcharinus plumbeus)*		X	X	X

TABLE 5-3. SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10' x 10' SQUARE (#34 at 39 40.0'N 74 00.0'W; 39 30.0' N 74 10.0'W) (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Atlantic cod *(Gadus morhua)*				X
Red hake *(Urophycis chuss)*	X	X	X	
Witch flounder (*Glyptocephalus* cynoglassus)	X	X		
Winter flounder (*Pleuronectes americanus)*	X	X	X	X
Yellowtail flounder (*Pleuronectes ferruginea)*	X	X		
Windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*			X	X
Monkfish *(Lophius americanus)*	X	X		
Bluefish *(Pomatomus saltatrix)*			X	X
Long finned squid *(Loligo pealei)*	n/a	n/a	X	
Summer flounder *(Paralicthys dentatus)*			X	X
Scup *(Stenotomus chrysops)*	n/a	n/a	X	X
Black sea bass *(Centropristus striata)*	n/a		X	X
Surfclam *(Spisula solidissima)*	n/a	n/a	X	X
Spiny dogfish *(Squalus acanthias)*	n/a	n/a	X	X
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Cobia *(Rachycentron canadum)*	X	X	X	X
Dusky shark *(Charcharinus obscurus)*		X		
Sandbar shark *(Charcharinus plumbeus)*		X	X	X
Tiger shark *(Galeocerdo cuvieri)*		X		

TABLE 5-4. SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10' x 10' SQUARE (#35 at 39 40.0'N 73 40.0'W; 39 30.0' N 73 50.0'W) (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Whiting (*Merkyccuys bukubearus)*	X	X	X	
Red hake *(Urophycis chuss)*	X	X		
Witch flounder (*Glyptocephalus cynoglossus*)	X	X		
Yellowtail flounder (*Pleuronectes ferruginea*)	X	X		
Windowpane flounder *(Scopthalmus aquosus)*	X	X		X
Monkfish *(Lophius americanus)*	X	X		
Bluefish *(Pomatomus saltatrix)*	X	X		X
Long finned squid *(Loligo pealei)*	n/a	n/a	X	X
Atlantic mackerel (*Scomber scombrus*)		X		
Summer flounder *(Paralicthys dentatus)*	X	X	X	X
Scup *(Stenotomus chrysops)*	n/a	n/a	X	X
Black sea bass *(Centropristus striata)*	n/a		X	X
Surfclam *(Spisula solidissima)*	n/a	n/a	X	X
Spiny dogfish *(Squalus acanthias)*	n/a	n/a	X	X
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Cobia *(Rachycentron canadum)*	X	X	X	X
Blue shark *(Prionace glauca)*			X	X
White shark *(Charcharadon carcharias)*			X	
Tiger shark (*Galeocerdo cuvieri*)		X	X	
Dusky shark *(Charcharinus obscurus)*		X	X	
Sandbar shark *(Charcharinus plumbeus)*		X	X	X
Shortfin mako shark (*Isurus oxyrhyncus)*		X	X	X
Bluefin tuna (*Thunnus thynnus*)			X	X
Swordfish (*Xiphias gladius*)			X	
Skipjack tuna (*Katsuwonus pelamis*)				X

TABLE 5-5. HABITAT UTILIZATION OF IDENTIFIED EFH SPECIES AND THEIR SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10’ x 10’ SQUARES #26, #34, AND #35. (NOAA, 1999)

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Atlantic cod *(Gadus morhua)*				Bottom (rocks, pebbles, or gravel) winter for Mid-Atlantic
Red hake *(Urophycis chuss)*	Surface waters, May – Nov.	Surface waters, May –Dec.	Bottom (shell fragments)	
Witch flounder (*Glyptocephalus cynoglassus*)	Surface waters <13 C temp deep water high salinity	Surface waters <13 C temp deep water high salinity Mar-Nov Peaks May-Jul	Bottom habitats Fine grained Temp < 13 C 50-450 m depth salinity 34-36%	Bottom habitats Fine-grained Temp < 13C 25-300 m depth salinity 32-36%
Winter flounder (*Pleuronectes americanus*)	Bottom habitats Temps <10C 10-30% salinity depths <6 m	Pelagic and bottom waters <15 C, 4-30% salinity depths < 6m	Bottom habitats Mud, sand Temp <28 C 0.1-10m depth 5-33% salinity	Bottom habitats Mud, sand, gravel Temps <25 C 1-100 m depth 15-33% salinity
Yellowtail flounder (*Pleuronectes ferruginea*)	Surface waters Temp <15 C 30-90 m depth salinity 32.4-33.5%	Surface waters Temp < 15 C Depths 20-50 m Salinity 32.4-33.5%	Bottom habitats Sand, mud Temp < 15C Depths 20-50 m Salinity 32.4-33.5%	Bottom habitats Sand, mud Temp < 15C Depths 20-50 m Salinity 32.4-33.5%
Windowpane flounder *(Scopthalmus aquosus)*	Surface waters, peaks in May and Oct.	Pelagic waters, peaks in May and Oct.	Bottom (mud or fine sands)	Bottom (mud or fine sands), peak spawning in May
Atlantic sea herring *(Clupea harengus)*			Pelagic waters and bottom, < 10 C and 15-130 m depths	Pelagic waters and bottom habitats;
Monkfish *(Lophius americanus)*	Surface waters, Mar. – Sept. in temps of 15 C and depths from 25 – 1000 m	Pelagic waters w/ temps. of 15 C and depths of 25 – 1000 m		
Bluefish *(Pomatomus saltatrix)*			Pelagic waters	Pelagic waters
Long finned squid *(Loligo pealei)*	n/a	n/a	Coastal and pelagic waters Shore to 700 f6 4 F-27 F temp	Pelagic Coast to 1,000 ft Temp 39-81 F
Whiting (*Merluccius bilnearis*)	Surface waters yearround, peaks Jul-Sep Temps below 20C Depths 50-150m	Surface waters Yearround Peaks Jul-Sep Temps below 20C Depths 15-150m	Bottom habitats Temps below 22C Depths 30-325m	Bottom habitats Temps below 13 C Depths 30-325 m
Atlantic butterfish *(Peprilus tricanthus)*	Pelagic waters		Pelagic waters in 10 – 360 m	Pelagic waters

TABLE 5-5. HABITAT UTILIZATION OF IDENTIFIED EFH SPECIES AND THEIR SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10’ x 10’ SQUARES #26, #34, AND #35. (NOAA, 1999)

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Summer flounder *(Paralicthys dentatus)*		Pelagic waters, nearshore at depths of 10 – 70 m from Nov. – May	Demersal waters (mud and sandy substrates)	Demersal waters (mud and sandy substrates). Shallow coastal areas in warm months, offshore in cold months
Scup *(Stenotomus chrysops)*	n/a	n/a	Demersal waters	Demersal waters offshore from Nov – April
Black sea bass *(Centropristus striata)*	n/a		Demersal waters over rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas	Demersal waters over structured habitats (natural and man-made), and sand and shell areas
Surf clam *(Spisula solidissima)*	n/a	n/a	Throughout substrate to 3’ in depth	
Skipjack tuna (*Katsuwonus pelamis*)			pelagic	pelagic
Spiny dogfish *(Squalus acanthias)*	n/a	n/a	33-1,280 ft depths 37 F-68F temp	Depth 33-1,476ft 37 F-68F temp
King mackerel *(Scomberomorus cavalla)*	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone.	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone
Spanish mackerel *(Scomberomorus maculatus)*	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory

TABLE 5-5. HABITAT UTILIZATION OF IDENTIFIED EFH SPECIES AND THEIR SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10’ x 10’ SQUARES #26, #34, AND #35. (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Cobia *(Rachycentron canadum)*	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory
Swordfish (*Xiphias gladius*)			pelagic	pelagic
Shortfin mako shark (*Isurus oxyrhyncus*)			Coastal and pelagic	Coastal and pelagic
Dusky shark *(Charcharinus obscurus)*		Shallow coastal waters	Coastal and pelagic	Coastal and pelagc
Sandbar shark *(Charcharinus plumbeus)*		Shallow coastal waters	Coastal and pelagic waters	Shallow coastal waters
Blue shark (*Prionace glauca*)			Coastal and pelagic	Coastal and pelagic
Tiger shark *(Galeocerdo cuvieri)*		Shallow coastal waters	Coastal and pelagic	Coastal and pelagic
White shark (*Charcharadon* carcharias)			pelagic	pelagic

A review of EFH designations and the corresponding 10’ x 10’ squares, which encompass the Barnegat Inlet to Little Egg Inlet study area was completed. The following is an evaluation of the potential effects associated with this project on EFH species:

Atlantic cod: no adverse effect is anticipated as adult fish are anticipated to avoid the project area during the temporary period when turbidity is high and feeding habitat is disrupted.

Red hake: no adverse effect is anticipated on eggs and larvae because these life history stages are pelagic in surface waters and juveniles are anticipated to move away from the project area during the temporary construction period.

Witch flounder: no adverse effect is anticipated on eggs because they are pelagic and temporary impacts due to the project will take place on the bottom.

Winter flounder: no adverse effect is anticipated on adult and juveniles because both stages can move away from the project impact area. <u>Minimal adverse effect on eggs and larvae as they are demersal at these life stages.</u>

Yellowtail flounder: no adverse effect is anticipated on larvae because they are pelagic and work will be conducted on the bottom during the temporary construction period.

Windowpane flounder: no adverse effect is anticipated on eggs and larvae as they are pelagic and work will be conducted on the bottom during the temporary construction period. No adverse effect on juveniles and adults as they are anticipated to move away from the project area during the temporary construction period.

Atlantic sea herring: no adverse effect is anticipated as adults and juveniles can move away from the project area during the temporary construction period.

Monkfish: no adverse effect on eggs and larvae is anticipated because these life history stages are pelagic and work will be completed on the bottom during the temporary construction period.

Bluefish: no adverse effect on juveniles and adults is anticipated because these life history stages can move away from the project area during the temporary construction period.

Long-finned squid: no information is available for eggs and larvae. No adverse impact is anticipated for juveniles and adults as they can move away from the project area during the temporary construction period.

