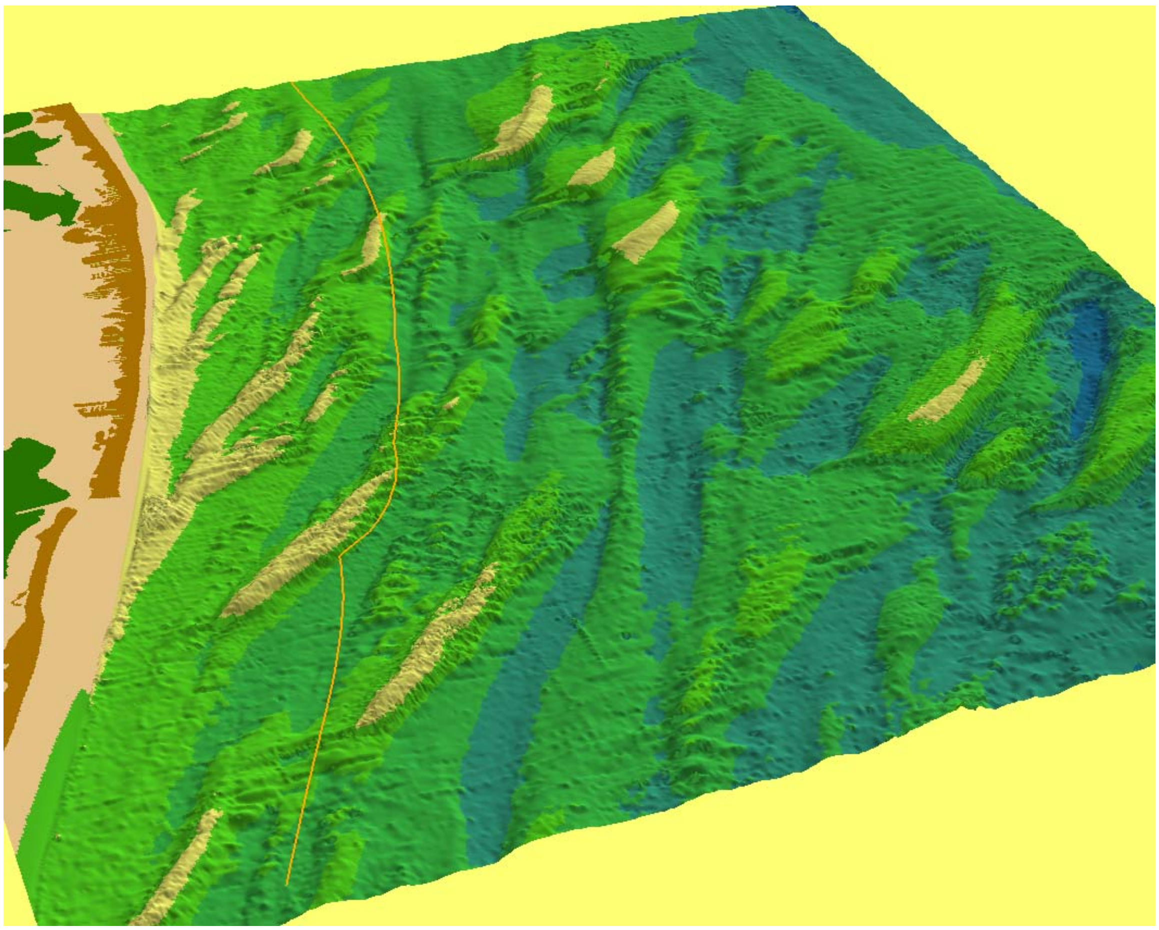
Atlantic Coast of Maryland Shoreline Protection Project
Final Supplemental Environmental Impact Statement
General Reevaluation Study:
Borrow Sources for 2010 - 2044



U.S. Army Corps of Engineers
Baltimore District

August 2008

Cover: Relief map of Continental Shelf of Ocean City area, looking northeast. Figure prepared by Maryland Geological Survey from National Oceanic and Atmospheric bathymetric data. Lighter colors denote shallower depths while darker colors denote deeper depths. Shoals are pronounced light-colored linear and chevron-shaped features. Line parallel to coast is 3-mile limit of Maryland State Waters.

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COVER SHEET

August 2008

LEAD AGENCY: U.S Department of Defense, Department of the Army

COOPERATING AGENCIES: Minerals Management Service (cooperating agency); Maryland Department of Natural Resources (sponsor); Worcester County, Maryland (partner); Ocean City, Maryland (partner)

TITLE: Final Supplemental Environmental Impact Statement for Atlantic Coast of Maryland Shoreline Protection Project. General Reevaluation Study: Borrow Sources for 2010 - 2044. Ocean City, Maryland

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ABSTRACT: The U.S. Army Corps of Engineers, Baltimore District (USACE) has prepared a Final Supplemental Environmental Impact Statement (FSEIS) for the Atlantic Coast of Maryland Shoreline Protection Project (Project) to evaluate the impacts of dredging several new offshore shoals to provide sand for the project for the years 2010 - 2044. Between 6,800,000 and 15,000,000 cubic yards of sand would be needed through 2044, depending on future storminess. Borrow sources to obtain up to 15,000,000 cubic yards of sand were identified. Offshore shoals are the best sand sources for the project since these contain large quantities of suitable sand that can be cost-effectively obtained. Three offshore shoals located in Federal waters were recommended: Weaver Shoal, Isle of Wight Shoal, and Shoal "A." Sub-areas on each shoal were delineated based on suitability of sand for beach nourishment purposes. Sand at Shoal "B," also known as Bass Grounds or First Lump, is also suitable, however that shoal is currently an important fishing grounds. Accordingly, Shoal "B" would not be utilized unless future reevaluation finds that its relative value as a fishing grounds has declined substantially. Dredging guidelines to minimize long-term impacts to the offshore shoals were formulated. No more than about 5% of the total volume of any shoal would be dredged. Dredging would avoid the crest, be conducted uniformly over a wide area, and go no deeper than ambient depths of the adjacent seafloor. Dredging would be preferentially conducted on the up and downdrift ends of each shoal if suitable sand is present there.

PUBLIC COMMENTS: The FSEIS is a revision of a draft document of the same name published in May 2007, and incorporates revisions to address comments received. USACE has distributed copies of the FSEIS to appropriate members of Congress, Federal and State agencies, local government officials, libraries, and other interested parties. The FSEIS is being filed with the U.S. Environmental Protection Agency (USEPA). A USACE decision on proposed actions will not be made earlier than 30 days after USEPA issues a public notice of availability for the FSEIS. USACE will issue a Record of Decision (ROD) published in the Federal Register.

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Atlantic Coast of Maryland Shoreline Protection Project:
Final Supplemental Environmental Impact Statement

TABLE OF CONTENTS

SECTION **TITLE** **PAGE**

EXECUTIVE SUMMARY ES-1

SECTION 1. INTRODUCTION
1.0 INTRODUCTION 1-1
1.1 PROJECT AUTHORITY 1-3
1.2 STUDY PURPOSE....................1-3
1.3 STUDY AREA 1-4
1.4 STUDY PROCESS....................1-4
1.5 OTHER USACE AND STATE OF MARYLAND PROJECTS ON MARYLAND'S OCEAN COAST....................1-4
1.6 PREVIOUS STUDIES....................1-8

SECTION 2. EXISTING CONDITIONS AND AFFECTED ENVIRONMENT
2.0 INTRODUCTION 2-1
2.1 PHYSICAL ENVIRONMENT....................2-1
2.1.1 Physiography, Topography, and Bathymetry 2-2
2.1.2 Geology 2-11
2.1.3 Soils 2-15
2.1.4 Hydrology 2-15
2.1.5 Climate....................2-16
2.2 AIR QUALITY....................2-19
2.3 WATER QUALITY....................2-20
2.4 HABITATS....................2-20
2.5 LIVING THINGS 2-21
2.5.1 Plants....................2-21
2.5.1.1 Phytoplankton 2-21
2.5.1.2 Submerged Aquatic Vegetation (SAV) and Wetlands....................2-21
2.5.1.3 Upland Vegetation 2-22
2.5.2 Animals....................2-22
2.5.2.1 Zooplankton....................2-22
2.5.2.2 Invertebrates....................2-22
2.5.2.3 Finfish 2-24
2.5.2.4 Wildlife 2-26
2.5.3 Rare, Threatened, and Endangered Species....................2-26
2.6 HUMAN ENVIRONMENT / COMMUNITY SETTING 2-27
2.6.1 Historic and Cultural Resources 2-27
2.6.2 Population 2-28

2.6.3 Economics....2-28
2.6.4 Transportation....2-29
2.6.5 Navigation....2-29
2.6.6 Infrastructure....2-29
2.6.7 Land Use....2-29
2.6.8 Public Health and Safety....2-30
2.6.9 Visual and Aesthetic Values....2-30
2.6.10 Noise....2-30
2.6.11 Recreation (Other than Fishing)....2-30
2.6.12 Fishing: Commercial and Recreational....2-30
2.6.13 Parks....2-32
2.6.14 Hazardous, Toxic, and Radioactive Waste (HTRW); Formerly-Used Defense Sites (FUDS); and Munitions and Explosives of Concern (MEC)....2-33
2.7 FUTURE WITHOUT PROJECT CONDITIONS....2-34
2.7.1 Ocean City (Fenwick Island)....2-34
2.7.2 Seafloor....2-35

SECTION 3: PROBLEMS, NEEDS AND OPPORTUNITIES
3.0 INTRODUCTION....3-1
3.1 OCEAN CITY SAND NEEDS....3-2
3.2 CONCERN OVER ENVIRONMENTAL AND FISHERY IMPACTS OF SEAFLOOR BORROW ACTIONS....3-2
3.3 STUDY OBJECTIVES....3-3

SECTION 4: BORROW AREA SELECTION
4.0 INTRODUCTION....4-1
4.1 POTENTIAL BORROW AREAS....4-1
4.2 IDENTIFICATION OF POTENTIAL CANDIDATE SHOALS....4-2
4.3 EVALUATION OF CANDIDATE SHOALS....4-3
4.3.1 Fenwick Shoal....4-3
4.3.2 Weaver Shoal....4-3
4.3.3 Isle of Wight Shoal....4-4
4.3.4 Shoal “E”....4-4
4.3.5 Shoal “A”....4-4
4.3.6 Ebb Shoal....4-4
4.3.7 Little Gull Bank....4-5
4.3.8 Shoal “B”....4-6
4.3.9 Great Gull Bank....4-6
4.4 SELECTION OF BORROW AREAS....4-7

SECTION 5: DEVELOPMENT OF A BORROW PLAN
5.0 INTRODUCTION....5-1
5.1 ENGINEERING....5-1
5.1.1 Sand Grain-Size Requirements....5-2
5.1.2 Borrow Area Analysis....5-3

5.1.2.1 Obtaining and Processing Borrow Area Sand Samples..5-3
5.1.2.2 Identification of Sub-Areas on Candidate Borrow Areas.....................................5-3
5.1.2.3 Determination of Beachfill Volumes Available in Each Subarea 5-9
5.1.3 Shoreline Impacts 5-10
5.1.4 Engineering Recommendations 5-10
5.2 ENVIRONMENT AND FISHERIES...5-12
5.2.1 Dredging Guidelines...5-12
5.2.2 Dredging Constraints 5-12
5.2.2.1 Consideration of Factors Warranting Exclusion of Candidate Shoals 5-13
5.2.2.2 Apportioning Dredging Among Shoals 5-15
5.2.2.3 What Shoals Should be Dredged During any Given Beach Nourishment Period .5-17
5.2.2.4 Location and Thickness of Sand to Dredge on Individual Offshore Shoals..........5-17
5.2.2.4.1 Artificial Reefs...5-17
5.2.2.4.2 Shoal Habitats 5-17
5.2.2.4.3 Geomorphic Integrity Maintenance 5-18
5.2.3 Preliminary Assessment of Environmental and Fisheries Impacts of Alternatives..5-20
5.2.4 Environmental and Fisheries Recommendations...5-20
5.3 ECONOMICS 5-21
5.4 FORMULATION OF ALTERNATIVE DREDGING PLANS 5-21
5.4.1 Sand Volume Needs..5-22
5.4.2 Shoals to Dredge Over Proposed Life 5-22
5.4.3 Sequence of Dredging...5-27
5.5 EVALUATION AND COMPARISON OF ALTERNATIVE DREDGING PLANS 5-28
5.5.1 Estimating Costs 5-28
5.5.2 Benefits and Impacts...5-31
5.5.3 Cost-Benefit Analysis...5-31
5.6 RECOMMENDED BORROW PLAN 5-31

SECTION 6: IMPACTS TO PROJECT AREA

6.0 INTRODUCTION 6-1
6.1 PHYSICAL ENVIRONMENT 6-3
6.1.1 Physiography, Topography, and Bathymetry 6-3
6.1.2 Geology..6-5
6.1.3 Soils 6-5
6.1.4 Hydrodynamics..6-6
6.2 AIR QUALITY...6-6
6.3 WATER QUALITY..6-6
6.4 HABITATS..6-7
6.5 LIVING THINGS 6-7
6.5.1 Plants..6-7
6.5.1.1 Phytoplankton 6-7
6.5.1.2 SAV and Wetlands...6-7
6.5.1.3 Upland Vegetation 6-8
6.5.2 Animals...6-8
6.5.2.1 Zooplankton...6-8

6.5.2.2 Invertebrates..6-8
6.5.2.3 Finfish..6-9
6.5.2.4 Wildlife..6-9
6.5.3 Rare, Threatened, and Endangered Species..6-10
6.6 HUMAN ENVIRONMENT / COMMUNITY SETTING..6-11
6.6.1 Cultural and Historical Resources..6-11
6.6.2 Population..6-12
6.6.2.1 Environmental Justice..6-12
6.6.3 Economics..6-12
6.6.4 Transportation..6-12
6.6.5 Navigation..6-12
6.6.6 Infrastructure..6-13
6.6.7 Land Use..6-13
6.6.8 Public Health and Safety..6-13
6.6.9 Visual and Aesthetic Values..6-13
6.6.10 Noise..6-13
6.6.11 Recreation (Other than Fishing)..6-13
6.6.12 Fishing: Commercial and Recreation..6-14
6.6.13 Parks..6-14
6.6.13.1 Wild and Scenic Rivers..6-15
6.6.14 Hazardous, Toxic, and Radioactive Waste (HTRW); Formerly-Used Defense Sites (FUDS); and Munitions and Explosives of Concern (MEC)..6-15
6.7 IRRETREIVABLE USES OF RESOURCES..6-15
6.8 CUMULATIVE IMPACTS..6-16
6.9 COMPLIANCE WITH ENVIRONMENTAL STATUTES..6-18

SECTION 7: PUBLIC INVOLVEMENT AND AGENCY COORDINATION
7.0 INTRODUCTION..7-1
7.1 COOPERATION WITH MINERALS MANAGEMENT SERVICE..7-1
7.2 COORDINATION WITH RESOURCE AGENCIES, NON-FEDERAL SPONSORS, AND PUBLIC..7-1
7.3 FEDERAL REGISTER NOTICES..7-2
7.4 AGENCY AND PUBLIC REVIEW OF THE DRAFT SEIS..7-3
7.5 FUTURE AGENCY COORDINATION..7-3

SECTION 8: REFERENCES..8-1

Annexes - Supplemental Documentation

A - 404(b)1 Evaluation

B - Supplemental Environmental and Engineering Information

1. Summary Information from MMS (2006). Studies Conducted by VERSAR, Inc. of Offshore Shoals and Seafloor Flats off Maryland/Delaware, 2002-2004.
2. Great Gull Bank Dredging and Impacts: 1998 and 2002
3. MGS Monitoring Report of Borrow Areas 2 and 3
4. Projected Dredging Impact Area as Function of Total Volume and Thickness of Material Removed
5. LTSM Project Dredging Record

C - Coordination
C1 Summary of Prior Coordination Regarding Dredging Great Gull Bank for Assateague Island
C2 Coordination Summary: Atlantic Coast Project New Borrow Sources
C3 Copies of Coordination Records and Correspondence Prior to Release of May 2007 Draft SEIS
C4 Public and Agency Release of Draft SEIS
C5 Comments Received on Draft SEIS and Responses

D - EFH Impacts Assessment Report

E - List of Preparers

LIST OF FIGURES

Figure 1-1: Atlantic Coast of Maryland Project 1-2
Figure 1-2: Study area....................1-5
Figure 2-1: Shoreline geomorphic features 2-2
Figure 2-2: Continental shelf geomorphology off Ocean City....................2-3
Figure 2-3: Offshore shoals off Maryland....................2-6
Figure 2-4: Offshore shoals off Ocean City....................2-9
Figure 2-5: Offshore shoal relief and area versus volume....................2-10
Figure 2-6: Average monthly sea surface temperatures 2-16
Figure 2-7: General areas of erosion and deposition on offshore shoals....................2-17
Figure 5-1: Weaver Shoal....................5-4
Figure 5-2: Isle of Wight Shoal 5-5
Figure 5-3: Shoal A....................5-6
Figure 5-4: Shoal B....................5-7

Additional General Reevaluation Study Reports and Appendices (Not Included in this SEIS)

The following General Reevaluation Study documents are available by request from the Baltimore District:

1	Alternative Approaches for Storm Protection In High Maintenance Areas. Alternative Evaluation. December 1999. Prepared by OFFSHORE & COASTAL TECHNOLOGIES, INC. - EAST COAST
2	Geotechnical Design Analysis. May 2004. Prepared by Baltimore District USACE
3	Ocean City Hotspot Study Reassessment of Design Criteria and Approaches. Draft October 2005. Prepared by Offshore & Coastal Technologies, Inc.
4	Atlantic Coast of Maryland Shoreline Protection Project Hot Spot Analysis Fact Sheet. January 2007. Prepared by Baltimore District USACE

EXECUTIVE SUMMARY

The general reevalution study of the authorized Atlantic Coast of Maryland Shoreline Protection Project sought additional sources of sand to maintain existing conditions at Ocean City through the 50 year economic life of the project which ends in 2044. Identified sand sources in state waters are forecast to be exhausted after about 2010. A minimum and maximum volume need over this time period were forecast. If conditions and project performance that have characterized the project since 1998 continue, it is estimated that 800,000 cubic yards of sand every 4 years will be needed. Barring severe storms, this would equate to a total volume need of 6,800,000 cubic yards through the end of the project economic life. However, if project performance over the entire project life since 1991 that required rehabilitation for several severe storms is considered, approximately 15,000,000 cubic yards would be needed through 2044. Accordingly, to allow for this possibility, it was considered appropriate to identify up to 15,000,000 cubic yards of sand to meet Ocean City’s sand needs through the end of the project’s economic life in 2044.