Whiting: no adverse effect is anticipated for all life stages. Eggs and larvae occur in surface waters and construction activities take place at the bottom. Juveniles and adults occur in bottom habitats but are able to move from the project area during the temporary construction period.

Atlantic butterfish: no adverse impacts are anticipated. All life history stages are pelagic that construction activities will take place on the bottom.

Summer flounder: no adverse effect is anticipated on eggs and larvae because they are pelagic and work will be conducted on the bottom during the temporary construction period. No adverse effect is anticipated on juveniles and adults because they can leave the construction area.

Scup: no adverse effect on juvenile and adults is anticipated because they can move out of the area during the temporary construction period.

Black sea bass: no adverse effect is anticipated on juveniles and adults as they can move out of the area during the temporary construction period.

Surf clam: surf clams are found on the continental shelf out to approximately 25 miles. Dredging from an offshore borrow source area will impact juvenile and adult surf clams through direct removal and larval surf clams by the generation of turbidity, causing reduced light penetration which can in turn effect settlement and subject the larvae to increased predation. This impact is considered to be temporary as benthic studies have demonstrated recolonization of benthic communities following dredging operations within 13 months to a few years. The proposed borrow areas were selected to minimize destruction of the benthic community by choosing areas where the surrounding macroinvertebrate community was similar to the borrow sites so that recruitment recolonization would be rapid. In addition, the borrow areas were selected based on their benthic community composition consisting primarily of dominant small taxa, such as polychates and small bivalves, species with fast recruitment rates.

Skipjack tuna: no anticipated adverse effects as all life history stages are pelagic and construction activities will take place on the bottom.

Spiney dogfish: shark species typically have eggs and larvae in shallow coastal waters and may be impacted by construction activities. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period.

King mackerel: no adverse effect on all life stages is anticipated as all life stages of this species are pelagic and construction activities will take place on the bottom.

Spanish mackerel: no adverse effect is anticipated for all life stages as they are all pelagic and construction activities will take place on the bottom.

Cobia: no adverse effect is anticipated for all life stages as they are all pelagic and construction activities will take place on the bottom.

Swordfish: no adverse effects are anticipated as all life history stages are pelagic and construction activities will take place on the bottom.

Shortfin mako, Dusky shark, Sandbar shark, Blue shark, Tiger shark, White shark:
shark species typically have eggs and larvae in shallow coastal waters and may be impacted by construction activities. No adverse impact is anticipated for juveniles or adults as these stages are expected to move out of the construction area during the temporary construction period.

In conclusion, of the 30 species identified with Fishery Management Plans, the proposed project could impact surf clams and the egg and larval stages of winter flounder and several shark species. This is in part due to the demersal nature of these life stages. The affect on surfclams and other benthic organisms present in the borrow areas is considered to be temporary as benthic studies have demonstrated recolonization following dredging operations within 13 months to 2 years. In addition, the dredging operation is designed to mitigate impacts by not only enhancing bottom topography by creating ridges as opposed to a large hole but also allowing for quicker recruitment from the immediately adjacent ridges where the benthic community is left intact. This is in contrast to the extended time period required for recruitment of benthic organisms spanning across a large hole. Elevation differences are also minimized with the creation of ridges as opposed to one large depression.

The total impact to EFH is considered minimal due to the fact that only approximately 1,100 acres (to be used over a 50 year period in portions) of sandy bottom habitat is proposed for utilization of this shore protection project, as compared to the total quantity of similar habitats (grain size and depth) available in the area. Along the 22-mile coastline of Long Beach Island, there is more than ten times the quantity of sandy bottom habitat available. Similar bottom habitat also exists offshore of Little Egg Inlet and Brigantine Inlet. The New Jersey Geologic Survey is completing a study in cooperation with the Federal Minerals Management Agency documenting appropriate borrow areas with sand quantities in the 300 million c.y. range. The 1,100 acres of the LBI proposed borrow areas will supply approximately 25 million c.y. over the 50 year project period of analysis.

5.10 MITIGATION MEASURES:

Mitigation measures are utilized to minimize or mitigate project impacts to environmental resources within the project area. The appropriate application of mitigation is to formulate a project that first avoids and then minimizes adverse impacts and last, compensates for unavoidable impacts. Several measures can be adopted to avoid or minimize project impacts on effected resources such as benthic organisms, fisheries, endangered species, vegetation, cultural resources, recreation, and noise.

Mitigation measures are either institutional in that environmental mitigation is inherent in project alternative selection, or as measures incorporated into the construction, operation, and maintenance of the project. Several institutional measures have already been adopted to minimize impacts on resources. These measures include selection of the berm and dune nourishment alternative. This alternative offers a more natural and softer approach to storm damage reduction. Another institutional measure is the utilization of offshore sand borrow areas. These areas are characterized by high energy and shifting sands resulting in a benthic community that is capable of recovering quickly. A third measure is selection of suitable sand grain sizes for beach nourishment. The selection of borrow areas is based on compatibility studies for sand grain sizes. The selection of coarser beach nourishment quality material would minimize impacts on water quality at the dredging and placement site.

Mitigation measures recommended for construction, operation, and maintenance of the project involve minimizing impacts to benthic organisms, fisheries, endangered species, recreation, noise, and cultural resources. The following measures are recommended, however, implementation is dependent upon circumstances encountered at the time of project construction or periodic maintenance.

Benthic Organisms: The majority of unavoidable impacts are likely to be incurred by benthic organisms within the borrow areas and deposition site. Measures to minimize the effects of dredging in the borrow areas would include dredging in a manner as to avoid the creation of deep pits, alternating location of periodic dredging, conducting operations during months of lowest biological activity (when possible), utilization of a pipeline delivery system to help minimize turbidity, and dredging in a manner to approximate natural ridge slopes to ensure normal water exchange and circulation. In fact, the dredging plan calls for reducing borrow area "lumps" down to existing surrounding bathymetry or slightly higher. Requirements for detailed, geo-referenced pre-dredge and post-dredge surveys also will aid in adhering to minimizing borrow area impacts. Implementation of a benthic-monitoring program concurrent with periodic maintenance activities would document project impacts and aid in avoiding impacts to sensitive areas during the periodic maintenance activities.

Fisheries: Adverse impacts to the surf clam population would be minimized by whatever means possible. These measures might include: relocation of borrow areas, the option for commercial harvesting of surf clams prior to dredging operations, dredging a smaller area to greater depth, and disturbing only a portion of borrow sites. Borrow areas B and E have been identified as prime fisheries habitat. The recommended plan was modified in an effort to eliminate use of borrow areas B and E altogether to avoid impact to EFH identified in these borrow areas.

Data on benthic community composition and surf clam populations have shown that borrow areas fully recover from dredging operations within a few years (Scott and Kelley, 1998) and other borrow areas along New Jersey that have been used as a sand source for beach nourishment and replenishment activities have displayed the ability to rapidly recover (i.e. within 2 years) even after multiple dredging operations. Data from benthic surveys conducted for this study suggest that the benthic community of the four proposed borrow areas are typical of the New Jersey coastline and the surf clam populations within these areas have a good potential for natural recruitment and growth.

Threatened and Endangered Species: Currently, piping plover' nest along a portion of the project area. If piping plovers are nesting within the project area prior to commencement of the initial beachfill and periodic renourishment activities, the Corps will contact the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife and the U.S. Fish and Wildlife Service. Determining appropriate measures to protect piping plovers from disturbance is of paramount importance. These measures may include establishing a buffer zone around the nests, and limiting construction to areas or periods outside the nesting season (April 1 to August 15). In the event that piping plovers expand their nesting habitat on Long Beach Island, the District will consult with the USFWS prior to initial nourishment and all subsequent renourishment activities and comply with the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act" dated April 15, 1994. Protective measures and further consultation would also take place during the life of the project if the Federally listed threatened seabeach amaranth were to become established in the project area. Currently, no extant occurrences of the seabeach amaranth are known within the proposed project area.. However, the species has recently naturally recolonized coastal sites within New York and Maryland. Therefore, it is possible that the Federally listed species could naturally reestablish within the project area during the project life (Arroyo, 1999).

Depending on the timing of dredging and the type of dredge to be used, it may be necessary to implement mitigation measures to avoid adversely impacting threatened or endangered sea turtles. If a hopper dredge is used the NMFS requires the use of NMFS approved turtle monitors on the dredge in order to document any impacts. Other measures to mitigate could include utilizing modified hopper dredges that reduce the risk of entrainment to turtles. It may not be necessary to implement these measures if dredging is conducted within the winter months when turtles are not present.

Seasonal restrictions may become more essential after initial construction, as habitat will be created Least Tern nest up until August 15, which will require extending the no sand placement "window" should nests be identified prior to renourishment cycles.

Air Quality and Noise: Utilizing heavy machinery fitted with approved muffling apparatus that reduces noise, vibration, and emissions can reduce air quality and noise impacts.

Cost Sharing for Mitigation Measures: Based on coordination that has occurred between the Corps and the resource agencies as well as on previous New Jersey shoreline projects, no costs associated with mitigation have been or are expected to be required. If mitigation requirements develop as a result of the review process, these will be cost-shared. Costs associated with the use of turtle monitors on hopper dredges or a piping plover survey prior to construction will be cost-shared.

5.11 ENVIRONMENTAL JUSTICE

All of the alternatives, including the selected plan (Berm and Dune Restoration) identified in this study comply with Executive Order 12989-Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994; and no impacts are expected to occur. The project is not located in proximity to a minority or low-income community.

6.0 PROJECT COST ESTIMATE

6.1 INITIAL CONSTRUCTION COSTS

REAL ESTATE.

OWNERSHIPS: The dune and berm will be constructed on existing beachfront owned by private and commercial owners, Long Beach Township, and the boroughs of Harvey Cedars, Surf City, Ship Bottom, and Beach Haven. Construction areas would exclude any existing structures. A total of approximately 845 privately owned parcels with 825 ownership's, 5 commercial parcels with 5 ownerships, and 116 public parcels with 6 ownerships are indicated to be impacted by the proposed project. The required staging/access areas are publicly owned, as are perpetual access areas. The TWAE will not require access from the adjacent properties during construction since the work will be primarily confined to the seaward side of the dune and equipment will be such as to work over the dune. Ownership information is indicated in Exhibit A.
(See Appendix C)

ESTIMATED VALUE: The detailed Real Estate Cost Estimate in MCACES format is included in Exhibit B. The required TWAE (approximately 19.72 ac.), perpetual restrictive dune/beach nourishment easements (approximately 330 ac. including the area from the landward toe of dune to the MHWL), are considered to have nominal value because of special benefits. The proposed project will create a betterment to the properties that otherwise would not exist.