Sources of sand to provide for continuation of the authorized Atlantic Coast of Maryland Shoreline Protection Project focused on offshore shoals in Federal waters since these contain large quantities of suitable sand that can be cost-effectively obtained. Engineering, economic, and environmental screening of these offshore shoals was conducted and three shoals in Federal waters were selected as recommended sand sources: Weaver Shoal, Isle of Wight Shoal, and Shoal "A." Weaver and Isle of Wight Shoals lie approximately 8 miles offshore. Shoal "A" lies approximately 9.5 miles offshore. Sand within the shoals was investigated and sub-areas were preliminarily delineated based on engineering suitability of the sand for beach nourishment purposes. Sand resources at Shoal "B," commonly called Bass Grounds or First Lump, lying 11.4 miles offshore were also found to be suitable, however that shoal is currently an important fishing grounds. The U.S. Fish and Wildlife Service and National Marine Fisheries Service recommended that Shoal "B" not be utilized at this time. Accordingly, the District recommends that Shoal "B" not be utilized as a source of sand unless future reevaluation finds that its relative value as a fishing grounds has declined substantially. The Baltimore District will coordinate with resource agencies in the future prior to each dredging cycle to evaluate the relative value of each shoal as a fishing ground. In the event relative fishery values of the shoals change substantially, shoal and or sub-areas utilized would be adjusted to minimize impacts to fisheries in coordination with resource agencies.

The ebb shoal of the Ocean City Inlet has been increasing continuously in volume since stabilization of the Ocean City Inlet in the 1930s. Flood-tidal shoals of the inlet have also grown over this period. This continuous growth is anomalous compared to that of accretion shoals of natural dynamic inlets. Under the separate Long-Term Sand Management (LTSM) Project, up to approximately 20,000 cubic yards of sand per year may be dredged from these sources for placement on Ocean City. The LTSM Project is authorized for 25 years. In the first seven twice-yearly dredging installments of the LTSM Project from January 2004 to June 2007, 32,000 cubic yards of sand were dredged from these accretion shoals and back-passed to Ocean City. Additional sand up to the 20,000 cubic yards per-year volume could potentially be dredged from the ebb shoal and other sources to meet some of Ocean City's future sand needs. Ongoing monitoring of the ebb shoal under the LTSM project provides opportunity for future review of this possibility.

Opportunities to minimize environmental impacts of dredging to the habitat functions of the offshore shoals were considered and evaluated in accordance with the recognition that these features were created under ancient geologic conditions and can thus be considered irretrievable resources. Dredging guidelines and constraints to minimize impacts to the long-term geomorphic integrity of the offshore shoals were formulated in coordination with resource agency personnel and academic experts. To best ensure that long-term habitat functions of these features are maintained, no more than about 5% of the total volume of any shoal should be dredged. Dredging on any given shoal should avoid the crest to maintain maximum relief off the seafloor, dredge thinly and uniformly over a wide area and no deeper than ambient depths of the adjacent seafloor to maintain topography, and in cases where suitable sand exists on the up and downdrift ends of the shoal dredging efforts should focus in these areas. Costs of dredging the three offshore shoals with the guidelines and constraints in place were evaluated and found to be unlikely to increase costs over dredging without such requirements.

Costs of dredging from the three recommended offshore shoals were investigated. Transport distance is the only cost factor differing among the three. It was found that baseline costs of dredging from Weaver and Isle of Wight were approximately equal, while dredging from Shoal "A" would cost approximately 5% more. This cost difference is far less than the contingency applied to allow for engineering uncertainties other than inflation. Based on uncertainty in total future sand needs and the recognition that additional investigations of the offshore shoal subareas is necessary, it was determined that a flexible borrow plan in which dredging from all three shoals is conducted would be optimal and cost-effective.

The original 1989 General Design Memorandum total project cost estimate was approximately $56.8 million. The present value of the project cost was computed using the authorized project interest rate of 8.875%. An updated project cost estimate was prepared in an accompanying project general reevaluation study factsheet. Using actual sunk costs to date and remaining estimated project costs for the remainder of the project (2007-2044), the updated total investment cost is approximately $54 million. This reduction in estimated cost occurred in part because inflation was less than originally projected, but also because of increased project efficiency.

In conducting this study, the Baltimore District, U.S. Army Corps of Engineers, has given consideration to the relevant aspects of public interest, including environmental, social, economic, and engineering concerns. The study was conducted in compliance with the National Environmental Policy Act of 1969, as amended. The recommended plan described herein will have significant temporary adverse impacts to benthos of the offshore shoals. Total bottom area impacted by dredging through the remainder of the project life was estimated to be about 7 square miles of seafloor. However, with the dredging guidelines and constraints in place it is anticipated that the long-term geomorphic integrity of these features, and their habitat functions for marine life, will be maintained.

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SECTION 1

INTRODUCTION

1.0 INTRODUCTION

This supplemental environmental impact statement (SEIS) evaluates environmental impacts of a proposed borrow plan to obtain sand for the Atlantic Coast of Maryland Shoreline Protection Project (Atlantic Coast of Maryland Project) in Ocean City, Maryland, from about 2010 to the end of the project economic life in 2044. The Baltimore District, U.S. Army Corps of Engineers (USACE), conducted studies to develop the borrow plan in partnership with the Maryland Department of Natural Resources (DNR), Worcester County, Town of Ocean City (Ocean City), and Minerals Management Service (MMS). DNR is the cost-sharing non-Federal sponsor of the study with the USACE; MMS is a cooperating agency. This SEIS includes documentation to meet the requirements of the National Environmental Policy Act (NEPA) of 1969, as amended.

The Atlantic Coast of Maryland Project is designed to provide coastal flood and erosion protection to Ocean City, Maryland against a 100-year storm on the Atlantic Ocean. The project was completed in 1994 and consisted of widening and raising the beach from 4th street to the Maryland/Delaware line (about 8.2 miles) with a 0.3 mile transition into Delaware, construction of a steel sheetpile bulkhead from 4th street to the north end of the boardwalk at 28th Street (about 1.5 miles), and construction of a sand dune from the north end of the boardwalk to the Maryland/Delaware line (about 6.7 miles plus the 0.3 mile transition into Delaware) (Figure 1-1). Semiannual beach monitoring of the Atlantic Coast of Maryland Project provides information on the condition of the project and the ability of the project to continue to provide protection. As part of the project design, periodic nourishment and maintenance of the beach are required to maintain the design level of protection. Since 1998, approximately 800,000 cubic yards of sand have been placed on Ocean City beach every four years by USACE. Nourishment sand is placed in several discontinuous reaches that include erosional hotspots located in the vicinity of 33rd, 81st, and 145th Streets. Sand accumulates along the southernmost mile of the beach and nourishment is not required there. Hydrographic surveys of the borrow areas are conducted immediately upon completion of dredging. Maintenance of the dune and berm is the responsibility of the non-Federal sponsor.

Prior to construction of the Atlantic Coast of Maryland Project, state and local government funded and constructed an enhanced recreational beach at Ocean City. To establish the recreational beach, 2.26 million cubic yards of sand were placed on 8.3 miles of beach. This effort was completed in the fall of 1988. USACE has subsequently placed sand on the Ocean City beach during seven different time intervals to establish, rehabilitate, and maintain the storm protection beach of the Atlantic Coast of Maryland Project (Table 1-1). Rehabilitation was undertaken because following completion of the storm protection beach fill in August 1991 the project was struck by several severe storms (October 1991, January 1992, December 1992, and March 1993). The need to repair associated storm damages to return the project to design level protection delayed turning the project over to the non-Federal sponsor until 1994.

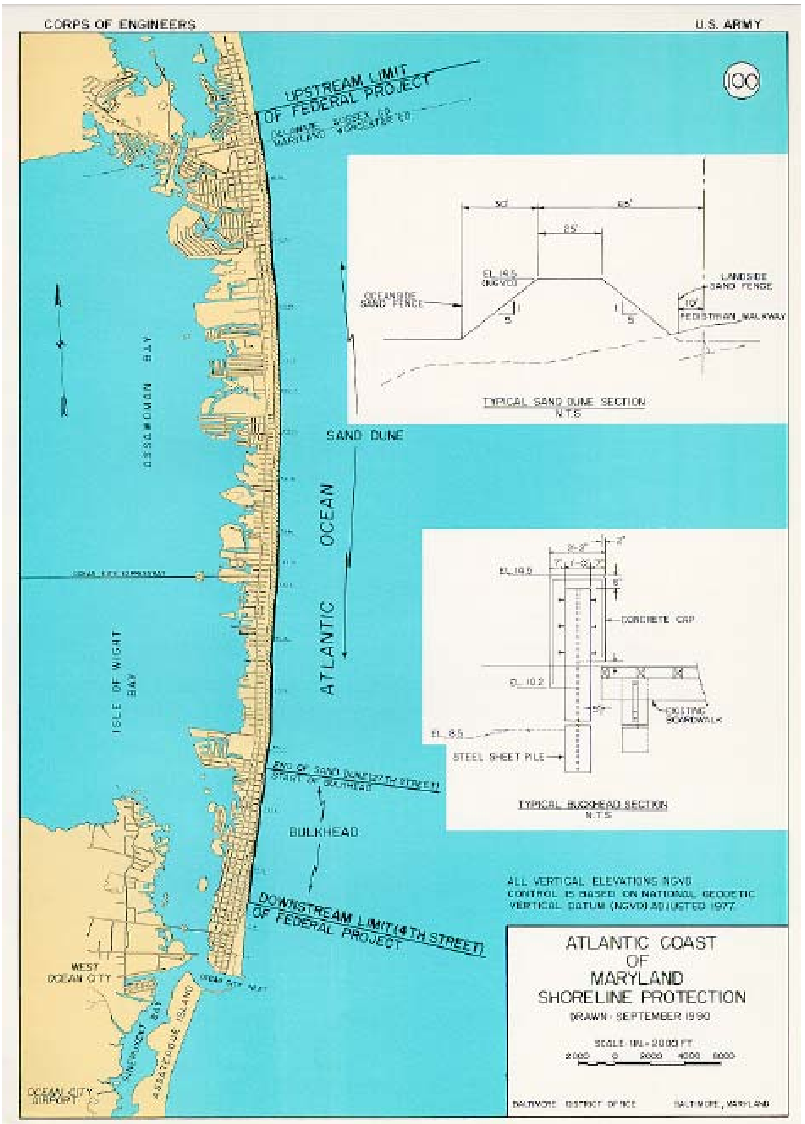

Figure 1-1: Atlantic Coast of Maryland Project.

Table 1-1: History of Federal sand placement at Ocean City and dredging dates.

Year	Purpose	Volume Placed (Cubic Yards)	Dredging Dates
1990	Storm protection beach fill	2,198,987	7/16 to 10/21
1991	Storm protection beach fill	1,622,776	6/21 to 8/6
1992	Rehabilitation #1	1,592,262	5/17 to 9/1
1994	Rehabilitation #2	1,245,125	4/29 to 6/26 & 9/14 to 10/14
1998	Renourishment #1	1,289,817	5/27 to 7/1 & 9/15 to 10/16
2002	Renourishment #2	744,827	5/1 to 6/26
2006	Renourishment #3	931,710	9/14 to 11/30

1.1 PROJECT AUTHORITY

The Atlantic Coast of Maryland Project was authorized initially by Congress under Section 501(a) of the Water Resources Development Act of 1986 (Public Law 99-662) based on the Report of the Chief on Engineers, dated September 29, 1981. In 1989, Congress, under Public Law 101-101, Section 104, dated September 29, 1989, modified the previous authorization to authorize the Secretary (of the Army) to construct hurricane and storm protection measures based on the District Engineer's Post Authorization Change Notification Report dated May 1989.

1.2 STUDY PURPOSE

This SEIS documents findings of investigations that began in 2001 to select borrow sources for the authorized Atlantic Coast of Maryland Project to maintain existing conditions at Ocean City through the 50 year economic life of the project. Identified sand sources in state waters are forecast to be exhausted after about 2010. These investigations were conducted under the auspices of a general reevalution (GR) study of the Atlantic Coast of Maryland Project.

The GR Study also evaluated whether modifications to the Atlantic Coast of Maryland Project to deal with erosional areas called hot spots should be made, and reevaluated the level of storm protection provided by the current project. The GR Study found that the level of protection provided met the project objectives. No modifications were proposed to deal with hot spots since options identified did not produce a favorable cost to benefit ratio, and USACE suspended further investigation of these topics. Since no changes to the Atlantic Coast of Maryland Project are proposed in association with these other components of the GR Study, no further consideration of them is provided in this SEIS. A separate summary fact sheet and engineering appendices provide information on these other study components. Copies of the fact sheet, engineering appendices, and additional information on these other components of the GR Study is available by request from USACE. The GR Study is completed upon finalization of this SEIS.

1.3 STUDY AREA

The study area considered in this SEIS encompasses state and Federal waters generally and the large sand shoals they contain from the Fenwick Island shoreline seaward out to about 14 miles offshore (Figure 1-2). (Fenwick Island in Maryland is fully developed and contained entirely within the municipal boundaries of Ocean City.) Particular focus was given to several offshore shoals located in Federal waters of the Atlantic Ocean from about 7 to 14 miles offshore of Ocean City, the ebb-shoal of the Ocean City inlet, and the waters of the Atlantic Ocean between these shoals and the coastline.

1.4 STUDY PROCESS

GR Studies reassess previously authorized projects if a significant period of time has elapsed, or if conditions have changed, since the initial feasibility study was completed (ER 1105-2-100). GR Studies reanalyze previously completed studies using current planning criteria and policies as required due to changed conditions and/or assumptions. The results of a GR Study may affirm the previous plan; reformulate it, as appropriate; or find that no plan is currently justified. Actions associated with a GR Study are subject to compliance with NEPA, and the regulations of the President's Council on Environmental Quality (CEQ). The nature and scope of the changes to the environmental effects of the project identified as a result of new information, of changed conditions, or changes to the project determine the appropriate type of NEPA documentation.

In light of anticipated significant impacts to whatever new borrow areas were selected, USACE determined that an EIS was the appropriate NEPA document. Accordingly, NEPA requirements for EIS preparation required incorporation into the study process. Coordination with resource agencies and academic experts provided information to help bound SEIS scope (content), formulate alternatives, and analyze impacts.

1.5 OTHER USACE AND STATE OF MARYLAND AND DELAWARE PROJECTS

There are several other existing water resource projects located on the Atlantic coastline in the Ocean City area. These projects include Delaware Coast Fenwick Island storm damage reduction; Ocean City Harbor and Inlet navigation; several Assateague Island Restoration efforts; and Long-Term Sand Management (LTSM) inlet mitigation. The Fenwick Island project was constructed by USACE, Philadelphia District. <u>Assateague Island State Park Sand Placement was constructed by Maryland.</u> The remaining projects were constructed by USACE, Baltimore District. The paragraphs below provide additional information on these projects.

<u>Delaware Coast, Fenwick Island</u>: Total project length 6,500 feet, including beachfill and dunes, extending north from about the Maryland/Delaware state line. Construction of beachfill portion of project completed in November 2005, dune construction completed in April 2006. Periodic renourishment is proposed to be conducted every four years.

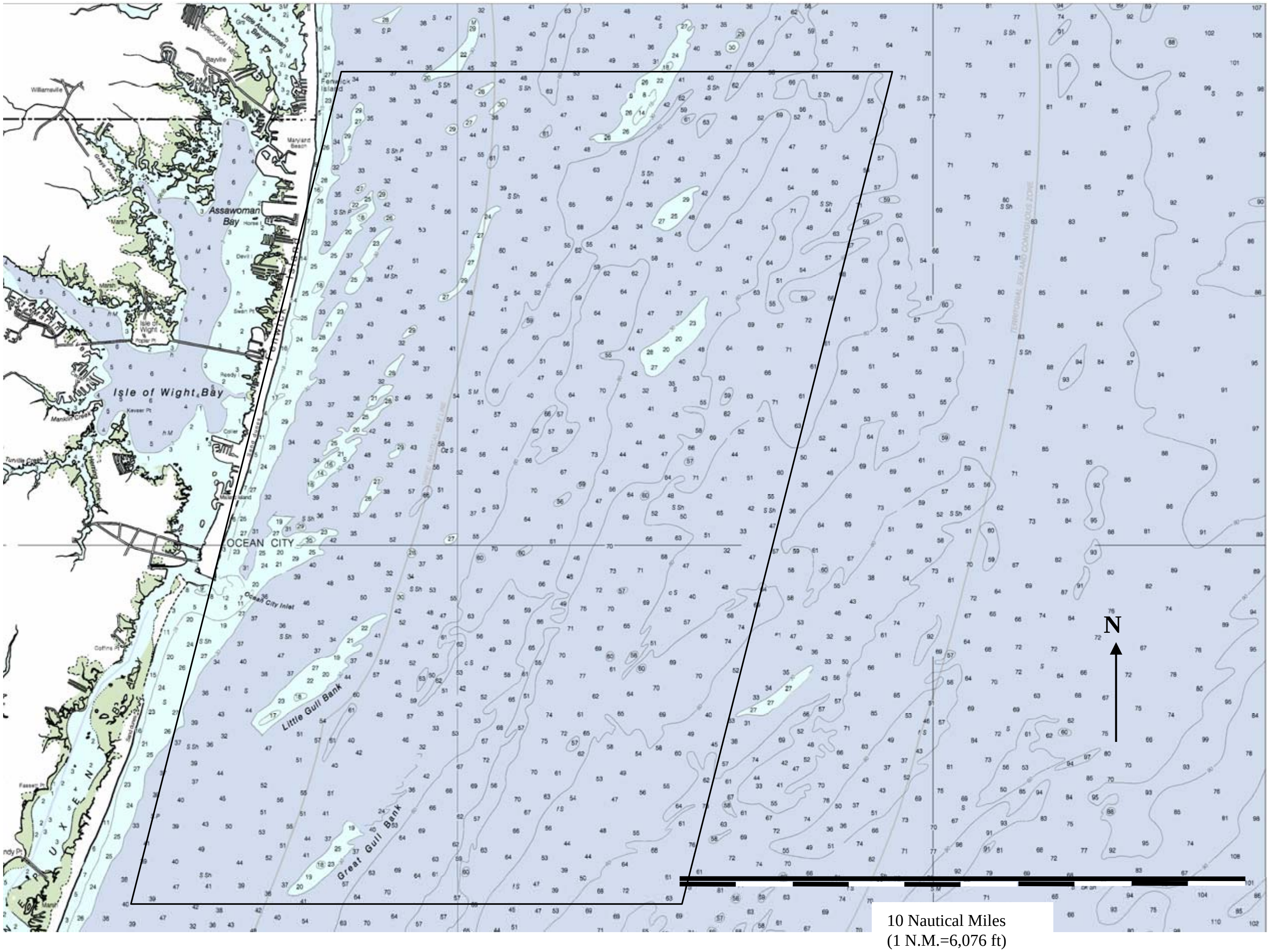

Figure 1-2: Study area. Soundings in feet. Map derived from NOAA National Ocean Service website data downloaded December 2006. Map source data from 1950 through present.

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Ocean City Harbor and Inlet: A natural inlet formed in 1933 and jetties were subsequently constructed by USACE in 1934-1935 to stabilize it. Maintenance dredging of the inlet was first conducted in 1935 and then subsequently conducted periodically on an as-needed basis. Through the 1980s and 1990s prior to implementation of the LTSM project, the inlet was maintenance dredged every 4 to 7 years. Following implementation of the LTSM project in 2004, inlet dredging has been effectively accomplished under the auspices of the LTSM project. Since that time, 2,000 to 3,000 cubic yards of material have been dredged from the inlet area twice yearly. The jetties have been periodically rehabilitated since their construction on an as-needed basis. The South Jetty was tightened to control water and sand flow through the jetty in 2002-2003.