DESCRIPTION OF NFS' EXISTING OWNERSHIP: Submerged lands below the MHWL of the Atlantic Ocean are owned by the State of New Jersey and managed by the NJDEP Bureau of Tidelands Management.

RECOMMENDED ESTATES: The construction, operation and maintenance of the dune and berm will require a standard restrictive dune easement and perpetual beach nourishment easement. A standard TWAE with a duration of two years will be required for access/staging during construction.

Dune/Berm:

<u>RESTRICTIVE DUNE EASEMENT</u>

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), to construct, operate, maintain, patrol, repair, rehabilitate, and replace a dune system and appurtenances thereto, together with the right to post signs, plant vegetation and prohibit the grantor(s), (his) (her) (its) (their) heirs, successors, assigns and all others from entering upon or crossing over said dune easement; reserving, however, to the grantor(s), (his) (her) (its) (their) heirs, successors, assigns, the right to construct dune walkover structures in accordance with any applicable Federal, State, or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape or dimension and prior approval of the plans and specifications for such structures shall have been obtained from the District Engineer, U.S. Army Engineer District, Philadelphia, and all other rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

PERPETUAL BEACH NOURISHMENT EASEMENT

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), to construct, operate, maintain, patrol, repair, renourish, and replace the beach berm and appurtenances thereto, including the right to borrow and/or deposit fill, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement; reserving, however, to the grantor(s), (his) (her) (its) (their) heirs, successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

Additionally, the following standard estate would be required for staging and access during construction:

TEMPORARY WORK AREA EASEMENT (Estate No. 15)

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract Nos. ____), for a period not to exceed two years, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to borrow and/or deposit fill, spoil, and waste material thereon and to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Barnegat Inlet to Little Egg Inlet Shore Protection Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

EXISTING FEDERAL PROJECTS: There are no federal projects in the proposed project area.

EXISTING FEDERAL OWNERSHIP: There is no Federally owned land within the project area.

NAVIGATIONAL SERVITUDE: Navigational Servitude will apply to this shoreline protection/erosion control project. No Federal Government interest in real property is required with respect to lands subject to navigational servitude. The non-Federal sponsor owns all the lands below the MHWL, but due to navigational servitude no right-of-entry will be necessary.

REAL ESTATE MAPPING: Plates R-1 through R-13, dated 11 February 1999, are attached as Exhibit D (See Volume 2 Real Estate Appendix). The maps include delineation of the land, estates, and acreage to be acquired and indicate parcels impacted by the project.

INDUCED FLOODING: No induced flooding is anticipated due to this proposed project.

BASELINE COST ESTIMATE FOR REAL ESTATE: The detailed real estate cost estimate in MCACES format is included in Exhibit B. Since the number of parcels impacted for this project is unusually large, costs to the non-Federal sponsor in the acquisition of the real estate are being kept in check. As the result of this project each property owner will accrue special benefits, therefore compensation is nominal. Informal value estimates will be completed in lieu of formal appraisals, since values will be less than $2,500 per tract, at an estimated cost of $25,000. Rather than obtaining Title Evidence for each individual parcel, Verification of Ownership's will be completed at an estimated cost of $10,000 for this job action. No individual survey and title description will be done on each parcel in the acquisition of the easements. Each municipality has affixed on their mapping a building line limit that has been surveyed, and is or will be required to be recorded at the Cape May County Courthouse. The easements for each parcel of this project will reference the building limit line. The cost for the preparation and recordation of these plats by the municipalities has been estimated at $3,000. These costs have been discussed with and agreed to by the non-Federal sponsor.

6.2 ENGINEERING AND DESIGN FOR MONITORING PERIODIC NOURISHMENT

A beachfill project has a specific longevity and must undergo periodic inspection, maintenance and renourishment in order to preserve project functionality over the designed lifetime. The project monitoring plan will document beach fill performance and evaluate conditions within the borrow areas over the 50 year period of analysis. Periodic assessments and monitoring data analysis will assist in producing recommendations for modifications to the quantities, location and cycle of future fills based on actual trends of fill behavior. The monitoring program for Long Beach Island was developed in accordance with EM 1110-2-1004, ER 1110-2-1407, CETN-II-26 and CETN II-35. The following items are included in the proposed monitoring program: pre- and post-construction beach profile surveys, semi-annual monitoring profile surveys, sediment sampling of the beach and borrow areas, aerial photography, and tidal data collection. Laboratory and data analysis will be conducted regularly using the field data collected in the program. The proposed monitoring program will begin at the initiation of pre-construction efforts and continue throughout the 50-year period of analysis. A more detailed description of the monitoring program is provided in Appendix A.

6.3 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION (OMRR&R)

Coordination has been accomplished with NJDEP, the non-Federal sponsor, and they are fully aware of their obligations concerning Operation and Maintenance of the Federal project. The monitoring plan will be included in the OMRR&R manual.

Since the project includes a protective beach fill and periodic nourishment, a set of minimum profile conditions will be specified below which the protective integrity and /or the restored beach alignment are in jeopardy. Comparative analysis of these minimum conditions with survey data will indicate where and when beach nourishment is needed. Additionally they will serve as performance criteria for the project. Permanent features in support of the condition surveys may include benchmarks, survey marker, gauges and other instruments. These items and the surveys are considered part of the continuing construction of the project and are cost-shared construction costs.

The annual operation and maintenance of the project includes maintaining the dunes, pedestrian accesses, beach shaping and beach surveys. The dunes will be maintained by shaping the sand with heavy equipment to ensure the presence of the design template. In addition, sand fence and replanting of dune grass that becomes damaged or suffers deterioration over time will be replaced or maintained, as needed. Dune walkovers from private homes down to the beach will also be the responsibility of the non-Federal sponsor should they require removal during the initial construction. The annual cost for these OMRR&R activities post initial construction is estimated to be $110,000 and is based on operation and maintenance experience for similar beachfill projects within the Philadelphia District. The non-Federal sponsor bears full financial responsibility for these OMRR&R activities. First Cost and nourishment cost estimates are found in **Table 6-1**.

Table 6-1A – Total First Cost – Selected Plan

Alternate 6 (22' NAVD Dune, 125' Berm using 7 year cycle)
Plan B (Borrow Areas D2)

Account Code	Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Project Costs
01.	Lands and Damages						
01.B	Post Authorization Planning						
01.B.2	Required Easements	1	Job	LS	$552,340	$82,851	$635,191
01.B.8	Surveys Appraisal & Admin	1	Job	LS	$26,000	$3,900	$29,900
	Total Lands and Damages				$578,340	$86,751	$665,091
17.	Beach Replacement						
17.00.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,366,281	$163,954	$1,530,235
17.00.16	Pipeline Dredging						
17.00.16.02	Site Work						
17.00.16.02.01	Excavation and Disposal						
17.00.16.02.01D1	BUNDYs 3 Thru 5	1,081,000	CY	$3.38	$3,653,780	$548,067	$4,201,847
17.00.16.02.01D1	BUNDYs 6 Thru 8	2,037,000	CY	$3.34	$6,803,580	$1,020,537	$7,824,117
17.0017	Hopper Dredging						
17.00.17.02	Site Work						
17.00.17.02.01	Excavation and Disposal						
17.00.17.02.01D2	BUNDYs 9 And 10	1,692,000	CY	$5.18	$8,764,560	$1,314,684	$10,079,244
17.00.17.02.01D2	BUNDYs 11 Thru 13	1,470,000	CY	$5.77	$8,481,900	$1,272,285	$9,754,185
17.00.17.02.01D2	BUNDYs 14 And 15	918,000	CY	$6.29	$5,774,220	$866,133	$6,640,353
17.00.99	Associated General Items						
17.00.99.03.01	Sand Fence	509,700	LF	$3.98	$2,028,606	$405,751	$2,434,327
17.00.99.03.02	Dune Grass	146,800	CSF	$19.73	$2,896,364	$579,273	$3,475,637
17.00.99.03.03	Roll-Out Boardwalks	70	Ea.	$14,323	$1,002,610	$200,522	$1,203,132
	Total Beach Replacement				$40,771,901	$6,371,176	$47,143,077
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,188,200	$168,400	$1,356,600
. 31.	Construction Management (S&A)	1	Job	LS	$800,000	$120,000	$920,000
	Total Project First Cost				$43,338,441	$6,746,327	$50,084,768
	(Rounded)				$43,338,000	$6,746,000	$50,084,000

Dredging quantity includes 7 yr. Nourishment cycle.