The inlet was originally authorized for a channel 16 feet deep and 300 foot wide from the Atlantic Ocean to the channel into Isle of Wight Bay, but was only dredged to 10 foot depth and 200 foot width; the unfinished portion was deauthorized. The Ocean City Water Resources Study authorized deepening of the inlet to 16 feet.

Assateague Island Emergency Sand Placement: Project constructed in August through September of 1998 to compensate for impacts of northeasters in January and February of 1998. USACE dredged approximately 134,000 cubic yards of sand from Great Gull Bank and placed it on northern Assateague along an 8,400 ft long reach of the island located from 3.2 to 4.8 miles south of the inlet within the National Seashore.

Assateague Short-Term Restoration: Project construction completed in December 2002 and involved placement of 1,800,000 cubic yards of sand on the northern end of the island from 1.6 to 7.4 miles south of the Ocean City Inlet dredged from Great Gull Bank (Annex B2). Project purpose is to restore the geologic integrity of the island jeopardized by interruption of longshore transport sand flow caused by the USACE' jetties at the Ocean City Inlet. Associated short-term monitoring is expected to be completed in November 2007.

Assateague Island State Park Sand Placement: Project construction occurred at the time of Assateague Short-Term Restoration Project described above. Independent state effort. placed 95,000 cubic yards of sand dredged from Great Gull Bank on the state park beach.

Long-Term Sand Management: Project implemented in 2004 and includes twice-yearly dredging of sand from natural accretion sites of the Ocean City Inlet vicinity for placement onto northern Assateague to maintain island geologic integrity and on Ocean City to contribute to needs of the Atlantic Coast of Maryland Project (Table 1-2 and Annex B5). Project is authorized for 25 year period to annually place 189,000 cubic yards of sand on northern Assateague and up to 20,000 cubic yards of sand on Ocean City. Dredging is conducted utilizing adaptive management principles and managed by an interagency committee including representatives of the National Park Service, USACE, U.S. Fish and Wildlife Service (USFWS), DNR, and Ocean City.

Table 1-2: LTSM Project volumes of material dredged and placed on Ocean City

Dredging Dates	Volume (cubic yards)
Jan. to Apr. 2004	5,810
Oct. to Nov. 2004	3,340
Mar. to Apr. 2005	550
Sep. to Nov. 2005	11,275
Apr. to May 2006	1,845
Aug. to Oct. 2006	8,800
Apr. to Jun. 2007	270
Totals	**31,890**

1.6 PREVIOUS STUDIES

Several previous USACE studies have been completed that describe formulation and analyze impacts to the human environment of the Atlantic Coast of Maryland Project. These reports are listed in Table 1-3 below.

Table 1-3: Previous Atlantic Coast of Maryland Project reports.

Report Title	Report Date
Atlantic Coast of Maryland and Assateague Island Virginia Feasibility Report and Final Environmental Impact Statement.	August 1980
Atlantic Coast of Maryland Hurricane Protection Project Final General Design Memorandum. (Book 1 contains Environmental Assessment)	August 1989
Environmental Assessment for the Use of Borrow Area No. 9 as Part of the Periodic Renourishment and Maintenance of the Atlantic Coast of Maryland Shoreline Protection Project.	November 1993
Ocean City, Maryland, and Vicinity Water Resources Study- Final Integrated Feasibility Report and Environmental Impact Statement.	June 1998

Numerous other reports regarding water resources in the study area have been prepared by USACE, Maryland Geological Survey, and others in the last few decades. Citations of reports of particular relevance to this study can be found in Section 8, References.

SECTION 2

EXISTING CONDITIONS and AFFECTED ENVIRONMENT

2.0 INTRODUCTION

An understanding of the natural and human environment of the study area is important to identify and evaluate the problems affecting the study area, and formulate and evaluate solutions to these problems. To that end, this section provides a general overview of conditions in the study area as defined in Section 1.3. This section focuses in greatest depth on the conditions of the offshore shoals and ebb shoal because of past, current, and potential future use as these features as sources of sand for Ocean City. Limited information is also provided for Fenwick (Ocean City) and Assateague Islands where pertinent. For certain topics, it is necessary to also provide information from geographic regions outside of the study area to allow for evaluation of the uniqueness and relative importance of the natural and human features of the study area. This larger context will be discussed, as appropriate, within the specific subsections below.

The sea floor is largely flat, but contains numerous but widely-spaced large sand shoals. Ocean water depths get progressively deeper heading offshore, except for on the crests of the shoals where the water is substantially shallower than in adjacent non-shoal areas. Fenwick and Assateague Islands form the Maryland ocean shoreline (Figure 1-1). Maryland's ocean coast lies entirely within Worcester County. Ocean City is one of the primary seaside resorts on America's east coast due to a variety of attributes including its convenience to major metropolitan areas and access by automobile from Washington, D.C., and Baltimore, Maryland. Fenwick Island extends into Delaware, where it includes the small developed town of Fenwick Island immediately north of the Maryland border, as well as Fenwick Island State Park. Assateague Island is preserved as open space under the administrations of the National Park Service, U.S. Fish and Wildlife Service (USFWS), and State of Maryland. The southern end of Assateague Island extends into Virginia.

This report was compiled using existing information from published reports and government literature; contacts with scientists, resource agency personnel, and the public; and research conducted for this study. A list of the written references used can be found in Section 9. Engineering appendices of this report contain U.S. Army Corps of Engineers' (USACE) investigations conducted specifically for the current study. Annex C contains records of notable resource agency, scientist, and personal contacts.

The existing conditions section is subdivided into physical environment, biological resources, and social conditions subsections.

2.1 PHYSICAL ENVIRONMENT

The physical environment subsection contains a summary of information on the physiography, geology, and waters of the study area.

2.1.1 Physiography, Topography, and Bathymetry

Fenwick Island lies within the Coastal Plain physiographic province. The Coastal Plain is a relatively flat, low-lying region along the coast. Prominent physical features of the Coastal Plain in the study area include mainland headlands, barrier islands, and inlets (Figure 2-1). The submerged portion of the study area lies on the Continental Shelf of the Atlantic Ocean. The Continental Shelf extends from the shore out to about 75 miles offshore of Ocean City. The shelf slopes gently downward proceeding seaward; its eastern edge lies where water depths reach about 700 feet. Seaward of the Continental Shelf eastern edge, the sea bottom slopes much more steeply downward; this seafloor region is known of as the Continental Slope. The Continental Shelf in the study area is essentially a smooth underwater plain, other than for a number of large shoals that rise up from the seafloor (Figure 2-2).

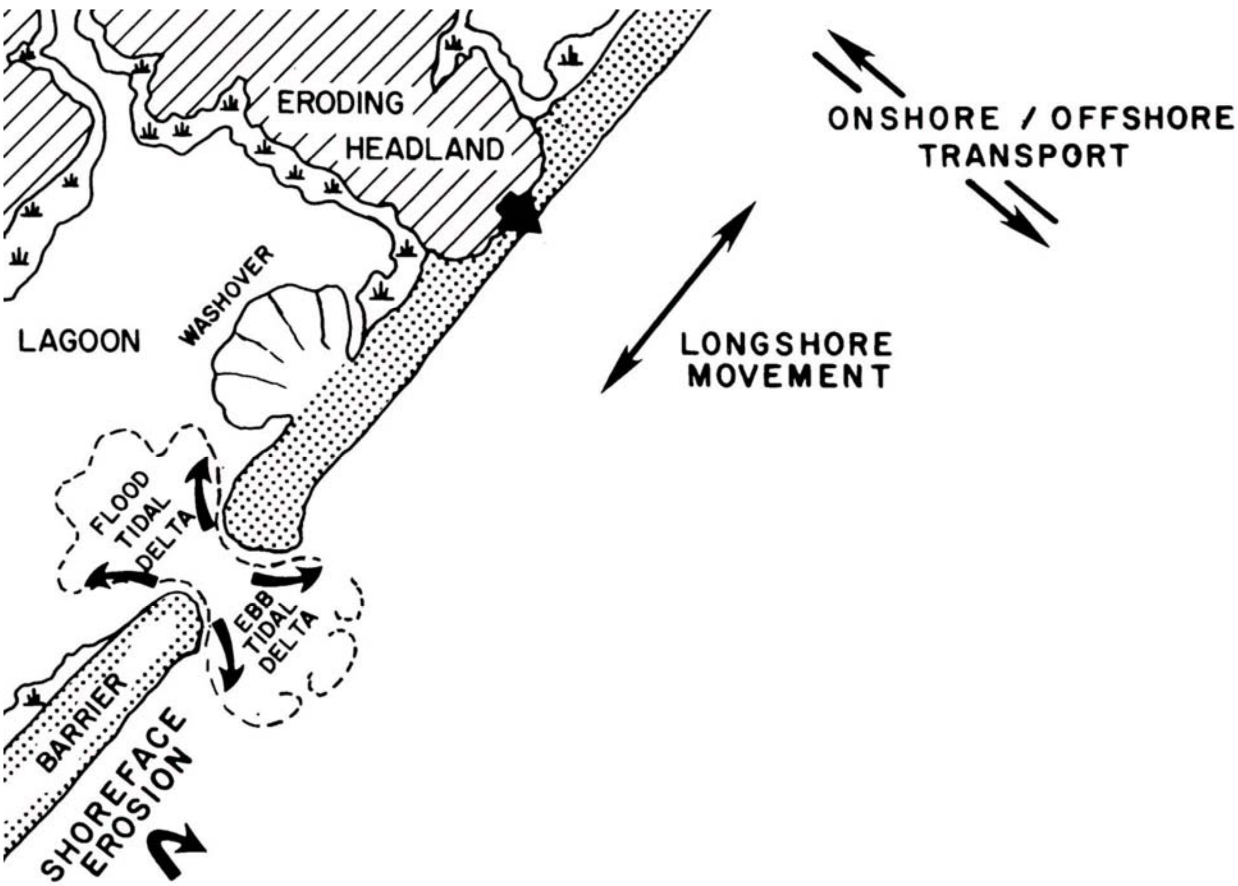

Figure 2-1: Shoreline geomorphic features. General sediment transport pathways shown. Modified from Kraft and others (1987).

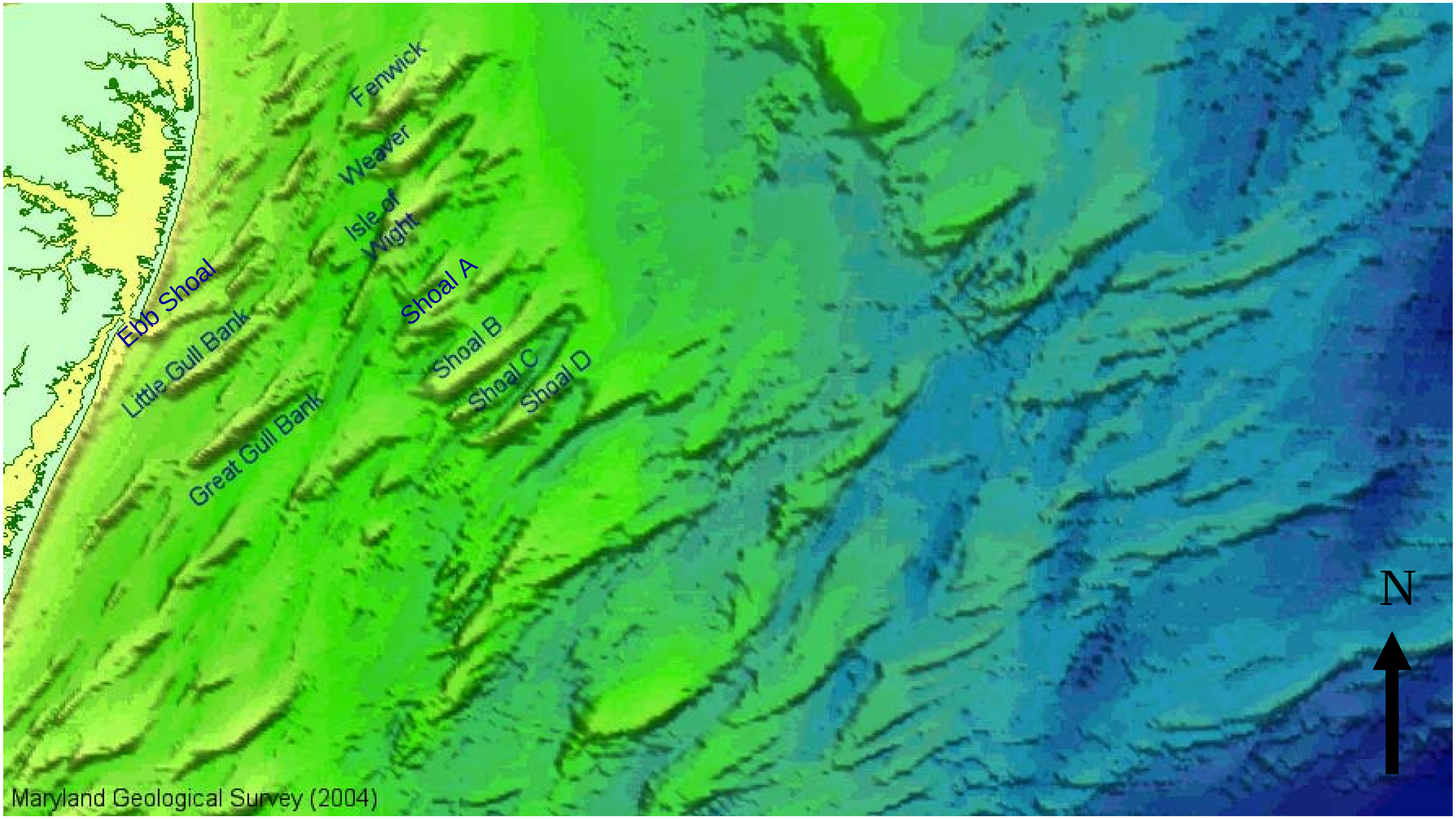

Figure 2-2: Continental Shelf geomorphology off Ocean City. Lighter colors denote shallower depths while darker colors denote deeper depths. Figure modified from a source figure provided by MGS prepared from NOAA bathymetric data.

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Fenwick Island is actually a spit connected to the mainland in Delaware. Fenwick Island is 12.9 miles long, the southern 9.2 miles of which lie in Maryland; the spit extends an additional 3.7 miles into Delaware to its attachment point with a mainland headland. In contrast, Assateague Island is a true island. Assateague is 37 miles long, the northernmost 22.6 miles of which lie in Maryland. The ocean shoreline of Fenwick Island is gently curving.

USACE, Maryland Geological Survey (MGS), Minerals Management Service (MMS), and academic scientists have studied the seafloor and shoals of the study area for several decades. Studies conducted since the 1980s have focused on their potential use as sources of sand for beach nourishment. Because these shoals have been studied from a regional perspective and or as sources of beach nourishment sand, shoals that have been studied are generally only those that are fairly large. For example, Duane and others (1972) studied only those shoals greater than about 3,000 feet in length and at least 10 ft in relief off the seafloor. Smaller shoals have not been inventoried, and data is not available to provide a complete inventory of shoals in the study area. Swift and Field (1981) identified 35 large shoals off Fenwick and Assateague Islands up to about 20 nautical miles off the coast of Delaware, Maryland, and Virginia to water depths of greater than 100 feet (Figure 2-3, Table 2-1).

Table 2-1: Characteristics of large shoals in ocean waters off Fenwick and Assateague Islands (Swift and Field, 1981).

Characteristic	**Range**		**Typical**
	Low	**High**	
Relief off seafloor (feet)	10	40	20 to 30
Length (miles)	2.3	11.5	5.2 to 8.6
Width (miles)	0.6	1.7	0.9 to 1.4
Azimuth	13°	61°	25 to 50°
Spacing (miles)	0.9	6.9	2.8 to 4.0
Angle of Intersection with Coast	10°	40°	15 to 35°
Maximum Side Slopes	0.2°	7.0°	0.75 to 2.0°

Swift and Field (1981) divided the shoals into three groups based on their geomorphic characteristics: offshore, nearshore, and shore-attached (Table 2-2). The offshore and nearshore shoals stand alone on the flat seafloor; the shore-attached shoals connect directly to the coastal barriers at water depths greater than a minimum of about 9 feet. All the shoals they studied were oriented such that their long axis is southwest/northeast in orientation. The characteristics of the shoals change somewhat proceeding seaward among the three groups.

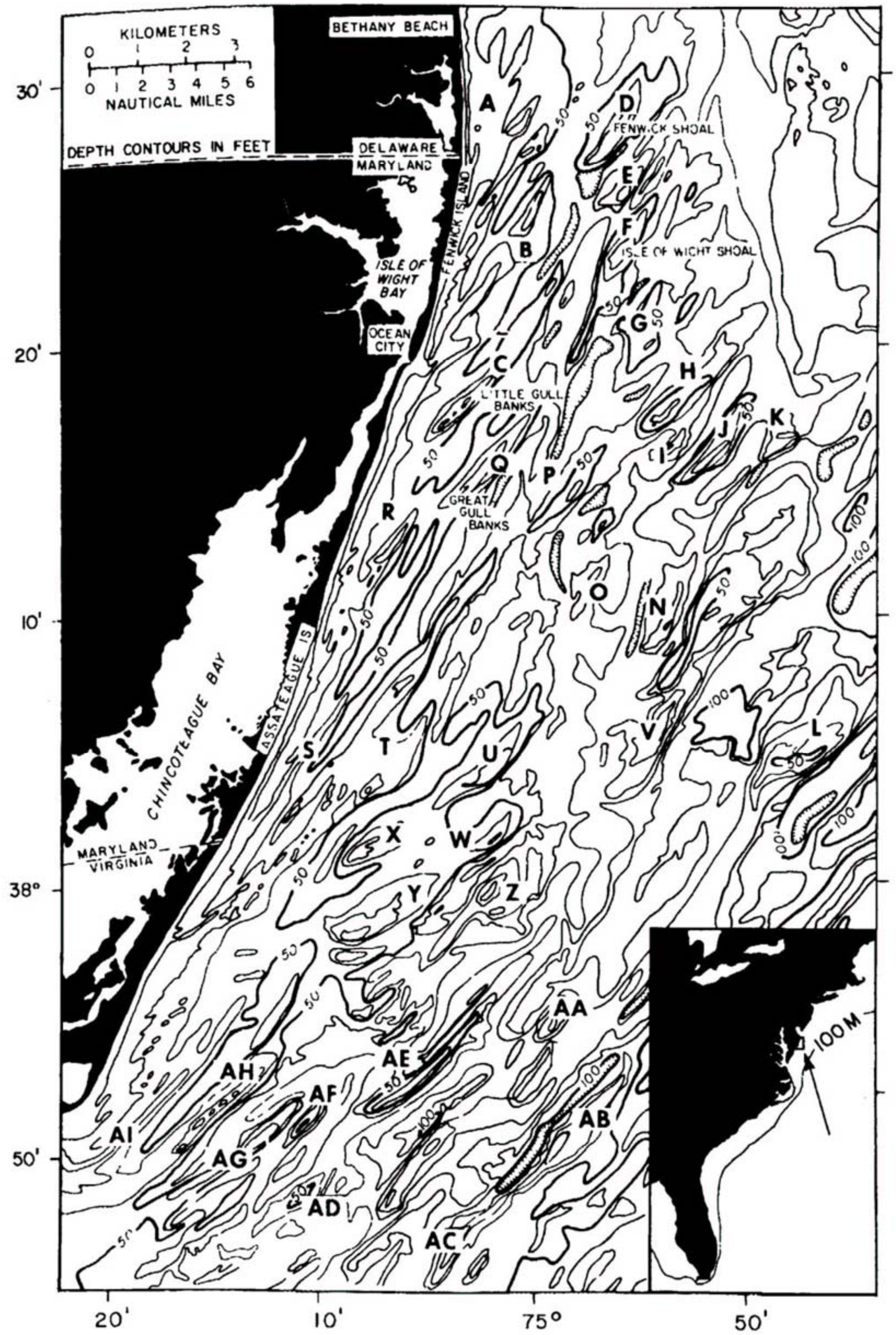

Figure 2-3: Offshore shoals inventoried by Swift and Field (1981). (Note: lettering system different from that used by MGS).

Table 2-2: Shoal geomorphic types and characteristics by type (Swift and Field, 1981).

Geomorphic Characteristic	Shoal Type (No. Measured)		
	Attached (12)	**Nearshore – Detached (8)**	**Offshore – Detached (15)**
Shape	Linear	Linear	Comma
Ambient Water Depth (ft)	>9	<50	>50
Mean Slope	1.5°	1.0°	0.5°
Steepest Slope	2.5°	2.0°	7.0°
Steepest Flank	Landward	Seaward	Seaward
Mean Asymmetry (landward : seaward slope)	1:1	1:2	1:5
Mean Aspect Ratio (length : width)	9:1	6:1	3:1
Maximum Cross-Sectional Area (acres)	21	46	119

Over the last several decades, a large shoal has formed at the ocean entrance to the Ocean City Inlet (Figure 2-2). This shoal is known of as the ebb shoal because it has been formed by interaction of the outgoing tidal currents from Maryland's coastal bays interacting with ocean waves and currents. Unlike the other natural shore-attached shoals presented in Table 2-2 that are linear or comma-shaped, this shoal is crescent-shaped. The ebb shoal exists in its current form as an indirect result of coastal engineering measures undertaken to stabilize the inlet, and to some degree as a consequence of measures undertaken to protect and maintain Ocean City. The ebb shoal was studied extensively by USACE during the Ocean City Water Resources Study, and the appendix for the 1998 report provides detailed information on the ebb shoal. Much of the discussion in this section on the ebb shoal is derived from that appendix. The formation and growth of this feature is summarized in Section 2.1.2. The ebb shoal attaches to the shoreline of Assateague Island about 2,000 feet south of the inlet. As of 1995, the ebb shoal extended from the northern shoreline of Assateague Island seaward about 4,300 feet, and was about 1.2 miles across from north to south.

Twenty-two large detached nearshore and offshore shoals were studied by MGS from 1.5 to 13.1 miles off the Maryland coast (Table 2-3). Figure 2-4 depicts the shoals in the coastal ocean waters off Fenwick Island. These shoals range from 0.7 to 10.5 square miles in area, and 2.0 to 7.0 miles in length; maximum width ranges from 0.6 to 2.5 miles. These shoals range in relief off the seafloor from about 25 to 50 feet. Side slopes are very gentle, and range from about 0.2° to 7.0°. Shoal morphometric data compiled by MGS indicates that shoal area and relief off the seafloor are positively correlated to shoal volume, with shoals of greater volume having greater area and relief (Figure 2-5). Shoal crest and base water depths gradually increase proceeding farther offshore. Offshore shoals show no clear simple relationship between distance offshore and their total volume, base length, or maximum width. These shoals occupy a total area of greater than 75 square miles. MGS has conducted limited studies of shore-attached shoals off Fenwick and Assateague Islands (Table 2-4). MGS investigations have focused on large shoals considered to have high potential as sources of sand for beach nourishment, they did not attempt to inventory all of the shoals on the Continental Shelf off Maryland.

Table 2-3: Shore-detached offshore and nearshore shoal geomorphic characteristics*. Shoals presented geographically from north (top) to south (bottom).

	Shoal (N to S)	Distance Offshore - Centroid (mi)	Total Sand (yd3)	Base Water Depth (ft)	Area (mi2)	Base Length (mi)	Maxi-mum Width (mi)	Shoal Crest Water Depth (ft)	Relief (ft)
1	Fenwick	6.8	211,000,000	-60	10.5		2.5	-12	48
2	Borrow Area 3**	3.1				3.5	0.8		
3	Borrow Area 8	1.5							
4	Weaver	7.2	93,000,000	-60	3.8	4.1	1.4	-24	36
5	Borrow Area 9	3.1							
6	Isle of Wight	7.2	136,000,000	-60	5.5	4.9	1.6	-18	42
7	Borrow Area 2**	2.5	11,000,000			2.4	0.7	-30	
8	E	6.4	31,000,000	-60	3.2	4.0	1.1	-45	15
9	A	9.6	103,000,000	-60	5.2	3.7	1.5	-32	28
10	Little Gull Bank	3.0	50,000,000	-43	2.9		0.9	-16	27
11	B	11.0	50,000,000	-60	4.4	4.7	1.2	-27	33
12	C	11.3	8,000,000	-60	0.7		0.6	-33	27
13	D	13.1	24,000,000	-60	2.5		0.9	-36	24
14	Great Gull Bank**	4.5	63,000,000	-50	2.8		0.9	-17	33
15	Charlene	2.2							
16	F	4.2	55,000,000	-53	5.9	7.0	1.2	-28	25
17	K	8.6	139,000,000	-70	8.5	6.5	1.9	-21	49
18	M	4.6	20,000,000	-55	1.5	2.0	0.9	-19	36
19	H	2.3	42,000,000	-54	4.4	6.9	1.1	-23	31
20	I	3.1	65,000,000	-54	5.1	5.6	1.3	-27	27
21	J	5.9	63,000,000	-63	4.1	3.7	1.5	-22	41
22	L	9.8	72,000,000	-70	4.2	3.4	1.7	-26	44
	Total		>1,236,000,000		>75				

***Information from MGS reports. Citations of reports included in Section 8. Data not available for blank cells.**
****Prior to dredging (Annex B).**

Table 2-4: Shore-attached shoals. Shoals presented geographically from north (top) to south (bottom).

Shoal Name
Borrow Area 5
Borrow Area 4
Borrow Area 6
Borrow Area 7
Ebb (Ocean City Inlet)
G

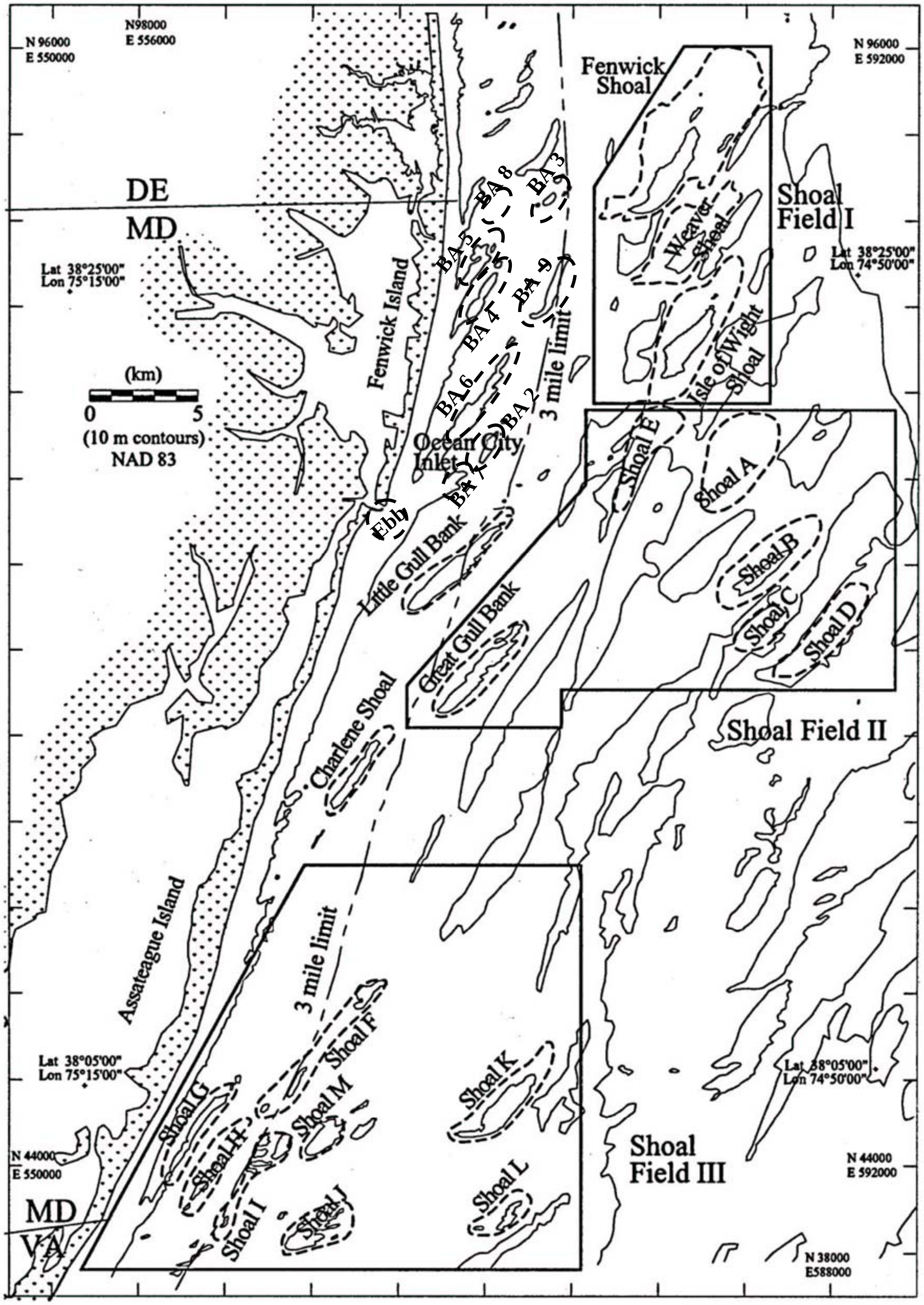

Figure 2-4: Offshore shoals off Fenwick Island (modified from an MGS source figure). BA=Borrow Area.

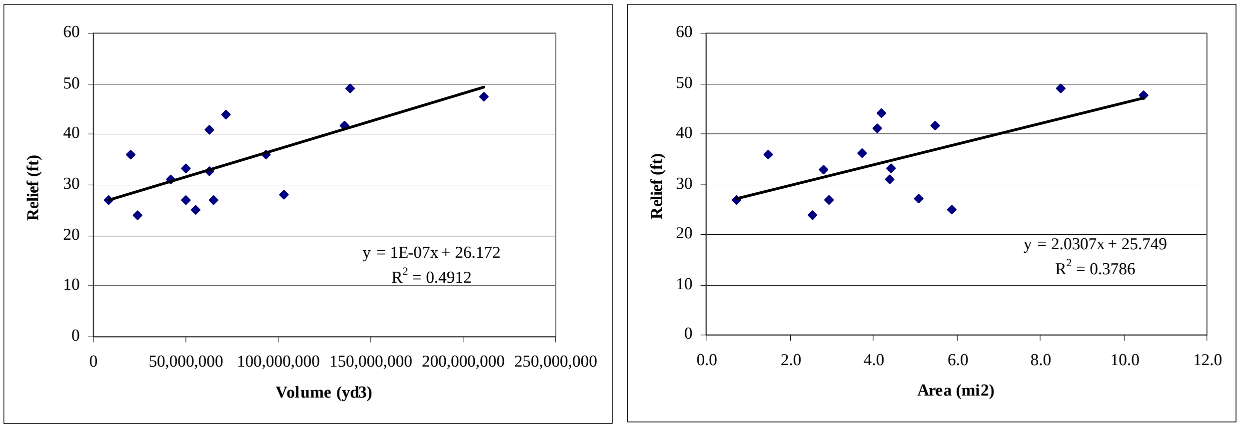

Figure 2-5: Offshore shoal relief and area versus volume.

Man's influence on seafloor bathymetry has been notable in state waters out to the 3 mile limit off Ocean City at several other sites in addition to at the ebb shoal. Several shoals romantically named Borrow Areas 2, 3, and 9 have been mined for the Atlantic Coast of Maryland Project. MGS conducted monitoring studies of Borrow Areas 2 and 3 (portion in Maryland waters only, portion also occurs in Delaware waters) for this study to characterize current physical conditions of these shoals and determine how dredging has impacted shoal character (Annex B). Approximately one third of the volume of Borrow Area 2 was extracted for beach sand from the shoal western flank, and shoal width was reduced by about half. The remnant shoal crest remained intact, but elevation lowered by 2 to 4 feet over much of the remaining shoal area from pre-dredge conditions. Borrow Area 3 dredging was conducted on the southern end of the shoal. Dredging appears to have had less notable long-term impact on this portion of the shoal, in part because it is an accretionary area and some recovery from dredging has occurred. Great Gull Bank geomorphic character was impacted by dredging to obtain sand for Assateague Island (Section 1.5). However, unlike previous dredging conducted to maintain Ocean City, dredging for Assateague of Great Gull Bank was purposefully conducted in a manner to attempt to maintain the overall geomorphic character of the shoal. Dredging was conducted on the southern accretionary end of the shoal and a uniform thickness of material was dredged from a wide area. The crest was avoided. Post-borrow bathymetric surveys of the Great Gull Bank borrow area were conducted in December 2002 and February 2003 and verified that dredging was done as per the dredging contract and met the environmental requirements (Annex B). No further monitoring has been conducted to determine how the Great Gull Bank has evolved since that time.

On the surface of the shoals and seafloor plain, smaller scale geomorphic features occur. These features include flat plane beds, ripples, and dunes (sand waves). These features occur as a function of waves and or currents acting upon the substrate. Table 2-5 presents general information on these features. Studies conducted for MMS of Fenwick, Weaver, and Isle of Wight Shoals found that the shoal crests had larger bedforms than did the shoal flanks.

Table 2-5: Small-scale geomorphic features of the seafloor (Morang and others, 1993).

Bedform	Height (ft)	Crest Spacing (ft)	Notes
Flat plane	-	-	Lacking positive relief or depressions. Can occur on compacted muds where overlying sands are scoured off, and on coarser sands where current velocity is too low for dunes to form
Ripple	Up to 1	Up to 2	Form at low current or wave energy conditions
Dune	Greater than 1	Up to about 3,300	Abundant in sandy areas where water depth is > 3 ft, sand is coarser than 0.15 mm (very fine sand), and current >1.3 ft/sec

The seafloor plain also has small-scale structures formed by living things, including worm tubes, shell, and corals. These structures are discussed in Section 2.4 (Habitats).

2.1.2 Geology

The Coastal Plain and Continental Shelf are closely related geologically, and both owe their origin to deposition and erosion of sediments on the eastern edge of North America accompanying the rise and fall of sea levels over geologic time. Sea level is currently rising at a rate in excess of 3 mm (0.12 inches) per year (0.3 m [1 foot] per 100 years) in Delaware and Maryland according to the National Oceanic and Atmospheric Administration. Sediments of the study area include gravel, sand, silt, and clay derived from rock (Table 2-6), as well as seashells and plant remains. Sediments of the study area are predominantly unconsolidated - the individual particles are not cemented together. These materials underlie the entire study area within both the Coastal Plain and on the Continental Shelf.

Following inlet formation during a hurricane in 1933 and subsequent stabilization by USACE (Section 1.5), sand carried southward by longshore drift was captured by the north jetty of the Ocean City Inlet, and the southernmost end of Fenwick Island accreted seaward of its pre-inlet position. Within about 5 years the southernmost end of the island came into a new balance with natural forces and has maintained a stable position since that time. Following implementation of beach nourishment programs in 1988 (Section 1.0), the entirety of the Fenwick Island shoreline position has been maintained at a relatively stable position.

Prevailing waves produce a southerly current along the Maryland shoreline for much of the year. This current of water transports sand in a southerly direction in what is known as the longshore transport system. The Assateague and Fenwick Island coastal barriers were formed by spit growth from sand transported southward from a coastal headland located near what is now Bethany Beach, Delaware over the last several thousand years. Historically, inlets opened in storms, migrated south for a period of up to several decades, and then closed in many locations along what are today Fenwick and Assateague Islands (McBride, 1999). Coastal engineering measures since that stabilization of the Ocean City Inlet in the 1930s have prevented the current inlet from migrating southward and have prevented the formation of new inlets through Fenwick

Island. Additionally, construction of the Ocean City jetties in the 1930's interrupted the southerly flow of sediment and induced sediment starvation of Assateague – causing the island to retreat to the west more rapidly than was otherwise occurring. Inlet stabilization also induced formation of a large ebb shoal at the mouth of the inlet. Growth of the ebb shoal and retreat of Assateague induced a local reversal in longshore transport at the northern end of Assateague Island such that sand along the northern 3.9 miles of the island generally flows north rather than south.

Table 2-6: Gravel, sand, silt, and clay particle sizes*.

General Size Class	**Specific Size Class**	**Millimeters (mm)**	**Phi (ϕ)****
Gravel	Boulder	256 to 4096	-12 to -8
	Cobble	64 to 256	-8 to -6
	Pebble	4 to 64	-6 to -2
	Granule	2 to 4	-2 to -1
Sand	Very coarse sand	1 to 2	-1 to 0
	Coarse sand	0.5 to 1	0 to 1
	Medium sand	0.25 to .5	1 to 2
	Fine sand	0.125 to .25	2 to 3
	Very fine sand	0.0625 to .125	3 to 4
Silt	Silt	0.0039 to .0625	4 to 8
Mud	Clay	< 0.0039	8 and >

*Gravel, sand, silt, and clay are distinguished from each other by particle size in the Wentworth system; this system is used throughout this report.

**The negative logarithm in base 2 of the particle size expressed in millimeters, larger phi numbers actually represent smaller size particles. Scale commonly used by engineers and scientists.

The nearshore and offshore detached shoals are believed to have formed originally as ebb-tidal shoals, that later became detached from the shore as sea-level rose over the last several thousand years. Evolution of these shoals has been studied by Snedden and others (1999), McBride and Moslow (1991), and Swift and Field (1981). Table 2-3 presented a summary of geomorphic character variation of these shoals. As the shoreline retreated with rising sea-level and inlets opened and closed, the ebb-tidal deltas became detached from the shore, and began to migrate and evolve independently of the retreating shoreline. Over thousands of years, the shoals appear to increase in cross-sectional area, undergo a decline in length to width ratio, and sand grain-size of the ridge may increase. Shoals may undergo growth in part by cannibalizing other shoals. As the shoals migrate and water deepens as a consequence of their direction of migration and rising sea level, fair-weather waves play a diminishing role as a factor controlling their character. Predominant storm waves originating from the northeast cause shoals to align along a northeast/southwest axis (Hayes and Nairn, 2004). Swift and Field (1981) determined that large shoals may migrate at rates ranging from 6 to 400 ft per year, generally to the southeast. MGS monitoring of Borrow Areas 2 and 3 for this study determined that these features are migrating to the south at a rate of 15 to 30 feet year; movement of smaller scale geomorphic features on the shoals (Table 2-5) was also found to be predominantly southerly.