Table 6-1B – Periodic Nourishment Costs

Periodic Nourishment Costs (Yr. 7)

Plan B (Borrow Areas A and D1)

Account Code	Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Project Costs
17.	Beach Replacement						
17.00.01	Mobilization, Demob, and Preparatory Work	1	Job	LS	$979,882	$117,586	$1,097,468
17.00.16	Pipeline Dredging						
17.00.16.02	Site Work						
17.00.16.02.01	Excavation & Disposal						
17.00.16.02.01.A	BUNDYs 3 Thru 6	1,184,000	CY	$3.34	$3,954,560	$593,184	$4,547,744
17.00.16.02.01.D1	BUNDYs 7 And 8	224,000	CY	$3.69	$826,560	$123,984	$950,544
17.00.17	Hopper Dredging						
17.00.17.02	Site Work						
17.00.17.02.01	Excavation & Disposal						
17.00.17.02.01.D1	BUNDYs 9 And 10	133,000	CY	$5.29	$703,570	$105,536	$809,106
17.00.17.02.01.D1	BUNDYs 11 Thru 13	348,000	CY	$5.83	$2,028,840	$304,326	$2,333,166
17.00.17.02.01.D1	BUNDYs 14 And 15	444,000	CY	$6.34	$2,814,960	$422,244	$3,237,204
	Total Beach Renourishment				$11,308,372	$1,666,859	$12,975,231
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$610,000	$85,050	$695,050
31.	Construction Management (S&A)	1	Job	LS	$400,000	$60,000	$460,000
	Total Periodic Nourishment Cost	1	Job	LS	$12,318,372	$1,811,909	$14,130,281
	(Rounded)				$12,318,000	$1,812,000	$14,130,000

Table 6-1C – Periodic Nourishment Costs (Yrs. 14, 21, 35, 42 and 49)

Plan B (Borrow Area D2)

Account Code	Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Project Costs
17.	Beach Replacement						
17.00.01	Mobilization, Demob, and Preparatory Work	1	Job	LS	$979,882	$117,586	$1,097,468
17.00.16	Pipeline Dredging						
17.00.16.02	Site Work						
17.00.16.02.01	Excavation and Disposal						
17.00.16.02.01.D2	BUNDYs 3 And 4	192,000	CY	$3.84	$737,280	$110,592	$847,872
17.00.16.02.01.D2	BUNDYs 5 And 6	547,000	CY	$4.09	$2,237,230	$335,585	$2,572,815
17.00.17	Hopper Dredging						
17.00.17.02	Site Work						
17.00.17.02.01	Excavation and Disposal						
17.00.17.02.01.D2	BUNDYs 7 Thru 9	293,000	CY	$5.26	$1,541,180	$231,177	$1,772,357
17.00.17.02.01.D2	BUNDYs 10 Thru 12	376,000	CY	$5.88	$2,210,880	$331,632	$2,542,512
17.00.17.02.01.D2	BUNDYs 13 Thru 15	480,000	CY	$6.51	$3,124,800	$468,720	$3,593,520
	Total Beach Replacement				$10,831,252	$1,595,291	$12,426,543
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$610,000	$85,050	$695,050
31.	Construction Management (S&A)	1	Job	LS	$400,000	$60,000	$460,000
	Total Periodic Nourishment Cost				$11,841,252	$1,740,341	$13,518,593
	(Rounded)				$11,841,000	$1,740,000	$13,581,000

Table 6-1D – Major Replacement Costs (Year 28)

Plan B (Borrow Area D2)

Account Code	Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Project Costs
17.	Beach Replacement						
17.00.01	Mobilization, Demob, and Preparatory Work	1	Job	LS	$979,882	$117,586	$1,097,468
17.00.16	Pipeline Dreding						
17.00.16.02	Site Work						
17.00.16.02.01	Excavation and Disposal						
17.00.16.02.01.D2	BUNDYs 3 And 4	263,000	CY	$3.76	$988,880	$148,332	$1,137,212
17.00.16.02.01.D2	BUNDYs 5 And 6	646,000	CY	$4.00	$2,584,000	$387,600	$2,971,600
17.00.17	Hopper Dredging						
17.00.17.02	Site Work						
17.00.17.02.01	Excavation and Disposal						
17.00.17.02.01.D2	BUNDYs 7 Thru 9	409,000	CY	$5.20	$2,126,800	$319,020	$2,445,820
17.00.17.02.01.D2	BUNDYs 10 Thru 12	505,000	CY	$5.84	$2,949,200	$442,380	$3,391,580
17.00.17.02.01.D2	BUNDYs 13 Thru 15	571,000	CY	$6.47	$3,694,370	$554,156	$4,248,526
17.00.99	Associated General Items						
17.00.99.03.01	Sand Fence	509,700	LF	$3.98	$2,028,606	$405,721	$2,434,327
17.00.99.03.02	Dune Grass	$146,800	CSF	$19.73	$2,896,364	$579,273	$3,475,637
17.00.99.03.03	Remove Roll-Out Boardwalks	70	Ea.	$823	$57,610	$11,522	$69,132
17.00.99.03.04	Reinstall Roll-Out Boardwalks	70	Ea.	$823	$57,610	$11,522	$69,132
	Total Beach Replacement				$18,363,322	$2,977,111	$21,340,433
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$735,000	$103,800	$838,800
31.	Construction Management (S&A)	1	Job	LS	$550,000	$82,500	$632,500
	Total Project First Cost				$19,648,322	$3,163,411	$22,811,733
	(Rounded)				$19,648,000	$3,163,000	$22,811,000

Dredging quantity includes 7 yr. Nourishment cycle.

6.4 ANNUALIZED COSTS

Table 6-2 displays the calculations for interest during construction. It is assumed the construction costs would be evenly distributed over the construction period. The duration of construction for the project is estimated at twelve months. The planning, engineering and design phase of study will begin 18 months prior to the start of construction. Therefore, in accordance with ER1105-2-100, paragraph 6-153, interest during construction was based on 30 months. The Economics of the NED plan are shown in **Table 6-3**, including annualized first costs, nourishment costs, monitoring costs associated with engineering and design for periodic nourishment, and a major rehabilitation cost (year 28).

Table 6-2

INTEREST DURING CONSTRUCTION (IDC)

LONG BEACH ISLAND SELECTED PLAN

DISCOUNT RATE =	6.875%	
P/L = JAN 99		
MONTHS =	30	
PED =		$1,357,000
Real Estate =		$665,000
Construction =		$48,062,000
		$50,084,000
CRF (i=.06875, n=50)		0.071317
Expected Average Annual Cost		**$3,571,829**

CONSTRUCTION PERIOD -- 24 MONTHS

MONTH	MONTHLY PAYMENTS	FUTURE VALUE FACTOR	INVESTMENT COST	
1	75,389	1.1743133	88,530	PED begins
2	75,389	1.1678246	88,041	
3	75,389	1.1613718	87,555	
4	75,389	1.1549547	87,071	
5	75,389	1.1485730	86,590	
6	75,389	1.1422266	86,111	
7	75,389	1.1359152	85,635	
8	75,389	1.1296387	85,162	
9	75,389	1.1233969	84,692	
10	75,389	1.1171896	84,224	
11	75,389	1.1110166	83,758	
12	75,389	1.1048777	83,295	
13	75,389	1.0987727	82,835	
14	75,389	1.0927014	82,378	
15	75,389	1.0866637	81,922	
16	75,389	1.0806594	81,470	
17	75,389	1.0746882	81,020	
18	75,389	1.0687500	80,572	PED ends
19	4,670,167	1.0628446	4,963,662	Construction Begins
20	4,005,167	1.0569719	4,233,349	
21	4,005,167	1.0511316	4,209,957	
22	4,005,167	1.0453236	4,186,695	
23	4,005,167	1.0395477	4,163,562	
24	4,005,167	1.0338037	4,140,556	
25	4,005,167	1.0280914	4,117,677	
26	4,005,167	1.0224107	4,094,925	
27	4,005,167	1.0167614	4,072,299	
28	4,005,167	1.0111433	4,049,797	
29	4,005,167	1.0055562	4,027,420	
30	4,005,167	1.0000000	4,005,167	
	$50,084,000		$51,785,926	TOTAL INV. COST
			50,084,000	MINUS FIRST COST
INTEREST DURING CONSTRUCTION (IDC)			1,701,926	
	CRF (i=.07125, n=50)		0.071317	
	IDC annualized		**$121,376**	

6.5 INCIDENTAL BENEFITS

Recreational Analysis. The beaches in New Jersey are consistently the number one travel destination within the state. Tourist dollars contribute directly and indirectly to the regional economy, as previously discussed. The number of visitors and the willingness t pay determines the value inherent to this type of recreation.

A contingent valuation method survey was completed by the Rutgers State University for the New Jersey Department of Environmental Protection and Energy and the U.S. Army Corps of Engineers to determine willingness to pay for the existing beach and an enhanced beach. The sampling was done on a regional basis, encompassing the major beach communities of Atlantic City, Ventnor, Margate and Longport. It consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach during the summer of 1994.

Beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. The primary factors of consideration were the quality of the beach scenery, how well maintained the beach was, the width of the beach, the number of lifeguards, and how family oriented was the beach.

The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time it was very crowded (only 2 feet between towels). Further it was determined that crowding was not considered a very important issue to the majority of beachgoers by asking respondents how important being alone is and how important is it to be with a large number of people. As might be expected, areas with more crowding tended to be frequented by people who like large numbers. People who like to be alone, frequented areas that tended to have little crowding. To estimate the value of the beach as it exists currently, an iterative bidding process was applied. Beachgoers were first asked if a day at the beach would be worth $4.00 to each member of their household. Based on their answers, they were then asked progressively higher or lower amounts until the amount they value the beach was determined. Using this method it was found that the average value of a day at the beach is $4.22.

The beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority were unwilling to pay any extra, 16% were willing to pay, on average, $2.92 more per visit. This would be equivalent to an average of $0.47 for all beachgoers. For the purpose of this study this value was indexed to an October 1998 price level.

The number of visitor days for the municipalities of Long Beach Island was collected from the respective boroughs and township. Long Beach Township Beach Patrol, which oversees twelve miles of beach actually tracts and tabulates head counts. For the remainder of the municipalities the number of visitor days was estimated by multiplying the number of beach tag sales by the number of days the tags are usable. To include for incremental weather and days of non-use it was estimated that beach seasonal beach tags on average would be used 45 days for the season of approximately a 100 day season (it already pays to purchase a seasonal badge for a stay of over two weeks) , a weekly badge for 5 days (out of 7), and daily badges counted for a one day use. This was then multiplied by 1.062 to capture the percentage of people who use the beach without buying a beach tag, based on estimates from previous studies.

Benefits were not computed to accrue from increased capacity because based on a daily seasonal average day crowding was found not to be a significant factor. However, benefits do arise from an increase in the value of the recreational experience. Benefits resulting from this increase in recreational experience were calculated by multiplying $0.50 by the number of visitors' days within the project area or about 3,846,000 per annum. The recreational benefits is for about $1,923,000 per year. A breakdown of estimated beach use for each community is as follows:

Barnegat Light...	289,000
Harvey Cedars...	295,000
Surf City...	742,000
Ship Bottom...	880,000
Long Beach Township...	1,006,000
Beach Haven...	634,000

Benefits During Construction & Advanced Nourishment Benefits. The proposed project will be constructed over 12 months with an additional month before and after construction for mobilization and demobilization. Portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. For the purposes of this study, no benefits during construction were included in the net benefits analysis.

Table 6-3

ECONOMICS OF THE NED PLAN

(January 1999 price levels. FY 99 Discount Rate 6 7/8 %.)

Benefit Cost Ratio. Total average annual benefits are displayed.

AVERAGE ANNUAL BENEFITS:		
STORM DAMAGE REDUCTION		$ 7,706,000
REDUCED MAINTENANCE & LOCAL COST FORGONE		$ 986,000
RECREATION		$ 1,923,000
TOTAL AVERAGE ANNUAL BENEFITS		**$10,615,000**
AVERAGE ANNUAL INITIAL CONSTRUCTION COSTS		**$ 3,572,000**
AVERAGE ANNUAL NOURISHMENT COSTS	$1.698,000	
AVERAGE ANNUAL MONITORING COSTS		$ 270,000
FOR E&D FOR PERIODIC NOURISHMENT		273,000
AVERAGE ANNUAL OMRR&R COSTS		$ 110,000
TOTAL AVERAGE ANNUAL COSTS		**$ 5,771,000**
BENEFIT-TO-COST RATIO	**1.84**	
NET BENEFITS	**$ 4,844,000**	
BCR (excluding recreation)	**1.50**	
NET BENEFITS (excluding recreation)	**$ 2,921,000**	
TOTAL COSTS (rounded):		
INITIAL CONSTRUCTION COSTS		$50,084,000
INTEREST DURING CONSTRUCTION (annualized $121,000)		$ 1,702,000
PERIODIC NOURISHMENT		$104,846,000
(includes major replacement at year 28: $22,811,000)		

6.6 RISK AND UNCERTAINTY ASSOCIATED WITH COASTAL PROJECTS

The Corps of Engineers has a long history of planning coastal protection measures as well as other types of water resources development projects. By providing protection against coastal hazards, gains in economic efficiency can be achieved that result in an increase in the national output of goods and services. A comprehensive guide for calculating NED benefits primarily for storm damage reduction and shore protection projects is contained in IWR Report 91-R-6 National Economic Development Procedures Manual - Coastal Storm Erosion, U.S. Army Corps of Engineers, Institute for Water Resources, September 1991.

Coastal protection projects, like all investments, involve an outlay of capital at some point in time in order to gain predicted benefits in the future. In addition, certain types of projects, particularly beach fill and periodic nourishment projects require a commitment to substantial future spending to sustain the projects and continue to gain the related benefits. In 1956, Congress defined periodic nourishment as construction for the protection of shores when it is the most suitable and economical remedial measure. One advantage to soft engineering options, such as beach fill, is that they do not represent an irrevocable commitment of funds. They can be discontinued at any future point in time, eventually allowing a return to the pre-project condition, without further expenditures.

In all evaluations, the aspect of future costs and benefits requires that the current and future dollar costs and benefits be compared in a common unit of measurement. This is typically accomplished by comparing their present values or the average annual equivalent of their present values. Therefore, the discount or interest rate used to determine the present value influences the relative economic feasibility of alternative project types. Since high discount rates reduce the influence of future benefits and costs on present values, high interest rates generally favor the selection of projects with low first costs but relatively high planned future expenditures over those with high first costs but low future cost requirements. This factor, among other important considerations, tends to favor the wide use of beach fills, dunes and accompanying renourishment relative to an extensive use of hard structural shore protection measures.

One standard for identifying and measuring the economic benefits from investments in a water resources project such as shore protection is the willingness of an individual to pay for that project. For coastal projects, this value can be generated by a reduction in the cost to a current land-use activity or the increase in net income possible at a given site. A project generates these values by reducing the risk of storm damage to coastal development. Conceptually, the risk from storms can be viewed as incurring a cost to development, i.e. capital investment, at hazardous locations. Thus, the cost per unit of capital invested at risky locations is higher than at lesser risk locations.

Natural Sources of Risk and Uncertainty. Storms and severe erosive processes damage coastal property in several ways. In addition to direct wind-related damage, which is ignored for purposes of this discussion, a storm typically produces an elevated water surface or surge above the normal astronomical tide level. This storm-driven surge is often sufficient, even without the effects of waves, to be life-threatening and/or to cause substantial inundation damages to property.

In addition to the surge, coastal storms generate large waves. Properties subject to direct wave attack usually suffer extensive structural and content damages as well as foundation scouring which can totally destroy structures. Storms also produce at least temporary physical changes at the land-water boundary by eroding the natural beach and dune that serve to buffer and protect shorefront property from the effects of storms. Increased wave energy during storms erodes the beach and carries the sand offshore. At the same time, the storm surge pushes the zone of direct wave attack higher up the beach and can subject dunes and, in turn, upland structures to direct wave action.

Frameworks for Deterministic and Risk-Based Evaluations. The first step in a project feasibility evaluation is to assess the baseline conditions, i.e., the conditions that would likely exist if a project was never implemented to address the existing problems in a systematic fashion. In the deterministic approach, which is currently the basic approach used by the Corps of Engineers, a single forecast defines physical, developmental, cultural, environmental and other changes expected to occur under the baseline or without project condition. These changes are considered to occur with certainty in the absence of any systematic adaptive measure of the type being considered as a project. This approach does allow, however, for individual property owners to respond to storm and erosion threats by constructing protective measures or by abandoning property. It also takes into account other systematic measured that are in place or expected to be instituted such as existing state, county or municipal protective measures, evolving building codes and changing land-use controls.

Benefits produced by a project depend on the project's type, scale, and storm parameters. Even if two alternative projects constructed side by side experience the same storm, benefits will differ, depending on the magnitude of residual losses if the storm exceeds the alternatives' design dimensions. As an example, a beach fill, even when inundated during a storm, still provides significant residual protection. Another significant factor is that in the coastal process, the wide range of storm parameters (wind direction, wind velocity, storm surge, storm duration, etc.) results in multiple storm damage mechanisms.

In addition to NED benefits, a second major consideration in applying benefit-cost analysis in choosing a particular type and size project is the stream of future project costs. The appropriate costs used in the analysis should provide a measure of all the opportunity costs incurred to produce the project outputs. These NED costs may differ from the expenses of constructing and maintaining the project. For coastal protection projects, expenses would include the first costs of project construction, any periodic nourishment and maintenance costs, and future rehabilitation costs.

The nature of future costs depends on the type of project. For instance, a structural type of project, e.g., a stone revetment, typically has high first costs and high future rehabilitation costs but low future maintenance costs. On the other hand, when compared to a hard structure project, a beach fill type project is composed of relatively low first costs, but larger recurring future maintenance costs (periodic nourishment).

Once the alternative plans are evaluated in economic terms, the expected net benefits can be calculated. Following the project selection criteria in P&G, the recommended type and scale of plan should be the one that reasonably maximizes net NED benefits. This is a key conceptual point in both the deterministic and risk analysis evaluation methodologies. Both methods apply the net benefits decision rule for selecting the economically optimal project.

The reduction of the affect of the discount rate from the FY98 rate of 7 1/8 % to the 6 7/8 % of FY 99 has been displayed for the recommended plan. A decrease in the discount rate has resulted in an increase to the benefit to cost ratio. It is recognized that over time there is variation in economic conditions as well as hydraulic and hydrological parameters. As part of a feasibility analysis detailed information has been collected to the extent defined by the scope of work. The analysis used statistical modeling techniques that took into account probability of occurrence of storm events, mechanism of storm damages, and resources that take into account regional labor and construction rates.

The benefits were recalculated with a ten- percent variation from the calculated expected mean as assessed in the storm damage reduction analysis. The following tables in the next two pages show the results with the 7 1/8% and 6 7/8% discount rates.

NED BENEFITS AT 7 1/8% DISCOUNT RATE WITH 10% VARIATION (PLAN A)

The NED plan was recomputed to show the affects of a change of the benefit stream values +\- 10 percent for Plan A. The results are displayed below. ($ in 000's)

SENSITIVITY ANALYSIS NED Benefits Changes	
-10% IN BENEFIT CATEGORIES:	
Average Annual Benefits:	$9,506
Average Annual Costs:*	$5,092
Benefit-Cost Ratio:	1.87
Net Benefits:	$4,414
+10% IN BENEFIT CATEGORIES:	
Average Annual Benefits	$11,6 18
Average Annual Costs:*	$5,092
Benefit-Cost Ratio:	2.28
Net Benefits:	$6,526

* Includes monitoring and interest during construction

NED BENEFITS AT 6 7/8% DISCOUNT RATE WITH 10% VARIATION (PLAN A)

The NED plan was recomputed to show the affects of a change of the benefit stream values +\- 10 percent at the 6 7/8% discount rate for Plan A. The results are displayed below. ($ in 000's)

SENSITIVITY ANALYSIS NED Benefits Changes	
-10% IN BENEFIT CATEGORIES:	
Average Annual Benefits Benefits:	$9,554
Average Annual Costs:*	$4,939
Benefit-Cost Ratio:	1.93
Net Benefits:	$4,615
+10% IN BENEFIT CATEGORIES:	
Average Annual Benefits	$11,677
Average Annual Costs:*	$4,939
Benefit-Cost Ratio:	2.36
Net Benefits:	$6,738

* Includes monitoring and interest during construction

NED BENEFITS AT 6 7/8% DISCOUNT RATE WITH 10% VARIATION (PLAN B)
The NED plan was recomputed to show the affects of a change of the benefit stream values +\- 10 percent at the 6 7/8% discount rate for Plan B. The results are displayed below. ($ in 000's)

SENSITIVITY ANALYSIS	**NED Benefits Changes**
-10% IN BENEFIT CATEGORIES:	
Average Annual Benefits Benefits:	$9,554
Average Annual Costs:*	$5,771
Benefit-Cost Ratio:	1.66
Net Benefits:	$3,783
+10% IN BENEFIT CATEGORIES:	
Average Annual Benefits	$11,677
Average Annual Costs:*	$5,771
Benefit-Cost Ratio:	2.02
Net Benefits:	$5,906