In contrast to the nearshore and offshore shoals, some of the shore-attached shoals, such as the one located at about the Maryland/Delaware state line, are believed to have originally formed as ancient barrier islands in the geologic past. This topic has been the focus of recent research by Dr. David Krantz of the University of Toledo, Ohio. The shore-attached shoal in this case represents a portion of the ancient barrier island that now juts out into the ocean. Ancient barrier islands are also expressed as important geomorphic features on the mainland.

While ebb shoals are features naturally associated with inlets under a wide range of wave and tidal conditions, the Ebb Shoal exists in its current form as a consequence of interruption of longshore transport caused by stabilization of the Ocean City Inlet by USACE in 1934, and recently to a lesser degree to beach nourishment of Ocean City since 1988. Extensive studies of the evolution of the ebb shoal were conducted by USACE during the Ocean City Water Resources Study utilizing data sets from 1933, 1937, 1962, 1977/78, and 1995. The ebb shoal grew rapidly in size from 1933 to 1962, but was then relatively stable in size through 1995. Over this same time period, the ebb shoal volume has continuously increased, however the rate was most rapid immediately following stabilization of the Ocean City Inlet (Table 2-7). Tightening of the South Jetty in 2002-2003 likely altered physical environment conditions in the vicinity of the ebb shoal, and ebb shoal size, position, and volume will presumably change in adjustment.

Table 2-7: Ebb Shoal volume, area, and growth rate since inlet stabilization. Volume calculated to -43 ft (-13 m).

Date*	Volume (yd3)	Area (acres)	Volume Change yd3/yr
June 1933	0	0	0
March 1937	1,700,000	203	415,000
May 1962	5,700,000	825	161,000
January 1978	11,700,000	907	379,000
October 1995	13,500,000	899	103,000

*The data presented for January 1978 is derived from surveys conducted in August 1977 and October 1978. The data presented for October 1995 is derived from surveys conducted in July, October, and December of that year. (USACE, 1998).

The dominant sea floor sediment type on the Continental Shelf in the study area is fine to coarse, well-sorted sand. These surficial sands are reworked sediments that were originally deposited in stream, bay, barrier island, and shoreface environments. Coarser gravels are concentrated in areas of greatest wave and current energies, such as along the shoal crest (Wells, 1994). Studies conducted by MGS of Fenwick, Weaver, and Isle of Wight Shoals show four general pattern of substrate conditions. Shoal crests consist of sand with almost no shell material. Shoal flanks have sand with some shell and other biogenic materials. Intershoal regions have sand with richer but not abundant benthos. Patch-mat regions occur between shoals that have muddy substrates, abundant patches/mats of worm tube colonies, and shell beds (Annex C). No new muds are currently being deposited on the Continental Shelf of the study area because wave and current energies are too strong for these small particles to settle out. Any muds at the seafloor surface are exposed underlying deposits from previous environmental conditions (Duane and others 1972 ; Swift and others 1972).

Sand deposits on the Continental Shelf are highly variable in thickness, areal extent and grain size. The surface sand overlies poorly sorted, very fine to fine sand and mud that is locally exposed at the sea floor surface. Sand contained in the offshore shoals is generally well-sorted, medium sand. Sediments underlying the offshore shoals are variable, but are often mud and poorly sorted fine sand. Aside from the offshore shoals, sand deposits on the sea floor are generally only several feet thick and of a finer grain size than Fenwick and Assateague Island beach sand. Sediments of the shore-attached shoals include a wide range of grain-sizes, presumably as a function of their origin as ancient barrier islands and back bays overlain by modern active seafloor sands (Wells, 1994).

Inlet bottom sediment patterns result from the complex interaction of inlet currents with bay and ocean waves. Sediments in the inlet generally consist of coarse-grained sand due to tides and currents scouring away finer-grained sediments. Sediment has accumulated on the seaward side of the inlet; this is known as an ebb-tidal delta or shoal. Inlets typically form during storm events, as did the Ocean City Inlet in 1933. Inlets can form either from the ocean or the bay side of an island. Once formed, inlets of the study area typically migrated in a southerly direction for a period of time, and eventually shoaled in and closed. Without intervention from man, inlets on Fenwick and Assateague Island would open and close naturally in a cycle taking from several years to decades to complete.

Beach sand exhibits a range of grain sizes as a function of waves, currents, and winds acting on the beach. Large particles accumulate in the surf zone where wave and current energy is very high. Fine particles wash offshore or may be blown towards land where they can form dunes. Historically from 1929 to 1954 prior to major beach nourishment efforts, median grain size of beach sand at the Maryland/Delaware border was found to range from 0.20 to 0.41 mm (2.24 to 1.3 phi) (USACE, 1966 cited in Ramsey, 1999) (Table 2-8). Beach sand median grain-size at the Md./Del. boundary was determined to be 0.212 mm (2.24 phi) in 1964 (USACE, 1966 cited in Ramsey, 1999), following major beach nourishment operations that utilized material from bayside sources in 1962 and 1963 (USACE, 1963). Variability in sampling methods, sample location on the beach profile, textural analysis methods, formulas used, and time of year of sampling can limit the ability to directly compare modern data to historic data. Accordingly, historic data although characterizing the beach at the time of sampling should be considered only an approximation of beach sand texture at that time (Ramsey, 1999).

Table 2-8: Historic beach sand grain-size data from samples at Maryland/Delaware boundary (USACE, 1966 cited in Ramsey, 1999).

Year	Median grain size (mm)	Median grain size (phi [ϕ])	Beach Site
1929	0.297	1.75	Mean high water
1936	0.354	1.5	Mid tide
1950	0.200	2.32	Mean high water
1954	0.406	1.3	Across profile

In 1986, prior to regular beach nourishment utilizing offshore sand that began in 1988, Ocean City beach sand was found to have a mean grain size of 0.36 mm (1.45 phi) (USACE, 1989). Following major beach nourishment actions in 1988, 1991, and 1992, sand of the constructed Ocean City beach was found to have a mean grain size of 0.43 mm (1.22 phi) in 1993 (USACE, current study). The historic texture characterizations and 1986 samples when compared to samples taken following regular beach nourishment indicate that beach nourishment has coarsened the beach at Ocean City over its historic condition.

In the subsurface below the seafloor off the Delmarva coast occur a number of former river channels from when sea level was lower that are now completely infilled by sediment and not readily apparent on the seafloor surface. These features are not identifiable without specialized geophysical profiling equipment. These features are known of as paleochannels. These channels were formed by rivers and inlets when sea level was lower over the last several thousand years, and have subsequently filled with sediment as the sea rose. The paleochannels are often of substantial length but limited width, and are usually buried under a significant thickness of overlying sediment. Paleochannel deposits include sand.

2.1.3 Soils

Soils are geologic materials modified by living things that are capable of supporting the growth of plants. Because of intense wave energy and currents, rooted plants are not capable of growing within the ocean waters or beach of the study area. Consequently, soils occur only on Fenwick Island from the dunes and westward where the island surface is protected from ocean wave impacts outside of the study area considered in this SEIS.

2.1.4 Hydrology

The coastal ocean waters between Cape Cod and Cape Hatteras are known of as the Mid-Atlantic Bight. The coastal ocean off the Delmarva Peninsula has one of the most extreme seasonal ranges of sea temperature in the world (MMS, 2000). Sea surface temperatures along the Maryland coastal ocean range from lows of about 43ºF in February to highs of about 76ºF in August. Sea surface temperatures are consistently cold during the months of January through March, warming from April through June, consistently warm from July through September, and then cooling from October through December (Figure 2-6) (USN, 2001). Ocean water salinity in the study area ranges from about 30 to 33 parts per thousand. Continental Shelf waters undergo progressive thermal stratification from spring through summer when the thermocline reaches a depth of 9 to 12 m (30 to 40 ft). At coastal locations within the 20 m (65 ft) contour, the stratification is somewhat less intense as the shallower depths permit some turbulent mixing through the water column. There may often be a slightly higher salinity on the bottom compared to the surface. Water quality in the Atlantic Ocean off Ocean City is generally very good (USACE, 1998).

The water circulation in this region of the inner Continental Shelf is characterized by a general southward movement of the surface and bottom water throughout the year. Average southerly currents are on the order of 10 cm/sec (0.3 ft/sec) or about 0.2 knots (0.4 km/hr) (Brooks, 1996). However, from April to September, the surface water movement may periodically reverse and move northward in association with the prevalence of south winds (USACE, 1998). The northeastwardly flowing Gulf Stream in the Atlantic Ocean is well offshore of Ocean City (generally more than 200 miles seaward). The ocean waters of the study area have a semidiurnal tide, which means two high and two low waters occur each day. The mean ocean tide range at Ocean City is 1.07 m (3.5 ft); spring tide range is 1.28 m (4.2 ft) (MMS, 2000).

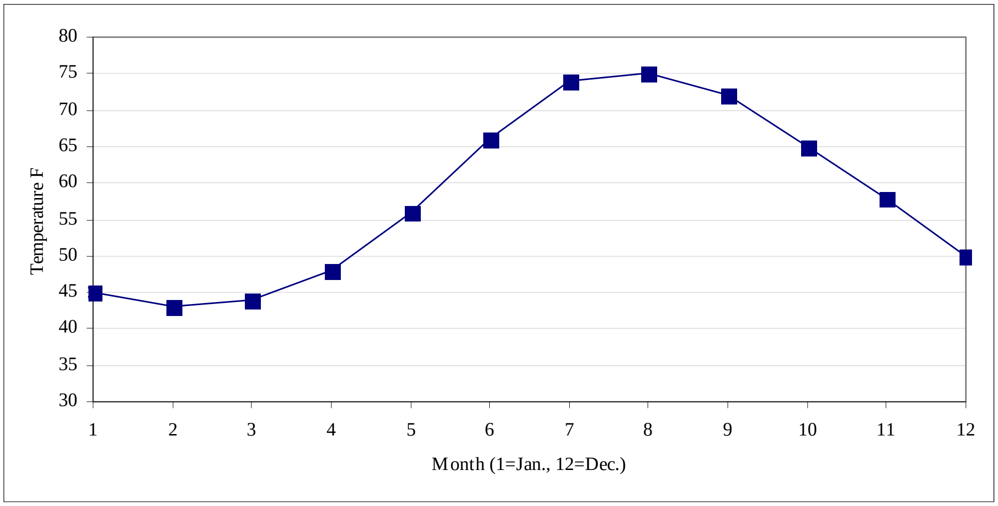

Figure 2-6: Average monthly sea surface temperatures. Maryland coastal ocean waters off Fenwick Island (U.S. Navy, 2001).

Waves incident from the west have limited impact on the study area, whereas waves incident from the east are capable of moving sand both alongshore and offshore, influencing both the shape of the shoreline and the beach profile. Waves occur much more frequently from the southeast quadrant than they do from the northeast; however, the waves from the northeast tend to be higher. The predominant southerly littoral drift along this segment of coast is a result of waves from the northeast and east quadrant. The average measured wave height off Ocean City is 0.7 m (2.3 feet). Average wave heights vary seasonally: the lowest monthly average wave occurs in July and August; the maximum monthly average wave height occurs in December, January, and February. The largest measured wave was 4.4 m (14 feet); this occurred during the January 1992 storm. Although not directly measured, mathematical models have estimated that wave heights reached 7.5 m (19 feet) during the March 1962 northeaster (USACE, 1998 Appendix A)

Storm waves from the northeast converge along the crests of both the shore-attached and shore-detached shoal crests such that wave energy is greatest along the crests. Storm waves diverge in the areas between shoals, producing lower wave energy conditions (Figure 2-7).

2.1.5 Climate

Worcester County has a humid continental climate modified by its nearness to the Atlantic Ocean, Chesapeake Bay, and Gulf Stream. The general atmospheric flow is from west to east. However, alternating pressure systems create variability in weather patterns. Average annual precipitation at Ocean City is 124 cm (49 inches), with about 25 cm (10 inches) of snow occurring annually. Heavy precipitation occurs mostly in the warmer portion of the year from thunderstorm activity. Droughts can occur throughout the year, but are most likely during the summer months. The prevailing winds are from the west to northwest, except during the summer months, when they are southerly. Onshore winds from the northeast, east, and southeast occur one-fifth of the time. Direct onshore winds can elevate nearshore waves and coastal water

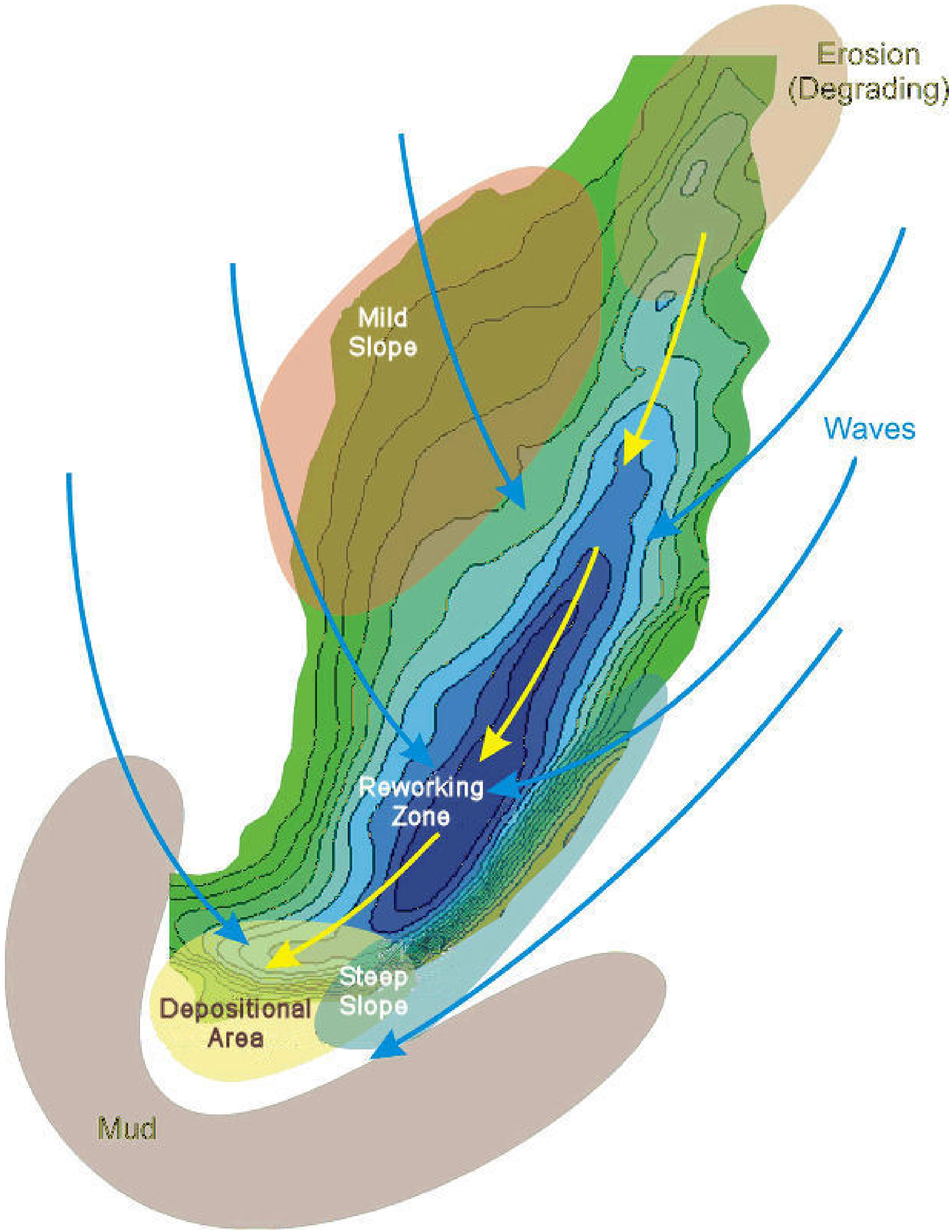

Figure 2-7: Offshore shoal dynamics. Figure modified by MGS from conceptual model from Hayes and Nairn (2004) based on work on Fenwick Shoal. Blue lines are waves and wave-induced transport, yellow lines are direction of dominant transport and migration of the feature. Note that shallowest area on shoal is dark blue.

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levels during storm events, increasing storm damages. Winds from the east and northeast tend to be of the highest magnitude. The average annual temperature at Ocean City is 14°C (57°F). Air temperatures over the coastal ocean typically run 1° to 3°C (5° to 10° F) cooler than temperatures on the coast.

Most coastal storms causing erosion and other damage in the study area are northeasters. These storms can produce damaging storm waves for a duration of up to several days; they occur most frequently between December and April. Hurricanes and tropical storms also impact the study area, although less frequently. Ocean City has been hit by a number of these major storms this century, including hurricanes in 1902 and 1933, the Ash Wednesday 1962 northeaster, the Halloween 1991 northeaster, the January 4, 1992 northeaster, and the December 1992 northeaster. The winds and waves during the 1933 hurricane were estimated at 160 kilometers per hour (100 mph) and 6 meters (20 ft), respectively. The 1962 northeaster caused the greatest storm damage to Ocean City: water covered Fenwick Island for two days at depths of up to 2.4 meters (8 ft).

The Gulf Stream mainly affects weather in this area during winter. In that case, cold air coming off the continent runs into warm Gulf Stream water and can produce, at minimum, extensive cloudiness. The Gulf Stream heat can also contribute to rapid and strong intensification of storm systems, such that some powerful storms that initiate further south may more greatly impact Delmarva after pulling up the Gulf Stream heat and moisture (Grumbine, personal communication).

2.2 AIR QUALITY

The U.S. Environmental Protection Agency sets standards for air pollutants that are considered harmful to public health and the environment. Currently, standards exist for six pollutants -- ground level ozone, particulate matter, carbon monoxide, sulfur dioxide, lead and nitrogen dioxide. The Maryland Department of the Environment (MDE) monitors air quality in Maryland to ensure that USEPA air quality standards are met. Specific information presented in this subsection was obtained from MDE. Air quality in Maryland has been improving since implementation of Clean Air Act regulations in the 1970s, however Maryland still has a significant ground-level ozone air pollution problem. Maryland meets the other five federal ambient air quality standards and is considered to be in attainment with respect to them. Ground-level ozone concentrations in Worcester County are impacted by movement of air masses into the area from regions to the northwest (Washington, D.C., Baltimore, and the Ohio Valley) where large quantities of this and other air pollutants are produced. Consequently MDE classifies Worcester County as an ozone transport region. However, ground-level ozone concentrations in Worcester County do meet USEPA standards for this pollutant, and consequently the county is considered to be in attainment with USEPA ground-level ozone requirements.

Worcester County lacks large stationary sources of air pollutants. Instead, on and off-road mobile sources and small stationary sources of air pollutants are major sources of air pollutants originating in Worcester County. Mobile sources in the county include motor vehicles and boats; small stationary sources include dry cleaners and gasoline stations.

2.3 WATER QUALITY

No significant water quality problems have been reported from the study area's ocean waters. The State of Maryland has designated all of its coastal waters (i.e., to the 3-mile limit) as Use II, shellfish harvesting waters. No water quality impacts that would threaten this designation have been reported. However, there is an area off 64th Street in Ocean City where shellfish harvesting is prohibited as a precautionary measure due to the discharge of the city's wastewater treatment plant. The restricted area encompasses the oceanside waters between 55th Street and 73rd Street, and extends offshore for 1.5 miles.

2.4 HABITATS

Habitats are the places where plants and animals live, where they feed, find shelter, and reproduce. The character of these places is determined by the physical environment (Sections 2.1 and 2.3) as well as the structure of any non-mobile living creatures that occur at that place.

The surface of the ocean serves as habitat for floating marine creatures, as well as for birds that rest upon the surface. The ocean's waters constitute habitat for a great diversity of floating and swimming organisms. The Atlantic Ocean coastal waters in the study area are designated by the National Marine Fisheries Service (NMFS) as "Essential Fish Habitat" (EFH) for 31 species of shellfish and finfish. Although utilizing the term "essential," the EFH designations are broad in nature and provide only limited means to discriminate between habitats of focused importance for these species survival versus vast areas of habitat that are occasionally used by these fish species. Additional information on this topic is contained in Annex D.

The seafloor serves as habitat for swimming and floating creatures that settle or rest upon the bottom, as well as living things that burrow into the bottom. Numerous organisms live on the seafloor that are unable to swim, but instead crawl or burrow to move. Animal and plant distributions on the seafloor are often closely associated with substrate types; water depth is also an important factor. On the seafloor in the study area, the offshore shoals, seafloor plain, and swales are the largest physical habitat features present. The seafloor up to several tens of feet below the surface also serves as a foraging ground for a number of species of seabirds that swim down from the surface. Some fish species appear to be attracted to the elevated bottom profile and edges of the shoals. The offshore shoals may serve as orientation and congregation points for a number of fish. These relationships were investigated in a study conducted for the MMS by VERSAR in 2006. As a consequence of their shallower depth and focusing of wave energies, the shoal crests are a higher energy environment than adjacent seafloor flats. Sand waves, ripples, and areas of gravel, sand, and mud of the seafloor provide smaller-scale habitat features for living things. Sand waves and ripples and seafloor deposits of sand and gravel are distributed throughout the study area. However, mud deposits are somewhat limited in area and only occur locally in swales in the seafloor plain and or between shoals.

The seafloor in the study area also contains several manmade artificial reef habitats, also known of as fish havens. These structures benefit and attract structure-oriented species. In addition to providing physical structure for fish, artificial reef materials serve as surfaces for a variety of fouling and encrusting invertebrate organisms to attach to, such as corals. Materials used to construct artificial reefs include natural and manmade materials such as marine vessels, rock rubble, and concrete debris. MMS compiled information on artificial reefs along the Mid-Atlantic in their 1999 report. Four artificial reefs have been established in Atlantic Ocean waters of the study area: offshore of 33rd Street (Purnell's Reef), and on three offshore shoals: Little Gull Bank, Great Gull Bank, and Bass Grounds (Shoal B).

The surf zone and beach constitute highly dynamic habitat. Strong wave energies and currents coupled with a constantly shifting sand substrate limit what organisms can occur there. Although the beaches of Ocean City are maintained by man, because of the high energy of the environment, essentially natural conditions prevail within the surf zone, and organisms of the surf zone are generally no different than of natural beaches.

2.5 LIVING THINGS

The plants and animals of the study area ocean waters lie within the Virginian biogeographical province, which extends from Cape Hatteras, N.C., to Cape Cod, Mass. Marine living things of this region are widely distributed within this region, but are distinct in diversity and distribution from biogeographical provinces to the north (Acadia) and south (Carolinian).

2.5.1 Plants

2.5.1.1 Phytoplankton

Plankton are small floating plants. Nutrients supplied from coastal runoff and vertical mixing in the water column support a relatively high abundance of phytoplankton out to about 20 m depth in the ocean. Peaks in phytoplankton populations vary annually, with peak abundances occurring in spring and late summer to late fall.

2.5.1.2 Submerged Aquatic Vegetation and Wetlands

Submerged aquatic vegetation (SAV) consists of vascular plants and macroalgae that are rooted and attached (respectively) to the bottom in shallow water. SAV is absent from the coastal ocean waters because the substrate is too dynamic and because water clarity in the nutrient rich coastal ocean waters promote phytoplankton growth in concentrations limiting to SAV growth.

According to USACE, Natural Resources Conservation Service (NRCS), and U.S. Environmental Protection Agency (USEPA) definitions, wetlands are areas that are frequently saturated or inundated long enough to promote low oxygen conditions in the soil and that support the growth of plants adapted to these conditions. Salt marsh is the common wetland of intertidal waters along protected areas of the Atlantic Coast. Salt marsh is absent from the ocean shoreline of the study area because wave energies are too strong to permit salt marsh plants to survive. The USFWS, however, also includes lands incapable of supporting plant growth as wetlands, and accordingly maps the beaches of the study area as marine open water and marine beach bar wetlands. The beaches of the study area will not be considered as wetlands though in this report, consistent with use of the term wetlands by USACE, NRCS, and USEPA.

2.5.1.3 Upland Vegetation

No upland vegetation grows from the shoreline seaward.

2.5.2 Animals

2.5.2.1 Zooplankton

Zooplankton are small floating or weakly swimming animals. Zooplankton and phytoplankton are of particular importance in marine ecosystems. Zooplankton include those species that spend their entire lives as plankton (holoplankton) as well as the eggs and larvae of many fish and invertebrates (meroplankton). Holoplankton abundance is highest in late spring, summer, and fall. Meroplankton are most numerous during late spring and summer.

2.5.2.2 Invertebrates

Invertebrates are animals without backbones. Benthic invertebrates dwell on the bottom. Benthic invertebrates range from sessile (fixed position) organisms such as barnacles, to weakly mobile organisms such as mollusks, to highly mobile crustaceans. Benthic invertebrates include animals that live in the substrate, such as worms and clams, as well as animals that live on the surface of the seafloor, such as crabs. Benthic invertebrates in marine environments are an important food source for many fish species. Invertebrates also include organisms that swim freely in the water column and that don't typically occur on the bottom known of as pelagic invertebrates.

The USFWS conducted a review of previous studies investigating benthic invertebrates of the study area for the OCWR Study in 1998 and prepared two Planning Aid Reports documenting these findings that were included in the OCWR Feasibility Report and EIS. MMS conducted a review of information on invertebrates occurring along the U.S. Coast, including study area waters, in 2000. The Virginia Institute of Marine Science (VIMS), under contract to MMS, conducted biological sampling of shoals and adjacent seafloor areas along the Maryland/Delaware border, including Weaver and Isle of Wight Shoals in 1998 and 1999. VERSAR, under contract to MMS, conducted comparative seasonal sampling of pelagic and mobile epibenthic invertebrates of four offshore shoals and adjacent seafloor flats from fall 2002 to summer 2004. VERSAR studied Shoal B, Shoal D, Fenwick Shoal, and Weaver Shoal in this effort.

<u>Offshore</u>

The USFWS review found that studies conducted up until that time determined that offshore shoals tend to possess lower numbers of benthic organisms, species, and biomass in relatively shallow areas (5.8 to 7.6 m) (19 to 25 feet) than in adjacent deeper intershoal areas (7.0 to 9.4 m) (23 to 31 feet). Swales adjacent to the shoals typically contain higher macroinvertebrate abundance, species richness, and biomass than do shoal ridges or flanks. The richer benthic fauna in the swales correlates with the presence of finer sediments and higher organic carbon content. The most common species of the offshore shoals in terms of frequency of occurrence are haustorid amphipods, isopods, bivalves, and polychaete worms. Benthic megafaunal species occurring on the offshore shoals and adjacent seafloor include lobed moon snails (*Polinices duplicatus*), whelks (*Busycon* spp.), starfish, and various crabs and shrimp.

The results of VIMS' studies were consistent with the findings of the studies reviewed by the USFWS in 1998. Generally, the deeper regions surrounding the shoals off the Maryland/Delaware coast appeared to be more biologically active and productive than the shoals. However, filter-feeding surface-dwelling benthos and sand dollars (*Echinarachnius parma*) were more prevalent on the shoals. Portions of shoals containing interbedded sands and muds appear to contain diverse and numerous surface-dwelling benthos and benthos that live in the sediment. Sandy portions of the shoals appeared to be preferred by moon shell (*Polinices* spp.) and sand dollar.

VERSAR collected 17 taxa of invertebrates. These taxa include identifiable species as well as some organisms that could not be identified to species, but could only be identified to more general taxonomic classification categories. VERSAR determined that highly abundant benthic invertebrates of the study area seafloor and shoals included right-handed hermit crab (Paguridae family), starfish (subclass Asteroidea), lady crab (*Ovalipes spp*), and portly spider crab (*Libinia emarginata*). Many taxa of mobile invertebrates occurred commonly between the shoals and seafloor sites. Among the mobile benthic invertebrates VERSAR sampled that didn't occur on both shoals and seafloor flats, blue crab (*Callinectes sapidus*) were found only on the shoal sites and common octopus (*Octopus vulgaris*) and sea slugs (Order Nudibranchia) only on the seafloor flats. However, since these taxa were infrequently sampled it is unclear whether their presence/absence reflects habitat preferences or chance. Squid (Class Cephalopoda) were the only pelagic invertebrate collected, but occurred throughout the study area in high abundance in all seasons but winter. Two species were most commonly identified in studies conducted by the MMS: shortfin squid (*Illex illecebrosus*) and longfin inshore squid (*Loligo pealei*).

Nearshore and Surf Zone

The USFWS in their review determined that mollusc species likely to be found in the subtidal zone of the outer beach include whelks and surf clam. Crabs likely to be found in the subtidal zone of the outer beach include lady crab (*Ovalipes ocellatus*) and horseshoe crab.

Nearshore benthic communities are dominated by crustaceans such as mole crab (*Emerita talpoida*) and bay possum shrimp (*Neomysis americana*). Mole crab is also common in the intertidal zone. Common species of the upper beach include ghost crab (*Ocypode albicans*) and beach fleas (*Talorchestria* spp.)

Inlet

The USFWS in their review determined that benthic organism density, biomass, and species number are generally low in the vicinity of the inlet. The relatively low benthos development in the vicinity of the inlet appears to be due to the presence of a shifting sand bottom substrate associated with high current velocity conditions. In contrast, stable attachment substrate such as rocks, pilings, and other submerged structures are extensively colonized by fouling organisms.

2.5.2.3 Finfish

Finfish support commercial and recreational fisheries, and many of these species are important top to mid-level carnivores. Information on fisheries is provided in Section 2.6.12. The USFWS conducted a review of previous studies investigating finfish of the study area for the OCWR Study in 1998. MMS conducted a review of existing information on finfish along the U.S. Coast, including study area waters, and issued a report summarizing this work in 2000. VIMS, under contract to MMS, completed a literature review in 2000 of finfish occurring along the Maryland/Delaware border with a focus on those species reproducing in the area and ichthyoplankton. MMS also funded VIMS and VERSAR, Inc., to conduct field-sampling efforts. In June 1998, VIMS conducted video sled transects of Fenwick and Weaver Shoals, identifying seabed habitat features and fish. In May 1999, VIMS collected juvenile finfish from two sites on sand-bottom sites on Fenwick Shoal and two sites dominated by worm tubes in an adjacent seafloor flat to the southeast between Fenwick and Weaver Shoals. At each site, four beam trawls were collected in the day, and four at night. A report summarizing the findings of VIMS field sampling was issued by MMS in 2000. The results of the VIMS sampling were also subsequently released in a paper by Diaz and others (2003) published in the journal Estuaries. VERSAR conducted two years worth of intensive seasonal sampling of finfish at Shoal B, Shoal D, Fenwick Shoal, and Weaver Shoal and adjacent seafloor flats from fall 2002 to summer 2004. This study included results of daytime net sampling and a nighttime bioacoustic survey. The findings of the VERSAR effort were issued in a report by MMS in 2006. The VIMS and VERSAR studies are the first in the region that specifically investigated finfish abundance and species composition at the offshore shoals. NMFS monitors fishery catch of numerous finfish species that support fisheries on the Continental Shelf, as well as finfish unintentionally caught in these fisheries. Among these latter efforts, investigations of Atlantic sturgeon (*Acipenser oxyrhynchus*) are of interest to this study since this species is likely to be Federally-listed as threatened or endangered in the future. The Atlantic States Marine Fisheries Commission has compiled information on occurrence of many fish species in ocean waters, including Atlantic sturgeon.

<u>Offshore</u>

The USFWS and VIMS reviews found a wide variety of finfish present in the ocean waters of the study area, but most of the fishes in the coastal area are seasonal migrants. Low abundance occurs in winter, as most species leave the area for warmer waters offshore and southward. Spring brings a progressive influx of species that reach a peak in the fall. Warm waters of the Gulf Stream provide a pathway for more southerly species to reach the vicinity of the study area during summer and fall months. Spawning often takes place over relatively wide geographical areas. The production of pelagic eggs and larvae by most species further enhances the dispersal of the reproductive effort. As a consequence, the larvae of many species may occur in the vicinity of the borrow sites at different times of the year, but no species appears to concentrate a significant part of its spawning effort here.

The VIMS sampling of juvenile fish in 1998 and 1999 found 25 taxa. Sand lance (also known as sand eels) (*Ammodytes* spp.), smallmouth flounder (*Etropus microstomus*), spotted hake (*Urophycis regia*), northern sea robin (*Prionotus carolinus*), and clearnose skate (*Raja eglanteria*) tended to be the most abundant species. Sand lance occurred only on dynamic coarser sands near the top of the shoals. Worm tube habitats off the shoals had about twice as many fish relative to the bare sand habitats on the shoals during the day, but at night the pattern reversed with more fish present on the bare sand shoal habitats.

VERSAR collected 57 taxa of finfish using a combination of small otter trawls, large commercial trawls, and gill net sets. Spotted hake, scup (*Stenotomus chrysops*), and winter skate (*Raja ocellata*) were the finfish collected in greatest numbers over their study period, while windowpane flounder (*Scophthalmus aquosus*) and winter skate were highly prevalent species, being collected at nearly every site throughout the entire year. Finfish abundance and species diversity were generally higher at the seafloor flats than on the shoals. Windowpane, butterfish (*Peprilus triacanthus*), and spotted hake were caught throughout seasonal samples in higher numbers over the seafloor flats than over the shoals. Other finfish species showed seasonal patterns of distribution. Scup in fall, winter skate in winter, and northern sea robin in summer are examples of common species that were captured in daytime netting more frequently on seafloor flats than on the shoals. Sand lance were netted more frequently on the shoals. Netted finfish of the shoals and seafloor flats differed most greatly in species composition in fall and winter, and were far more similar in spring and summer. Nineteen species of finfish were collected only on either shoals or seafloor flat sites but not both. However, 18 of these species were infrequently collected and it is unclear whether their presence/absence resulted from habitat preference or chance. Among these, only bay anchovy (*Anchoa mitchilli*) was commonly captured; it was collected only at seafloor-flat sites. Nighttime bioacoustic surveys conducted during spring, summer, and fall found that finfish concentrated on two of the four shoals they studied that had greatest relief (Fenwick and Weaver Shoals), indicating that finfish migrate back and forth between the shoals and seafloor flats during the course of the day. Data was not collected to adequately determine which finfish species are making preferential use of these two shoals at night. Additional summary data from the VERSAR studies are presented in Annex B1.

According to the Atlantic States Marine Fisheries Commission, little is known about Atlantic sturgeon in the ocean. Juvenile Atlantic sturgeon appear to migrate northward in coastal ocean waters off the Delmarva Peninsula in late winter/early spring, and then return southward in the fall. Juveniles and adults have been caught in ocean waters ranging from 25 ft (7 m) to 140 ft (43 m) depth, with the greatest recorded depth being 250 ft (75 m). It is an opportunistic bottom-feeding species that has been captured over sand, gravel, silt and clay. Recent NMFS studies indicate that substantial numbers of Atlantic sturgeon are unintentionally caught as fishing bycatch and killed.

<u>Nearshore</u>

Finfish of the nearshore must be able to tolerate the currents and turbidity associated with the surf. Bony fish likely to be found in the nearshore of Assateague Island include weakfish, bluefish (*Pomatomus saltatrix*), striped bass (*Morone saxatilis*), northern puffer (*Sphaeroides maculatus*), porcupine fish (*Diodon hystrix*), striped burrfish (*Chilomycterus schoepfi*), and common trunkfish (*Lactophrys trigonis*). Cartilaginous fishes likely to be found in nearshore include spiny dogfish (*Squalus acanthias*), little skate (*Raja erinancea*), barndoor skate (*Raja laevis*), and bluntnose stingray (*Dasyatis sayi*).

2.5.2.4 Wildlife

Wildlife of coastal ocean waters include a variety of sea turtles, birds, and marine mammals. All of the sea turtles and marine mammals occurring in the study area migrate with the seasons, as do the majority of the birds. Wildlife species associated with warm water conditions are present in warm weather months whereas those associated with cold water conditions occur in the area in winter. No amphibians occur in Maryland coastal ocean waters. All the sea turtles of the ocean waters of the study area are either threatened or endangered species. Several of the marine mammal species that may occur in the study area are also rare species. Information on rare species is provided in Section 2.5.2.5.

A number of bird species may be found feeding and/or resting in the waters in the vicinity of the offshore shoals. These include shorebirds such as gulls and terns; waterfowl such as scoters and Oldsquaw; loons; as well as more open ocean species such as Gannet, Black-legged Kittiwake, storm petrel, and shearwater. Research being conducted by Dr. Doug Forsell of the USFWS (Annex C) indicates that seabirds may forage preferentially on shoal crests or edges in situations where mollusks within the shoals are closer to the surface or mobile prey are concentrated by currents, respectively. Seabirds can dive tens of feet into the ocean while foraging; food in shallower water depths though is more economically accessed for the birds.

Several species of marine mammals may occur in the vicinity of the offshore shoals, although the bottlenose dolphin (*Tursiops truncatus*) is the only common one. Several other species of dolphin, porpoise, seal, and whale are infrequent visitors to the area.

2.5.3 Rare, Threatened, and Endangered Species

The coastal Atlantic Ocean waters off Fenwick Island are not noted for the regular presence of rare animal species; however, transient and migrant whales and sea turtles are encountered in the waters of the study area (Table 2-9). All the sea turtles occurring in study area waters are Federally-listed as threatened or endangered. In contrast, both common and rare marine mammals occur in the study area. Common marine mammals are discussed in Section 2.5.2.4. Sea turtles only infrequently nest on ocean beaches north of the mouth of the Chesapeake Bay, and thus don't normally nest on Fenwick Island. Loggerhead turtles are rare nesters on southern Assateague, but are not known to have recently nested on Fenwick Island. Detailed information on threatened and endangered sea turtle and whale species of the study area is presented in NMFS' Biological Opinion contained in Annex C3.