* Includes monitoring and interest during construction

6.7 LOCAL COOPERATION

Cost Apportionment. The cost apportionment between Federal and non-Federal total first cost of the selected plan is shown in **Table 6-4**. The selected plan is economically justified on benefits associated with storm damage reduction. There are no separable recreation features included with this project. Recreation benefits resulting from the selected plan are not considered in justification. All recreation benefits are assumed to be incidental to the project. In accordance with Section 103 of the Water Resources Development Act of 1986, Federal responsibility for hurricane and storm damage reduction is 65 percent of the estimated total project first costs, including Lands, Easements, Rights-of-Ways, Relocations and Dredged Material Disposal Areas (LERRD). The estimated market value of LERRD provided by non-Federal interests is included in the total project cost, and they shall receive credit for the value of these contributions against the non-Federal cost share. The cost sharing for the selected plan is based on a total first cost of $ 50,084,000, which does not include IDC at $1,702,000

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Table 6-4
Cost Sharing for the Selected Plan
(January 1999 Price Level)

ITEM			**COST**		
Initial Beach Replenishment			**$ 50,084,000**		
Lands, Easements, Rights-of-Way, Relocations, Disposal Areas (LERRD)			$ 665,000		
Periodic Nourishment (7 year cycle) Average over 7 cycles			$13,700,000		
PROJECT FEATURE	**FEDERAL COST**	**%**	**NON-FEDERAL COST**	**%**	**TOTAL COST**
Initial Project Costs (Cash Contributions)	$ 32,555,000	65%	$ 17,529,000	35%	$ 50,084,000
LERRD	$0	0%	$665,000	100%	$665,000
Total Initial Project Costs	$ 32,555,000	65%	$ 18,194,000	35%	$ 50,749,000
Periodic Nourishment (50 Years) (includes major replacement costs and E&D for continuing construction)	$ 68,150,000	65%	$ 36,696,000	35%	$ 104,846,000
Ultimate Project Cost (50 Years)	$ 100,705,000	65%	$ 54,890,000	35%	$ 155,595,000

*NOTE: Ultimate project cost does not include OMRR&R costs throughout the 50 year period of analysis which are estimated at $110,000 ($/yr) and are the responsibility of the non-Federal sponsor IDC total is $$ 1,702,000 , it is not included in the above cost estimates.

6.8 SPONSOR FINANCING.

Sponsor Financing. In accordance with Section 215 of the Water Resources Development Act of 1999, WRDA 99, the Barnegat Inlet to Little Egg Inlet Feasibility Study was cost shared 65%-35% between the Federal Government and the State of New Jersey. The contributed funds of the local sponsor, the New Jersey Department of Environmental Protection (NJDEP) demonstrates their intent to support a project for Long Beach Island. The State of New Jersey has a stable source of funding for shoreline-related projects equaling, at minimum, $25 million annually. Additionally the sponsor has indicated support for the project in a letter dated September 1999. The State of New Jersey has a stable source of funding for shore protection projects as described in the Introduction of this report. The State has incorporated this project into its forecast of expenditures. **Table 6-5** presents the State's anticipated levels of funding.

Table 6-5
Shore Protection Funding
(in $millions)

FISCAL YEAR	FEDERAL	STATE	LOCAL	TOTAL
94	1.7	1.7	0.0	3.4
95	10.7	4.6	0.0	15.3
96	27.7	11.6	3.4	42.7
97	29.0	16.4	4.6	50.0
98	25.9	11.8	3.3	41.0
99	21.8	8.5	2.4	32.7
00	25.1	10.2	3.3	38.6

Source: Presentation by Bernard Moore, Administrator, Engineering and Construction, NJDEP, at the Symposium "Investing in Our Beaches, Separating Fact from Fiction" November 28, 1995, 1997.

In an effort to keep the Sponsor involved and the local government informed, meetings were held throughout the feasibility phase. In addition, newsletters were sent periodically describing the study process for (see Appendix E).

Coordination efforts will continue, including coordination of this study with other State and Federal agencies. It is currently anticipated that a public meeting will be held upon approval of this Feasibility Study.

6.9 LOCAL COOPERATION/PROJECT COOPERATION AGREEMENT

A fully coordinated Project Cooperation Agreement (PCA) package (to include the Sponsor's financing plan) will be prepared subsequent to the approval of the feasibility phase and will reflect the recommendations of this Feasibility Study. NJDEP, the non-Federal sponsor, has indicated support of the recommendations presented in this Feasibility Study and the desire to execute a PCA for the recommended plan. Other non-Federal interests, such as the local municipalities, have indicated their support of the project.

Toward satisfying its responsibilities of local cooperation, the non-Federal sponsor will:

a. Provide 35 percent of the costs allocated to initial construction and 35 percent of the costs allocated to periodic nourishment, (if the current administration's policy is adopted into law) as further specified below:

(1) Enter into an agreement which provides, prior to construction, 25 percent of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

(4) Provide or pay to the Government the cost of providing all retaining dikes, bulkheads, and embankments, including all monitoring features, that may be required at any dredged material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the costs allocated to initial construction and 35 percent of the costs allocated to periodic nourishment, as further specified below.

b. Provide 100 percent of the costs allocated to initial construction and periodic nourishment of private shores;

c. For so long as the project remains authorized, assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

d. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land, which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

e. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

f. Hold and save the Government free from all damages arising for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterment's, except for damages due to the fault or negligence of the Government or the Government's contractors.

g. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

h. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

i. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

j. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

k. Prevent future encroachments on project lands, easements, and rights-of-way, which might interfere with the proper functioning of the project.

l. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface" Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act.

m. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army,” and Section 402 of the Water Resources Development Act of 1986, as amended.

n. Not use Federal funds to meet the non-Federal sponsor’s share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

o. Provide the non-federal share that portion of total cultural resource preservation mitigation and data recovery costs attributable to shore protection (initial construction and periodic nourishment) that are in excess of one percent of the total amount authorized to be appropriated for recreation.

p. Provide and maintain necessary access roads, parking areas and other public use facilities, open and available to all on equal terms.

q. Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources Development Act of 1986, as amended.

r. Not less than once each year inform affected interests of the extent of protection afforded by the Project.

s. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the Project.

t. For so long as the project remains authorized, the non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based including the public use of private lands for the purpose of accessing and using the recreational beach.

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7.0 CONCLUSIONS & RECOMMENDATIONS

Study Continuation: Needs and Requirements. As a requirement in completing the feasibility study, a public notice shall be issued to inform all interested parties of the plan selected herein. Because the design of the recommended plan is not technically complex and is essentially complete, a typical Design Memorandum would not be required before the initiation of construction. The District will ask that the project proceed to Preconstruction, Engineering and Design phase if the Administration's policy makes shore protection projects higher budgetary priority.

Additional Tasks. The technical work remaining consists of additional environmental benthic surveys, cultural investigations of potential targets in benthic areas and hydraulic analyses. The additional hydraulic work is aimed at optimizing the nourishment cycle costs through use of various methodologies explained in this document. In addition, final environmental coordination and documentation can be accomplished concurrent with preparation of plans and specifications for construction. In the event this study leads to Federal construction, the non-Federal sponsor shall reimburse the costs for these activities as a cost shared project item.

Selected Plan Reach. The storm damage reduction plan for Long Beach Island identified in this report generally extends from groin 4 (Seaview Drive, Loveladies) to the terminal groin (groin 98) in Long Beach Township, a section known as Holgate, approximately 17 miles. The Barnegat Light (northern end of the study area) area is not included in the nourishment aspect of the project because of minimal erosion and substantial dune/berm complex. It may play a role as a source for sand should the Sand Recycle Plant alternative be a cost effective alternative to hydraulic nourishment. The US Fish and Wildlife Service (USFWS, 1996) states that they do not consider beach nourishment on the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge necessary. Hence, the Holgate Unit (southern end of study area) was also not included in the project. Due to the fact that both ends of the project terminate at a groin, no tapers would be needed.

Selected Plan Details. The template for the plan is a dune of elevation of 22 ft NAVD, with a 30 ft dune crest width, 1V:5H slopes from dune crest down to a berm at elevation +8 ft NAVD, a berm width of 125 ft from centerline of dune (approximately 105 feet of dry berm from the seaward toe of dune to MHW), 1V:10H slopes from the berm to MLW, and maintenance of the profile shape from MLW to depth of closure (occurring at approximately -29 ft NAVD). Average dune widths for LBI are already at +29 feet NAVD. Dune elevations are at 19 ft on average while berm width averages are at 111 feet. As part of the berm and dune restoration approximately 1,030.85 acres would be covered, of these, approximately 365.10 acres would be above mean high water (MHW) and 665.75 acres would be below MHW. The elevation of MHW is 1.5 ft in NAVD datum. The above surface areas extend from the inland toe of dune to MHW and from MHW to depth of closure at -29.0 ft NAVD.

Sand Quantities and Additional Design Features. A total sand fill quantity of 7,400,000 cubic yards is needed for the initial fill placement. Renourishment of the beach template will require approximately 1,900,000 cubic yards of sand fill every seven years from the borrow area's identified adjacent to the project site, for the 50 year period of analysis. Planted dune grass will total 337.0 acres while 509,700 linear feet of sand fence is estimated for the entrapment of sand on the dune and to delineate walkovers. Walkovers will consist of a rollout boardwalk type of construction, which will traverse the dune and avoid compromising the dune fill by allowing a gap in the dune.

Monitoring. To properly assess the functioning of the proposed plan, monitoring of the placed beachfill, borrow area, shoreline, wave and littoral environment is included with the plan. Environmental monitoring is being addressed through coordination with other interested agencies, and will be detailed as part of the Plans and Specifications for the project. The proposed Coastal Monitoring Plan is presented in Appendix A, Section 2.

Cost Sharing. For construction, the Federal Government shall contribute 65% of the first cost of the selected plan, which is currently estimated to be $ 32,555,000. Periodic nourishment of the selected plan will likely be cost shared as per WRDA 99, Section 215, which allows feasibility studies completed prior to December 31, 1999 to use WRDA 86 cost sharing at 65% Federal and 35% non-Federal proportionments.

Future Modifications of the Report. The NED plan identified herein reflects the information available at the time and current departmental policies governing formulation of individual projects. This NED plan may be modified before being transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

RECOMMENDATIONS

Overall Assessment. In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the project with the policies, desires and capabilities of the State of New Jersey and other non-Federal interests. I have evaluated several alternative plans for the purposes of Hurricane and Storm Damage Reduction. A project has been identified that is technically sound, economically cost effective over the life of the project, is socially and environmentally acceptable, and has broad local support. Therefore, I recommend that Federal participation continue in the planning, design, and construction of a hurricane and storm damage reduction project for Long Beach Island, New Jersey.

Project Cost. The total initial project cost of construction is estimated to be $ 50,084,000 (does not include LERRD of 665,000). The Federal share of this first cost is $ 32,555,000 and the non-Federal share is $ 17,529,000. Lands Easements, Rights-of-Ways, Relocations and Dredged Material Disposal Areas (LERRD) costs are $665,000 and will be credited against the non-Federal sponsor's cash contribution.

Continuing Construction Cost. Periodic nourishment is expected to occur at 7 year intervals subsequent to the completion of initial construction (projected to be 2001) of the dune/berm component of the project. Over the 50-year period of analysis, the total periodic nourishment cost in present day dollars is estimated to be $ 104,846,000 and includes E&D monitoring and major renourishment costs.

Ultimate Project Cost. The ultimate cost of construction which includes initial construction, project monitoring, interest during construction and fifty years of periodic nourishment is estimated to be $ 156,632,000 cost shared $ 101,811,300 Federal (65%) and $ 55,485,700 non-Federal (35%). All cost also include planning, engineering, and design. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) is a non-Federal responsibility ($110,000 annualized).

Modifications. The recommendations contained herein reflect the information available at the time and current departmental policies governing formulation of individual projects. These recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

30 Sept 99
Date

Debra M. Lewis
Debra M. Lewis
Lieutenant Colonel, Corps of Engineers
District Engineer

CENAD-DE (CENAP/Sept 99) (1105-2-10c) 1st End Mr. Pippens/8725
SUBJECT: New Jersey Shore Protection Study, Barnegat Inlet to Little Egg Inlet, Long Beach Island, Final Interim Feasibility Report and Integrated Environmental Assessment

Commander, North Atlantic Division, Corps of Engineers, ATTN: CENAD-ET-P, FT. Hamilton Military Community, 301 General Lee Avenue, Brooklyn, New York 11252

FOR COMMANDER, HQUSACE ATTN: Policy Review Branch, Policy Review and Analysis Division, Kingman Building, Fort Belvoir, Virginia 22060-5576

I concur in the Conclusions and Recommendations of the District Commander. The plan developed is technically sound, economically justified, and socially and environmentally acceptable, and Federal participation in the design and construction of this hurricane and storm damage protection project is recommended.

M. STEPHEN RHOADES
Brigadier General, USA
Commanding

9.0 CLEAN AIR ACT STATEMENT OF CONFORMITY

Clean Air Act
Statement of Conformity
Barnegat Inlet to Little Egg Inlet (LBI),
New Jersey Feasibility Study
Ocean County, New Jersey

Based on the air quality analysis in the subject report, I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP), the U.S. Environmental Protection Agency had no adverse comments under their Clean Air authority. No comments from the air quality management district were received during coordination of the draft feasibility report and Environmental Impact Statement. The proposed project would comply with Section 176 (c) of the Clean Air Act Amendments of 1990.

30 Sept 99
Date

Debra M. Lewis
Debra M. Lewis
Lieutenant Colonel, Corps of Engineers
District Engineer

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8.0 EVALUATION OF 404(b)(1) GUIDELINES

I. Project Description

A. Location:

The proposed project site includes the communities of Long Beach Township, Barnegat Light, Harvey Cedars, Surf City, Ship Bottom, and Beach Haven. The site is located in Ocean County, New Jersey. The project would use offshore sand borrow areas.

B. General Description:

The purpose of the proposed project is to reduce impacts from Hurricanes and Storm damage, which results in erosion, inundation and wave attack along the oceanfront of Long Beach Island. The berm and dune restoration extends from groin 4 (Seaview Drive, Loveladies) to the terminal groin (groin 98) in Long Beach Township B Holgate, approximately 17 miles. The Barnegat Light (northern end of the study area) area is not included in the nourishment aspect of the project because of minimal erosion and substantial dune/berm complex. It may play a role as a source for sand should the sand recycle plant alternative be a cost effective alternative to hydraulic nourishment. The US Fish and Wildlife Service (USFWS, 1996) states that they do not consider beach nourishment on the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge necessary. Hence, the Holgate Unit (southern end of study area) was also not included in the project. Due to the fact that both ends of the project terminate at a groin, no tapers would be needed. The template for the plan is a dune at elevation of +22 ft NAVD, with a 30 foot dune crest width, 1V:5H slopes from dune crest down to a berm at elevation +8 ft NAVD, a berm width of 125 feet from centerline of dune (105 feet of dry beach from the seaward toe of dune to MHW), 1V:10H slopes from the berm to MLW, and maintenance of the profile shape from MLW to depth of closure (occurring at approximately -29 ft NAVD). From centerline of dune it ranges from a minimum of 1045 feet to a maximum of 4500 feet. Average dune widths for LBI are already at +29 feet NAVD. Dune elevations are at 19 feet on average while berm width averages are at 111 feet. As part of the berm and dune restoration approximately 1,030.85 acres would be covered, of these, approximately 365.10 acres would be above mean high water (MHW) and 665.75 acres would be below MHW. The elevation of MHW is 1.5 feet in NAVD datum. The above surface areas extend from the inland toe of the dune to MHW and from MHW to depth of closure at -29.0 feet NAVD.

C. Authority and Purpose:

D. General Description of Dredged or Fill Material:

1. The proposed dredged material is fine sand as defined by the Unified Soil Classification System.

2. This plan would require 4.95 million cubic yards of sand for initial berm placement, and 2.45 million cubic yards for dune placement. Approximately 1.9 million cubic yards would be needed for periodic nourishment every 7 years over a 50-year period of analysis.

3. Five offshore borrow areas were proposed as a source of sand for this project (see Figure 2-2). Only Borrow Areas A, D and D2 will be utilized for the project. It is proposed that all material needed for the initial berm and dune restoration and future nourishment would be obtained from using a combination of the borrow areas.

E. Description of Proposed Discharge Site:

1. The proposed location is depicted in Figures 1-1 of this report.

2. The proposed discharge site is comprised of an eroding berm and dunes along the coastline of Long Beach Island, Ocean County, New Jersey.

3. The proposed discharge site is unconfined with placement to occur on a shoreline area.

4. The type of habitat present at the proposed location is intertidal and nearshore habitat.

5. This plan would require 4.95 million cubic yards of sand for initial berm placement, and 2.45 million cubic yards for dune placement. Approximately 1.9 million cubic yards would be needed for periodic nourishment every 7 years over a 50-year period of analysis. The berm and dune restoration extends from groin 4 (Seaview Drive, Loveladies) to the terminal groin (groin 98) in Long Beach Township B Holgate, approximately 17 miles. The Barnegat Light (northern end of the study area) area is not included in the project because of low erosion and healthy beaches. The US Fish and Wildlife Service (USFWS, 1996) states that they do not consider beach nourishment on the Holgate Unit of the Edwin B. Forsythe National Wildlife Refuge necessary. Hence, the Holgate Unit (southern end of study area) was also not included in the project. Due to the fact that both ends of the project terminate at a groin, no tapers would be needed. The template for the plan is a dune at elevation +22 ft NAVD, with a 30 foot dune crest width, 1V:5H slopes from dune crest down to a berm at elevation +8 ft NAVD, a berm width of 125 feet from centerline of dune (105 feet of dry berm from toe of dune to MHW), 1V:10H slopes from the berm to MLW, and maintenance of the profile shape from MLW to depth of closure (occurring at approximately -29 ft NAVD). Average dune widths for LBI are already at +29 feet NAVD. Dune elevations are at 19 feet on average while berm width averages are at 111 feet. As part of the berm and dune restoration approximately 1,030.85 acres would be covered, of these, approximately 365.10 acres would be above mean high water (MHW) and 665.75 acres would be below MHW. The elevation of MHW is 1.5 feet in NAVD datum. The above surface areas extend from the inland toe of the dune to MHW and from MHW to depth of closure at -29.0 feet NAVD.

F. Description of Placement Method:

A hydraulic dredge or hopper dredge would be used to excavate the borrow material from the borrow area. The material would be transported using a pipeline delivery system to the berm and dune restoration site. Subsequently, final grading would be accomplished using standard construction equipment.

II. Factual Determination

A. Physical Substrate Determinations:

1. The final proposed elevation of the beach substrate after fill placement would be +8.0 feet NAVD at the top of the berm and +22.0 feet NAVD at the top of the dune. The proposed profile of the berm would be 10H:1V from the toe of dune to MLW, and maintenance of the profile shape from there to the depth of closure. The dune would have a 1V:5H slope from dune crest down to the berm.

2. The sediment type involved would be sand.

3. The initial phase of construction would establish a construction template that is higher than the final intended design template or profile. It is expected that compaction and erosion would be the primary processes resulting in the change to the design template. In addition, the loss of fine-grained material into the water column would occur during initial settlement. Until the berm template is achieved and stabilized, sand will erode into the water column. The Corps plans for an approximate loss of 15% to 20% dredging losses. If 400,000 cu yd. are needed to create the new beach profile, 480,000 are dredged. Material lost in establishing the template actually serves to create the area known as the depth to closure.

4. The proposed construction would result in removal of the benthic community from the borrow areas, and burial of the existing beach and nearshore communities.

5. Other effects would include a temporary increase in suspended sediment load and a change in beach profile, particularly in reference to elevation.

6. Actions taken to minimize impacts include selection of fill material that is similar in nature to the pre-existing substrate. In addition, standard construction practices to minimize turbidity and erosion would be employed and complete elimination of borrow areas identified as essential fish habitat.