Table 2-9: Rare species in coastal ocean waters off Ocean City.

	Common Name	***Scientific Name***	**Federal Status**	**State Status**	**Occurrence**
Sea Turtles	Kemp's Ridley	*Lepidochelys kempii*	Endangered	Endangered	Transient
	Leatherback	*Dermochelys coriacea*	Endangered	Endangered	Transient
	Green Turtle	*Chelonia mydas*	Threatened	Threatened	Transient
	Atlantic Loggerhead	*Caretta caretta*	Threatened	Threatened	Transient, rare nester on Assateague Island
Marine Mammals	Fin Whale	*Balaenoptera physalus*	Endangered	Endangered	Transient
	Humpback Whale	*Megaptera novaeangliae*	Endangered	Endangered	Transient
	Right Whale	*Eubalaena glacialis*	Endangered	Endangered	Transient

2.6 HUMAN ENVIRONMENT / COMMUNITY SETTING

2.6.1 History and Cultural Resources

Sea level in the study area has been rising for the last 17,000 years when sea-level was almost 450 feet lower than at present, according to data compiled by Dr. David Krantz, and the shoreline was many miles seaward of its location today. According to review information compiled by the MMS, paleoindian hunter-gatherers colonized the Mid-Atlantic region about 12,000 years ago. Beginning about 9,500 years ago, Indian populations grew larger and settlements more permanent. At about 3,000 years ago Indians began to use ceramics and developed agriculture, and social interactions became increasingly complex. Large villages appeared by about 900 A.D. and persisted until European contact. Indian sites now inundated on the Continental Shelf have been subjected to erosion and redeposition in accompaniment with rising sea level and shoreline erosion. Although Indian artifacts from times of lower sea level are recovered from the seafloor, it is believed that the context within which these artifacts were deposited have been destroyed by natural processes in the vast majority of cases.

According to information compiled for the 1998 OCWR Study, Worcester County has been continuously occupied since the earliest prehistoric period (Paleolithic to the present). Prehistoric resources have been found most commonly at the well-drained soils inland from the bays, although extraction of marine resources from the bays can be documented throughout prehistory. During the historic period, the well-drained soils away from the bays attracted farmers, but the bays continued to provide fishing opportunities for the population. According to Ocean City Convention and Visitors Bureau and Department of Tourism, prior to the 1860s, Fenwick Island was a barren uninhabited barrier island. Ocean City was developed beginning in the 1860s and 1870s first as a haven for recreational fishermen, and later as a family seaside resort. It was incorporated by the State of Maryland in 1875.

Several shipwrecks (purposeful sinkings for artificial reef construction were covered in Section 2.4) are mapped to occur in study area waters on National Oceanic and Atmospheric Administration nautical charts (Figure 1-2). Shipwrecks date from European settlement onward, with the most recent shipwrecks having occurred during World War II in association with German U-Boat activities, including one located in the vicinity of Fenwick Shoal. Investigations of the potential for submerged cultural resources to be found on offshore shoals of the study area were conducted in association with MGS investigations of the area in 1993. Results from these investigations were published in 1994. The survey indicated that two known wrecks and two additional sites potentially possessing historical cultural resources occurred in these waters. They noted that further investigation would be needed to determine the historical cultural significance of these

2.6.2 Population

According to the Maryland Office of Planning, the year-round population of Ocean City was 7,200 in 2000. Retirees comprise a significantly larger percentage of Worcester County's population base than that of the state as a whole. In Ocean City itself, more than 25 percent of residents are over the age of 65 which ranks 4^{th} in the State of Maryland. According to the Town of Ocean City Comprehensive Plan, during the peak days of the summer tourism season, the population of Ocean City swells to about 340,000.

2.6.3 Economics

A destination resort, Ocean City is nationally recognized as a clean, safe, and successful community for its residents, vacation homeowners and visitors with tourism as the basis of its economy. The tourism industry can be broken down into three classifications: 1) hotels, motels, and condominium rentals 2) restaurants and nightclubs and 3) retail shops and malls. According to the Town of Ocean City Comprehensive Plan, peak tourist visitation occurs in summer months. Fall and spring weekends also draw substantial numbers of visitors. Visitation on winter weekends is typically about 1/3 of summer visitor numbers. Ocean City attracts vacationers from Maryland, Pennsylvania, Delaware, the District of Columbia and parts of Virginia. Tourist spending spurs the economic sectors of retail sales, food and beverage sales, lodging, real estate development and related services.

According to the Maryland Department of Planning, the median household income for Ocean City in 2000 was $35,800 compared to $40,650 for Worcester County and $52,900 for the State of Maryland. The poverty rate for Ocean City residents in 2000 was 8.4 percent compared to 9.6 percent for Worcester County and 8.5 percent for the State of Maryland.

According to the Town of Ocean City, assessed property values were $3.8 billion dollars in fiscal year 2002. Property taxes comprised about 4 percent of tax revenues for fiscal year 2002. The Town Council approved budget for fiscal year 2003 is $46.5 million.

2.6.4 Transportation

Three major U.S. highways serve the county: U.S. Routes 13, 50, and 113. U.S. Routes 13 and 113 allow travel between Worcester County and Wilmington, Delaware and Norfolk, Virginia. U.S. Route 50 provides east/west access to Baltimore and Washington, D.C. All three highways have been substantially upgraded recently, in some cases to interstate levels.

Worcester County is served by both the Salisbury-Wicomico County and Ocean City airports. Salisbury has regularly scheduled flights to Philadelphia, Baltimore and Washington, D.C. with connections to all major cities, and Ocean City serves the general aviation market.

No passenger rail service is available in the study area. However, a Conrail mainline and two short lines, MD & DE Railroad and the Eastern Shore Railroad, provide freight service to the area. Inter-city bus service is supplied by Carolina Trailways; within the county bus service is provided by Worcester County Ride. Within the Town of Ocean City, a bus line serves passengers virtually around the clock during the peak tourist season.

2.6.5 Navigation

A Federal channel extends from waters of the Atlantic Ocean through the Ocean City Inlet into the coastal bays. Information on this waterway is provided in Section 1.5.

The boating industry is vital to the Ocean City region. Many commercial vessels dock at the Ocean City harbor, whereas recreational and charter vessels dock at numerous marinas throughout the coastal bays. Most of the major commercial navigation facilities are located near the inlet.

2.6.6 Infrastructure

A sanitary sewer outfall pipe extends roughly 4,000 feet out into the ocean perpendicularly from Ocean City. The last 1,000 linear feet of the pipe has vertical diffusers off the top spaced at 20 foot intervals. The top of the diffuser is approximately 3 feet above the pipe. The pipe lays on the ocean floor, covered with a stone and concrete mat. There are no fiber-optic cables or oil or gas pipelines in the surf zone or seafloor off Ocean City.

2.6.7 Land Use

Virtually all Ocean City beachfront land has been commercially developed and includes hotels, motels, boarding houses, boardwalk, amusement centers, restaurants, and shopping centers. The ocean beach is used for recreational purposes. No other single material resource has had as much effect on the growth and development of Ocean City. Use of the waters of the Atlantic Ocean in the study area is described under navigation (Section 2.6.5) and fishing (Section 2.6.12).

2.6.8 Public Health and Safety

The Ocean City beach patrol works to protect swimmers using the beach. Recently, concern has arisen over whether induced changes in beach slope and wave energy in the surf zone accompanying placement of coarser-grained sands may be increasing risk of physical injury to bathers. No comprehensive study has been conducted yet to evaluate this topic, however (Annex C).

As one of its missions, the Coast Guard works to eliminate deaths, injuries, and property damage associated with maritime transportation, fishing, and recreational boating. DNR police perform boating law enforcement duties in state waters and ensure that anyone born on or after July 1, 1972, possess a certificate of boating safety education in order to operate any motorized vessel..

2.6.9 Visual and Aesthetic Values

The aesthetic features of the beach and seaside resort amusement amenities of the town attract people to the area. This lively human environment contrasts markedly with the vast openness of the adjacent Atlantic Ocean.

2.6.10 Noise

The Ocean City beach is typically fairly noisy during tourist season daylight and early evening hours. Autos, amusements, boardwalk activities, summer beach-goers, and boat noise all contribute to ambient noise. In contrast, the ocean is fairly silent except for the noises of wind, waves, and occasional passing boats.

2.6.11 Recreation (Other than Fishing)

Ocean City has a robust recreation-based tourism industry. Water-based recreational opportunities include swimming, saltwater fishing, crabbing, power-boating, sailboarding, parasailing, jetskiing, surfing, and water skiing. Land-based recreational activities include wildlife viewing and photography, golf, and sun bathing. Most of these activities are supported by privately owned service and recreational facilities in the area.

2.6.12 Fishing: Commercial and Recreational

From a dietary and fishing perspective, edible sea creatures are traditionally divided into two groups: shellfish and finfish. Shellfish are those species of invertebrates that have hard outer shells, and include mollusks, such as clams, and crustaceans, such as crabs. Finfish are vertebrates, and include both bony fish and cartilaginous fish that lack a bony skeleton, such as sharks. Study area waters contain commercial and recreationally-fished shellfish and finfish. Important fishing grounds for any particular species are typically sites of ecological importance for that species also, since many individuals of a given species have to be concentrated in an area to make fishing worthwhile. Ecological concerns and fishing concerns have substantial overlap, but are not equivalent. Ecological concerns typically focus on the well-being of a species population within a greater ecosystem health context, whereas fishing concerns typically focus on maintaining sufficient population numbers of a species to support fishing. Commercial fishermen fish for a living, whereas recreational fishermen fish for sport. Substantial recreational fishing activity in study area waters concentrates on artificial reefs created to support structure-oriented fish species.

Offshore

The USFWS compiled information on fishing activity in study area waters for the OCWR Study in 1998. Important commercial invertebrate species include surf clam (*Spisula solidissima*) and whelks, which are called conch by commercial fishermen. Horseshoe crab (*Limulus polyphemus*) were formerly caught in great abundance on the study area seafloor in May and June, prior to implementation of recent restrictions designed to protect this species.

There is substantial commercial fishing activity in the waters of the Atlantic Ocean. Fish species caught by commercial vessels working off Maryland's Atlantic coast include clearnose skate *(Raja eglanteria),* smooth dogfish *(Mustelus canis),* black sea bass *(Centropristis striata*), weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), windowpane flounder, butterfish, northern kingfish (*Menticirrhus saxatilis*), Atlantic croaker *(Micropogonias undulatus),* and striped searobin (*Prionotus evolans*).

The USFWS investigated commercial fishing activity in the vicinity of Shoal A, Shoal B, Isle of Wight Shoal, and Weaver Shoal in July 2004 for this study (Annex C.) Shoals in general were viewed to have good potential as fishing grounds for surf clam. However, none of these four shoals was being fished by surf clammers surveyed at that time. Harvesting occurred in the vicinity of Shoal B until the late 1990s. Most surf clamming currently takes place offshore in water depths of 12 to 25 fathoms (72 to 150 ft) further seaward of the study area. Prior to the early 1970s, Isle of Wight and Weaver Shoals probably had commercially-harvestable populations of surf clam. Commercial fish trawlers contacted reported trawling Isle of Wight and Weaver Shoals, with some limited trawling of Shoal B. All four shoals are fished for whelk by pot fishermen who fish for sea bass and conch (whelk). The artificial reef area of Shoal B however, is the only pot fishing ground for sea bass.

The offshore shoals are called ridges and offshore lumps by Mid-Atlantic recreational fishermen. Shoal B is commonly called the "bass grounds" among fishermen. Substantial recreational fishing also takes place in the vicinity of the shoals and fish havens. Popular saltwater fishermen's publications and websites (such as www.usfishing.net) note that the ridges and offshore lumps are concentrated areas for recreational fishing for a variety of species at different times of year. Summer flounder (fluke) and weakfish are fished offshore on bathymetric highs, with summer flounder being fished later in the recreational fishing season (which runs from April through October) on bathymetric highs at about 60 feet (10 fathoms) and weakfish occurring in schools at times of year on bathymetric highs at less than 10 fathoms. Striped bass are taken by recreational fishermen on lumps and ridges within the 10 fathom line in spring and fall. (At this time [April 2004] federal regulations prohibit the fishing for Striped Bass in Federal waters beyond 3 miles). Bluefish are caught on Fenwick Shoal in December. Sea bass, trout, flounder and croaker are caught in September and October along the shoals and artificial reef sites.

The USFWS investigated recreational fishing activity in the vicinity of Shoal A, Shoal B, Isle of Wight Shoal, and Weaver Shoal in July 2004 for this study (Annex C3). The USFWS survey found that the artificial reef at Shoal B is a very popular recreational fishing ground, while the other three shoals receive comparatively little use by recreational fishermen.

According to the Recreational Fishing Alliance, Fenwick Island Shoal previously supported a recreational fishery of 30 to 40 boats per day during the 1950s and early 1960s. These party and charter boats fished there from late April until early July. The fishery that the shoal supported collapsed in the early 1970s following intensive harvest operations by the surf clamming fleet in the area in the 1960s and early 1970s. According to Captain Monty Hawkins, the destruction of live bottom habitat by surf clammers was likely a causal factor in the decline of bottom fisheries, such as for scup, black sea bass, and even cod.

Nearshore Waters

Maryland state regulations prohibit commercial surf clam harvesting within the 3 mile limit, and finfish trawling within one mile of shore. Thus the waters of the state within these limits have no commercial fishery for surf clam or finfish.

Recreational fishing is common in the inlet area, particularly along the jetties. The ebb shoal is not an important recreational finfish area, in part because of dangerous navigation conditions, but also because the strong waves and currents would limit what fish occur there to be essentially equivalent to those of the surf zone as opposed to the deeper waters of the inlet or somewhat calmer offshore conditions. There is recreational clamming activity on the ebb shoal; people access the area by boat (Jim Casey, personal communication)

People fish the surf of the beach for striped bass, bluefish, and speckled trout. Inside the Ocean City Inlet fishermen catch striped bass.

2.6.13 Parks

A number of parks, recreational areas, and wildlife management areas are located in close proximity to the study area. The northernmost 3 miles of Fenwick Island (actually a spit as discussed in Section 2.1.1) in Delaware from its attachment point to the mainland is contained in Fenwick Island State Park. Assateague Island immediately south of the Ocean City Inlet is contained within Assateague Island National Seashore, managed as open space under the administration of the National Park Service. A portion of Assateague Island within Maryland is owned by the state and managed as Assateague State Park. The portion of Assateague Island within Virginia is contained within Chincoteague National Wildlife Refuge and is managed by the USFWS. These areas provide outdoor recreational and educational opportunities as well as wildlife habitat.

There are no parks or Wild and Scenic Rivers in the study area ocean waters.

2.6.14 Hazardous, Toxic, and Radioactive Waste (HTRW); Formerly-Used Defense Sites (FUDS); and Munitions and Explosives of Concern (MEC)

The Ocean City beach has been routinely nourished by USACE and state of Maryland since the late 1980s and is an intensely used recreational area. Consequently, given the active status of the beach as a project site and intense public use, no HTRW materials are believed to be present. The region is lacking industries that typically produce substantial hazardous, toxic, or radioactive contamination. Thus, the study area lacks sites that would be regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). No RCRA or CERCLA sites were found in a records search for the project area conducted during the Ocean City Water Resources Study. It is believed that the offshore shoals of interest to the study also lack HTRW materials, given the lack of sources of HTRW materials from within the study area, their distance offshore, and preponderance of coarse-grained sands to which contaminants do not typically bind. Consequently, it is unlikely that HTRW materials would have been deposited on the offshore shoals of interest to this study. USACE has determined that no further HTRW investigations are needed.

FUDS include a variety of former military installations and areas impacted by military activities. MEC consists of any munitions, weapon delivery system, or ordnance items that may contain explosives, propellants, and/or chemical agents and that are armed or remain unexploded. All MEC present a potential hazard and can appear intact, in parts or in fragments. MEC presents an immediate risk of acute physical injury from fire or explosion resulting from accidental or unintentional detonation.

MEC are frequently associated with FUDS. FUDS are located on both the Delaware and Maryland ocean coastlines. Firing ranges were located along the Delaware coast from what is now Fenwick Island State Park to what is now Delaware Seashore State Park. Various projectiles were fired from these sites in a seaward direction from the 1920s until the early 1970's. Assateague Island contained two known rocket and bombing impact ranges. The Assateague ranges covered about 350 acres each on the land portions, and extended about 3,000 feet into the ocean.

The offshore shoals of interest to this study fall just within the range fans of satellite anti-aircraft (AA) gun emplacements located in Delaware. An archive search report (ASR) for the Delaware Target Areas was completed in October 2001. AA guns that were fired included 40 mm, 75 mm (3"), 90 mm, and 120 mm mobile gun batteries. The maximum range of each gun varied. The maximum range of the 75 mm gun was about 7 miles and the range of the 90 mm gun was about 11 miles. The range fans were defined after WWII. Prior to World War II, gun emplacements on the Delaware shore apparently fired generally offshore, but not in defined range fans.

USACE conducted investigations of potential ordnance and unexploded waste (OEW [now referred to as MEC]) at the FUDS on Assateague Island. Investigations were focused on all of Assateague Island because it was believed the island was used as a rocket and bombing impact range from 1944 through 1947 by the Army and Navy and as OEW burial trenches. Since the island has shifted since the 1940's it is expected that some or all of the trenches are now underwater but no underwater investigations were undertaken. One of the burial trenches was exposed through erosion of the island in 1992. Army and Navy EOD units responded and cleared out all the exposed buried MEC. MEC has occasionally washed on Assateague and has been removed.

In addition to the known FUDS described above, it is possible that other unknown munitions dumpsites occur in the seafloor study area. Based on the known military activity and possibility of unknown MEC, the seafloor in the region of the offshore shoals is presumed to have a moderate probability of containing MEC.

2.7 FUTURE WITHOUT PROJECT CONDITIONS

The without-project condition is assumed to be the situation that would result if new borrow sources aren't identified and a borrow plan isn't developed that is more sensitive to maintenance of seafloor habitat than was the case in the past. Without continuation of the Federal project, it is anticipated that the state of Maryland and Ocean City would fund future beach nourishment work because of the great economic importance of Ocean City to the region, although at a lesser scale and lower level of protection than is currently accomplished with Federal involvement. This scenario was also forecast as the without-project condition of the 1989 GDM. Absent involvement of the public sector in comprehensive beach nourishment, private interests would likely fund measures to protect individual structures and properties. Because it is disadvantageous to individuals to undertake the great expense of beach nourishment that provides benefits to many in common, these measures would likely be local and by necessity structural in nature. These solutions would induce loss of the recreational beach, ultimately damaging the feature that is the economic base of Ocean City. However, because the project has a 50-year project life, it is assumed that the Federal government will continue beach nourishment out to the year 2044.