B. Water Circulation, Fluctuation and Salinity Determinations

1. Water. Consider effects on:

a. Salinity - No effect.

b. Water Chemistry - No significant effect.
c. Clarity - Minor short-term increase in turbidity during construction.
d. Color - No effect.
e. Odor - No effect.
f. Taste - No effect.
g. Dissolved gas levels - No significant effect.
h. Nutrients - Minor short-term effect
i. Eutrophication - No effect.
j. Others as appropriate - None

2. Current patterns and circulation

a. Current patterns and flow - Circulation would only be impacted by the proposed work in the immediate vicinity of the borrow area, and in the placement areas where the existing circulation pattern would be offset seaward the width of the berm and dune restoration.

b. Velocity - No effect on tidal velocity and longshore current velocity regimes.

c. Stratification - Thermal stratification occurs beyond the mixing region created by the surf zone. There is a potential for both winter and summer stratification. The normal pattern should continue post construction of the proposed project.

d. Hydrologic regime - The regime is largely marine and oceanic. This would remain the case following construction of the proposed project.

3. Normal water level fluctuations - the tides are semidiurnal with a mean tide range of 4.1 feet and a spring tide range of 5.0 feet in the Atlantic Ocean. Construction of the proposed work would not affect the tidal regime.

4. Salinity gradients - There should be no significant effect on the existing salinity gradients.

5. Actions that would be take to minimize impacts - None are required, however, the borrow area would be excavated in a manner to approximate natural ridge slopes to ensure normal water exchange and circulation. Utilization of clean sand and its excavation with a hydraulic dredge would also minimize water chemistry impacts.

C. Suspended Particulate/Turbidity Determinations

1. Expected changes in suspended particulate and turbidity levels in the vicinity of the placement and borrow sites - There would be a short-term elevation of suspended particulate concentrations during construction phases in the immediate vicinity of the dredging and discharge activities. Elevated levels of particulate concentrations at the discharge location might

also result from “washout” after beachfill is placed.

2. Effects (degree and duration) on chemical and physical properties of the water column

a. Light penetration - Short-term, limited reductions would be expected at the borrow and placement sites from dredge activity and berm washout.

b. Dissolved oxygen - There is a potential for a decrease in dissolved oxygen levels but the anticipated low levels of organics in the borrow material should not generate a high, if any, oxygen demand.

c. Toxic metals and organics - Because the borrow material is essentially all fine sand as defined by the Unified Soil Classification System, no toxic metals or organics are anticipated.

d. Pathogens - Pathogenic organisms are not known or expected to be a problem in the borrow or placement areas.

e. Aesthetics - Construction activities and the initial construction template associated with the fill site would result in a minor, short-term degradation of aesthetics.

3. Effects on Biota

a. Primary production, photosynthesis - Minor, short-term effects related to turbidity.

b. Suspension/filter feeders - Minor, short-term effects related to suspended particulates outside the immediate deposition zone. Sessile organisms would be subject to burial within the deposition area.

c. Sight feeders - Minor, short-term effects related to turbidity.

4. Actions taken to minimize impacts include selection of clean sand with a small fine grain component and low organic content. Standard construction practices would also be employed to minimize turbidity and erosion.

D. Contaminant Determinations

The discharge material is not expected to introduce, relocate, or increase contaminant levels at either the borrow or placement sites. This is assumed based on the characteristics of the sediment, the proximity of borrow sites to sources of contamination, the area’s hydrodynamic regime, and existing water quality.

E. Aquatic Ecosystem and Organism Determinations

1. Effects on plankton -The effects on plankton should be minor and mostly related to light level reduction due to turbidity. Significant dissolved oxygen level reductions are not anticipated.

2. Effects on benthos - There would be a major disruption of the benthic community in the borrow area, when the fill material is excavated, and in the placement area due to burial or displacement. The loss is somewhat offset by the expected rapid opportunistic recolonization from adjacent areas that would occur following cessation of construction activities. Recolonization is expected to occur at the placement site by vertical migration also. Surf clams are found in the borrow site, but evidence for their recovering is good.

3. Effects on Nekton - Only a temporary displacement is expected as the nekton would probably avoid the active work areas.

4. Effects on Aquatic Food Web - Only a minor, short-term impact on the food web is anticipated. This impact would extend beyond the construction period until recolonization of the buried area has occurred.

5. Effects on Special Aquatic Sites B No wetlands would be impacted by the project. Wetlands were found in the original study area. The placement site/project area has been reduced in scope to no longer include wetlands.

6. Threatened and Endangered Species - Several species of threatened and endangered sea turtles might be in the sand borrow areas depending on time of year. Sea turtles have been known to become entrained and subsequently destroyed by suction hopper dredges. Use of a hopper dredge during a time of high likely presence in the area could potentially entrain and destroy a sea turtle(s). The piping plover, a Federal and state threatened species, could potentially be impacted by construction of the proposed project. This bird nests on ocean beaches and nesting sites do occur within the project area. Once constructed, the project could provide more nesting habitat for the plovers and other beach nesters. Avoidance of nesting times could minimize the impact to plovers during construction. Use of seasonal dredging restrictions and implementation of a comprehensive beach nesting bird management plan coordinated with USFWS and NJDEP Endangered and Non-Game Species Program will minimize impacts to nesting least terns and black skimmers.

7. Other wildlife - The proposed plan would not affect other wildlife.

8. Actions to minimize impacts - Impacts to benthic resources can be minimized at the borrow area by dredging in a manner as to avoid the creation of deep pits, using one borrow area as the primary source of initial fill and alternating locations of periodic dredging. Depending on the timing of the dredging and the type of dredge to be used, potential impacts to Federal and

state threatened or endangered sea turtles can be minimized by employing NMFS approved monitors, hardened drag arm deflectors and trawling if a hopper dredge is used. Impacts to the Federal and state threatened piping plover can be avoided or minimized by establishing a buffer zone around a nest(s) and limiting construction during the nesting season. Impacts to the surf clam population may be minimized by selective use of borrow area(s), the commercial harvest of surf clams prior to dredging, dredging a smaller area to a greater depths, and only disturbing a portion of the sites. The possibility of re-seeding a dredged area with surf clam spat has been proposed as a mitigation measure.

F. Proposed Placement Site Determinations

1. Mixing zone determination

a. Depth of water - zero to 10 feet mean low water
b. Current velocity B there is no tidal current in the area, predominate current is longshore current which is wave dependent for its velocity
c. Degree of turbulence - Heavy
d. Stratification - None
e. Discharge vessel speed and direction - Not applicable
f. Rate of discharge - Typically this is estimated to be 780 cubic yards per hour
g. Dredged material characteristics - fine sand as defined by the Unified Soil Classification System.
h. Number of discharge actions per unit time - Continuous over the construction period

2. Determination of compliance with applicable water quality standards - Prior to construction a Section 401 Water Quality Certificate and consistency concurrence with the States∍ Coastal Zone Management Program would be obtained from the State of New Jersey.

3. Potential effects on human use characteristics

a. Municipal and private water supply - No effect
b. Recreational and commercial fisheries - Short-term effects during construction.
c. Water related recreation - Short-term effect during construction.
d. Aesthetics - Short-term effect during construction.
e. Parks, national and historic monuments, national seashores, wilderness areas, etc. - no effect

G. Determination of Cumulative Effects on the Aquatic Ecosystem - None anticipated.

H. Determination of Secondary Effects on the Aquatic Ecosystem - Any secondary effects would be minor and short in duration.

III. Finding of Compliance or Non-Compliance with the Restrictions on Discharge

A. No significant adaptation of the Section 404(b)(1) Guidelines was made relative to this evaluation.

B. The alternative measures considered for accomplishing the project are detailed in Section VII of the document of which this 404(b)(1) analysis is part.(Volume II, Appendix C, Environmental Analysis.)

C. A water quality certificate would be obtained from the New Jersey Department of Environmental Protection.

D. The proposed berm and dune restoration would not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

E. The proposed berm and dune restoration would comply with the Endangered Species Act of 1973. Informal coordination procedures have been completed.

F. The proposed berm and dune restoration would not violate the protective measures for any Marine Sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

G. The proposed berm and dune restoration would not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on life stages of aquatic life and other wildlife dependent on the aquatic ecosystem; aquatic ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values would not occur.

H. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include selection of borrow material that is low in silt content, has little organic material, and is uncontaminated.

I. On the basis of the guidelines, the placement site for the dredged material is specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

9.0 CLEAN AIR ACT STATEMENT OF CONFORMITY

Clean Air Act
Statement of Conformity
Barnegat Inlet to Little Egg Inlet (LBI),
New Jersey Feasibility Study
Ocean County, New Jersey

Based on the air quality analysis in the subject report, I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP), the U.S. Environmental Protection Agency had no adverse comments under their Clean Air authority. No comments from the air quality management district were received during coordination of the draft feasibility report and Environmental Impact Statement. The proposed project would comply with Section 176 (c) of the Clean Air Act Amendments of 1990.

Date	Debra M. Lewis Lieutenant Colonel, Corps of Engineers District Engineer

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10.0 COORDINATION AND PUBLIC INVOLVEMENT

Coordination for this project was done with Federal, State and local resource agencies. Agencies notified of this study included the U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS), New Jersey Department of Environmental Protection (NJDEP), and New Jersey State Historic Preservation Office. Information in this document was generated based on comments and concerns of the interested public.

Section 106 Coordination. In a letter dated January 24, 1997, the NJSHPO provided a review of the Brigantine to Hereford Inlet cultural resources report (Dolan Research and Hunter Research 1997b) in connection with the review of the Townsends Inlet to Cape May Inlet Feasibility Study. This letter established cultural resources management guidelines for shoreline projects in New Jersey. These guidelines apply to the present study. The District plans to "ground truth" the one high probability target identified in the project's borrow area during the Plans and Specifications phase of the project study. The District will coordinate the results of this investigation with the NJSHPO and will conclude Section 106 project review prior to project implementation.

USFWS Coordination. Two Planning Aid Reports and a draft Section 2(b) report were prepared by the USFWS and are provided in Appendix C of this report. A final section 2(b) Fish and Wildlife Coordination Act Report (August, 1999) was also prepared by the USFWS following the review of the draft document and is included in Appendix C, Environmental Analysis. These reports provide official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act. A specific response to USFWS letters detailing Corps responses to USFWS comments can be found in Appendix H (Public Comments and Responses). Comments received from Federal, State, and local government agencies along with various private organizations and individuals on the DEIS are also provided in Appendix H (Public Comments and Responses).

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