2.7.1 Ocean City (Fenwick Island)

The beaches of Fenwick Island in their current condition are an engineered system. Ocean City is dependent on regular beach nourishment to maintain storm protection functions of the constructed beach, and to maintain the quality of the recreational beach which is key to the City’s economy. In absence of regular beach nourishment, conditions on the island would revert to pre-beach nourishment conditions when the shoreline was eroding at an average rate of 1 to 2 ft/yr (USACE, 1998). If new borrow sources aren't identified proactively in a manner that facilitates optimal selection of engineeringly-suitable sand and development of cost-control measures, it is anticipated that other sources of sand would be more hurriedly selected at critical points in time. This decision-making environment would not promote engineering nor cost optimization measures. Accordingly, it is anticipated that sands that were obtained would be at greater cost and lesser suitability.

2.7.2 Seafloor

Without dredging, the future -project condition of the offshore shoals would remain similar to the existing conditions. Although dynamic, the shoals are relatively stable and persistent over time. Additional fisheries enhancement structures will likely be placed, although this selection process will consider competing use of shoals as sources of sand thus minimizing chance for resource conflicts. Without developing a borrow plan that considers maintenance of shoal geomorphic integrity, it is anticipated that location of suitable sand, cost, and shoreline erosion impact considerations would drive borrow plan formulation. Sand within the closest shoals would likely be consumed to the extent that these factors are met with substantial alterations to seafloor topography of the shoals dredged.

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SECTION 3

PROBLEMS, NEEDS, AND OPPORTUNITIES

3.0 INTRODUCTION

Two problems besetting Ocean City, Maryland, were identified by the U.S. Army Corps of Engineers (USACE) in the 1980 *Atlantic Coast of Maryland and Assateague Island, Virginia Feasibility Report and Final Environmental Impact Statement* (EIS): 1) Beach erosion from natural shoreline retreat processes threatened properties and existing development; and 2) tidal flooding during storms threatened Ocean City developments and properties, as well as potentially threatening human lives and health. In response to the need to prevent economic losses and protect lives and health, USACE and the State of Maryland implemented the Atlantic Coast of Maryland Shoreline Protection Project (Section 1.0).

Since project implementation, regular beach nourishment has controlled beach erosion for much of Ocean City. Additionally, construction and maintenance of a dune at the western edge of the beach has prevented tidal flood damages. Storm damages to Ocean City prevented as of July 1998 (the last year for which an estimate has been determined) are displayed in Table 3-1.

Table 3-1: Major storm events and estimated damages prevented in that storm-year's dollars[1].

Storm Date	Damages Prevented
October 1991	$32,000,000
December 1991	No Estimate
January 1992	$52,000,000
December 1992	$71,000,000
March 1994	$29,000,000
February 1998	$46,000,000

It was necessary to prepare this SEIS in light of two issues. 1) As was recognized in the 1989 General Design Memorandum (GDM), additional sources of sand now need to be identified to allow continuance of the project through the remainder of its 50-year economic life since the sources originally identified were not adequate for the entire project life. 2) At the time the original borrow plan was developed, the public and resource agency personnel's awareness of impacts of borrow actions on the seafloor was

[1] "Damages prevented" represent an estimate of the theoretical value of damage that might have occurred had the Corps project not been in place at the time of the storm event. These values are derived from the aggregated depth-damage curves (DDC) developed for the 1989 GDM. The DDC were developed using extensive inventorying and interviewing of the entire study area during the summer tourism season.

limited, and beach nourishment projects were localized along just several areas of the U.S. Atlantic Coast. Since that time, public and agency awareness of the impacts of sand mining have increased, and the magnitude of beach nourishment work planned and underway regionally has intensified.

3.1 OCEAN CITY SAND NEEDS

From 1988 through the end of 2002, the Baltimore District and State of Maryland have periodically placed sand on the beach of Ocean City utilizing sand dredged from offshore shoals in Maryland state waters (within 3 miles of the shoreline) (Section 1.0). Over this time period, approximately 11,345,000 cubic yards of sand has been dredged for this purpose from three offshore shoals: Borrow Areas 2, 3, and 9. Borrow Areas 2 and 3 were essentially exhausted by 1992, and Borrow Area 9 is expected to be exhausted after about 2010. Ocean City beach nourishment is conducted on a 4-year cycle. The last nourishment of the Ocean City beach using offshore shoal sand was conducted in 2002. Nourishment work is planned again for 2006 and 2010, again using sand from offshore shoals in state waters. Following the 2010 nourishment work, identified sources of suitable sand in offshore shoals within state waters will likely be exhausted. Additional long-term borrow source(s) need to be identified for the project to continue through its 50-year project life until the year 2044.

Based on project performance since 1998, in which a relative state of stability in the profile has been produced, it is estimated that 800,000 cubic yards of sand applied every 4 years (average of 200,000 cubic yards per year) will be needed to maintain existing conditions at Ocean City from 2010 through the remainder of the project life. Over this 34-year period, this would equate to a total volume need of 6,800,000 cubic yards. This relative profile stability since 1998 correlates to a period of relatively low storm intensity.

If total sand applied to maintain the project after 1991 following initial sand placement projects in 1988 and 1991 which served to build the profile up from the natural condition and three severe back to back storms in October 1991, December 1991, and January 1992 is instead used as a basis to estimate future sand needs, then average annual sand needs would be approximately 440,000 cubic yards per year. This need would total approximately 15,000,000 cubic yards from 2010 through 2044. Accordingly, to allow for this possibility, it was considered appropriate to identify up to 15,000,000 cubic yards of sand to meet Ocean City's sand needs through the end of the project's economic life in 2044.

3.2 CONCERN OVER ENVIRONMENTAL AND FISHERY IMPACTS OF SEAFLOOR BORROW ACTIONS

Environmental impact concerns were integrated into formulation of the original plan for beach nourishment of Ocean City, as documented in the 1980 EIS. This led USACE to reject Isle of Wight or Assawoman Bays as sources of sand for Ocean City because of concerns over negative impacts to estuarine life that would result from the large volume of sand that would need to be dredged. In formulation of the original plan to prevent erosion and storm damage at Ocean City, USACE took a far-sighted view in selecting a plan that used beach nourishment to meet these objectives. Seawalls that could potentially have also provided storm damage or erosion protection would have caused loss of the recreational beach. Without beach nourishment, prevailing patterns of shoreline retreat cause beach located on the oceanside of seawalls to be gradually lost. Offshore breakwaters might have been able to maintain a recreational beach for some period of time, but without beach nourishment even these structures would have likely resulted in shoreline retreat up to existing structures in Ocean City, with effective loss of the recreational beach. In the 1980 EIS, the negative environmental impact of destroying the existing benthos in the borrow area was addressed, as were negative impacts from entrainment (sucking in) of aquatic organisms into the dredge, and increased turbidity. However, no consideration was given to the shoals as habitat features on the seafloor.

Today as compared to 1980, there is substantial resource agency and public concern over environmental and fishery impacts associated with dredging large volumes of sand from the seafloor for beach nourishment projects. Concerns have increased because knowledge and awareness of habitats on the Continental Shelf seafloor, and potential cumulative impacts of the increasing number of ongoing and proposed borrow actions to obtain sand, has increased.

In the mid-Atlantic, concerns focus on potential negative impacts to offshore shoals that natural processes formed over thousands of years. The offshore shoals are probably non-renewable (Section 2.1.2). As was noted in Section 2.4, at least some of the offshore shoals appear to serve as orientation features and staging grounds for migrating fish and wildlife, and certain species make greater use of the shoals and nearby vicinity than over the adjacent seafloor flats. Whether the distance offshore, size, water depth, proximity to other shoals or other factors has any bearing on the importance of individual shoals as orientation or staging features is unknown. The relative importance of the shoals in comparison to each other as habitat is unknown. The geomorphic condition of the shoals may be an important physical environmental factor governing the habitat quality of the flats and troughs between the shoals. Additionally, alterations to seafloor condition that would adversely impact marine life, such as by creating pits with stagnant seawater, and converting bottom sediment type from one to another (such as from sands to muds) are also a concern. The U.S. Department of Interior's Minerals Management Service (MMS), and other resource agencies that have authority over whether or not to permit borrow actions, are requiring increasingly thorough information on likely impacts of projects before granting permission to use new sand sources. Accordingly, a need was identified to attempt to formulate a borrow plan for Ocean City that would incorporate consideration of measures to conserve seafloor habitats.

3.3 STUDY OBJECTIVES

Consistent with the study purpose presented in Section 1.2, and based on the problems, needs, and opportunities identified above, the following study objectives were established by the study team.

1) Identify cost-effective and engineeringly-practicable means to provide sufficient sources of suitable sand to meet Ocean City's routine and emergency nourishment needs through the year 2044.

2) Develop a borrow plan to provide sand for Ocean City in a manner sensitive to fisheries and the environment.

SECTION 4

BORROW AREA SELECTION

4.0 INTRODUCTION

As was described in Section 3.1, additional sources of sand to meet Ocean City's beach nourishment needs from about 2010 through the year 2044 need to be identified. The volume need estimates range from 6,800,000 cubic yards, based on project performance since 1998, to as much as 15,000,000 cubic yards of sand based on project performance from 1991.

4.1 POTENTIAL BORROW AREAS

Sand deposits occur in a variety of features on the continental shelf (Section 2.1.1), including within buried ancient river valleys (paleochannels), on the flat seafloor plains, in shore-attached and detached shoals, and in the ebb and flood shoals of the Ocean City Inlet. The Maryland Geological Survey (MGS), Minerals Management Service (MMS), U.S. Army Corps of Engineers (USACE), and others investigated the suitability of these seafloor features in the 1970s, 1980s, and 1990s as sources of sand for beach nourishment. Sand also occurs on the bottom of the coastal bays and on the mainland.

From the seafloor investigations, it was found that the shore-detached shoals contain large quantities of sand highly suitable for beach nourishment. Many of the shoals are located in relatively shallow water within the economical and engineering limits of dredging technology. USACE investigations of the ebb shoal of the Ocean City Inlet determined that it contained sand suitable for beach nourishment. However, the sands it contained were more heterogeneous than those of the offshore shoals (see Annex E). In contrast, MGS found that the shore-attached shoals (other than the ebb shoal) typically contain fine sands and muds. Thus, the shore-attached shoals were considered unsuitable as beach fill.

MGS determined that sand on the flat plains of the seafloor off the Delmarva coast are of variable thickness often of only several feet, and are often underlain by finer-grained materials unsuitable as beachfill. Such characteristics can make sheet sands difficult to dredge. Paleochannels are limited in size, and are usually buried under a significant thickness of overlying sediment. These qualities make paleochannel deposits difficult to dredge.

Sand from the coastal bays was dredged to repair storm damage to Ocean City and Assateague Island following the March 1962 northeaster. Isle of Wight Bay was considered as a source of sand for Ocean City in the 1980 EIS, but was rejected because of concerns over negative environmental impacts to the coastal bays. In addition, sand from the coastal bays would likely be difficult to dredge without obtaining substantial quantities of fine-grained sediments that would produce a fairly high overfill and renourishment ratios. Sinepuxent Bay was rejected as a source of sand for Assateague in the 1998 OCWR Study because of public and resource agency concerns over the potential severity of negative environmental impacts to estuarine life. The same negative environmental impact and engineering concerns remain at this time, thus the coastal bays are considered unacceptable sources of sand.

Although the Coastal Plain mainland contains abundant sand resources, obtaining sand from terrestrial sources in the quality and quantity necessary to meet the needs of Ocean City would be far more expensive than taking it from the Continental Shelf. In addition, certain environmental and social impacts of this (such as air pollution created and traffic hazards, respectively) are greater than of taking the material from the seafloor. Onshore sand sources were considered in the 1980 EIS and subsequent 1989 GDM; however, they were determined to be prohibitively expensive. Based on this information, and the determination that the general conclusions of those studies are still valid today, no efforts were made to identify mainland sites to provide sand to maintain the Ocean City beach through the remainder of the project life to 2044.

4.2 IDENTIFICATION OF POTENTIAL CANDIDATE SHOALS

Proceeding seaward and to the north and south of Ocean City, the closest shoals that individually or in combination could meet the sand volume needs of Ocean City to 2044 were identified. Information on the sand and offshore location of these shoals is presented in Table 4-1; information on their geomorphic character was presented in Table 2-3, and they are depicted in Figures 2-3 and 4. These nine shoals contain a total volume of approximately 750,100,000 cubic yards of sand, 413,000,000 cubic yards of which (not including the ebb shoal) are beach quality. This volume is substantially in excess of the maximum estimate of 15,000,000 cubic yards that may be needed by Ocean City through 2044. Because it was anticipated that the volume of sand needed for Ocean City could be obtained from among these offshore shoals economically and in an environmentally acceptable manner, no efforts were made to investigate other offshore shoals farther from Ocean City.

Table 4-1: Volume of sand and distance offshore of candidate shoals.

Shoal (N to S)	Total Sand (yd3)*	"Beach Quality" Sand (yd3)*	Distance of Shoal Centroid to Beach at Ocean City (miles)		
			Md./Del. Boundary	Centroid of Ocean City	Southern End of Ocean City
Fenwick	211,000,000	126,000,000	7.0	9.7	13.5
Weaver	93,000,000	82,000,000	7.0	8.3	11.5
Isle of Wight	136,000,000	71,000,000	8.0	7.8	10.2
E	31,000,000	11,000,000	9.0	6.7	7.2
A	103,000,000	37,000,000	11.0	9.4	10.0
Ebb	14,000,000	Undetermined	9.1	4.7	0.3
Little Gull Bank	50,000,000	31,000,000	10.2	5.9	2.5
B	50,000,000	39,000,000	13.8	11.4	11.0
Great Gull Bank	63,000,000	16,000,000	13.3	9.0	5.2

*For all but ebb shoal, information is from MGS reports and personal contacts. Ebb shoal total volume is extrapolated to 2004 from USACE (1998). Ebb shoal 1989 investigations were to too great a depth and may have covered area much greater than area currently considered to be ebb shoal.

4.3 EVALUATION OF CANDIDATE SHOALS

It was then necessary to evaluate each individual shoal to determine whether any engineering, economic, or environmental factors might favor or disfavor its selection.

4.3.1 Fenwick Shoal

Fenwick Shoal was formerly considered to be an important fishing ground (Section 2.6.11), according to Captain Monty Hawkins of Ocean City. However, for reasons that are not entirely clear, the shoal no longer supports intense commercial or recreational fishing activity. Thus, Fenwick Shoal was not considered to be of substantial enough importance as a fishing ground to warrant elimination of the shoal from consideration. Placement of artificial reefs on Fenwick Shoal have been proposed, but no permits have yet been issued for this.

Fenwick Shoal was believed to have greater risk than the other shoals of having unexploded ordnance (UXO). It lies about 6 to 7 miles offshore from the formerly used defense site (FUDS) at Fenwick Island, Delaware, within the firing fan of that facility (Section 2.6.14).

Although Fenwick Shoal lies in Federal waters, if the boundary between the states of Maryland and Delaware was extended seaward, the majority of the shoal would lie north of this line. The Maryland/Delaware state boundary also defines the northern limit of the Baltimore District on the Atlantic Coast, and the southern limit of the Philadelphia District. The state and district boundaries posed no actual legal restrictions on use of the shoal by Maryland. Sand in Federal waters is not restricted to use by just the state off which it lies offshore, but is instead available on a first to request basis from MMS. However, sand resources in offshore shoals available for beach nourishment off the state of Delaware are not as abundant as those off Maryland.

Beach sand north of about the Maryland/Delaware state line is naturally transported generally northwards, while beach sand south of this line is naturally transported generally southwards (Section 2.1.2). From a regional sand management perspective the study team believed that it might prove advantageous over the long run to make use of sand from within the sand transport "cell" that transports it, rather than taking sand from adjacent outside "cells."

Due to concerns over UXOs, desire to provide for the potential future use of the site by the Philadelphia District and state of Delaware, and desire to use sand from within the sand transport cell that includes Ocean City, Fenwick Shoal was excluded from further consideration.

4.3.2 Weaver Shoal

Nothing notable about Weaver Shoal was identified at this stage that would serve to reject it from further consideration.

4.3.3 Isle of Wight

Nothing notable about Isle of Wight Shoal was identified at this stage that would serve to reject it from further consideration.

4.3.4 Shoal "E"

Previous investigations completed by MGS in 1994 determined that this was not a high quality sand deposit compared to other shoals in the area. The shoal is relatively thin in profile, with a maximum thickness of about three meters. Sediments within the shoal are irregularly distributed with respect to grain size, and limited grain-size data available indicate that the southern portion of the shoal is finer in grain size than the target size.

Consequently, although this shoal is relatively close to Ocean City (Table 4-1), it was excluded from further consideration because of the expectation that it would not contain sand of the appropriate size in sufficient quantity to warrant dredging it.

4.3.5 Shoal "A"

Nothing notable about Shoal A was identified at this stage that would serve to reject it from further consideration.

4.3.6 Ebb Shoal

The ebb shoal is considered to be of lower habitat value for marine life than the offshore shoals because of its highly dynamic conditions. There is little fishing activity focused on the ebb shoal itself, although recreational clammers do access the ebb shoal by boat to clam there (George Ruddy, USFWS, and Jim Casey, Md. DNR, personal communication).

The ebb shoal was previously considered as a source of sand for Ocean City in several USACE reports. The ebb shoal was preliminarily identified as one of three potential shoal sources in the 1980 EIS. Dredging of the ebb shoal to provide sand for Ocean City was considered in greater detail in the 1989 GDM. Dredging of the ebb shoal for Ocean City was rejected entirely in USACE (1989) because of several major concerns: 1) Potential detrimental impacts to northern Assateague Island could result from increased wave energy; 2) There was a potential for increased shoaling in the inlet vicinity because of the larger volume of sand from the ebb shoal that would have to be used to compensate for the finer grain size of its sands than of the Ocean City beach; and 3) The state of coastal engineering was considered too rudimentary to predict these impacts with any certainty. Subsequently, USACE (1998) provided for limited dredging of comparatively small amounts of sand (approximately 20,000 yd^3/yr) from the ebb shoal for Ocean City under the LTSM project. This dredging would be done in accompaniment with thorough monitoring that would allow for impacts of the project to be carefully evaluated. In the event unacceptable impacts were identified, dredging would be modified to avoid or minimize those unacceptable impacts. Under the first seven dredging events of the LTSM Project since its beginning in early 2004, approximately 31,890 cubic yards of sand were placed on Ocean City (Table 1-2).

It is necessary to again give consideration to the ebb shoal as a source of substantial volumes of sand for Ocean City since conditions have fundamentally changed from those of USACE (1989) and USACE (1998). These changes include:

1) The Short-term Restoration of Assateague project was completed in 2002 and restored a portion (1,800,000 yd^3) of the sand lost to the island since inlet stabilization. This has presumably restored a substantial measure of geologic stability to Assateague.

2) The LTSM program was implemented in 2004 and is targeted to provide northern Assateague Island 189,000 yd^3/year of sand for the next 25 years from a variety of inlet area sources. Assuming that this is successfully implemented, this can prevent future losses of sand to Assateague Island from the stabilized inlet.

3) Coastal engineering modeling and forecasting capabilities have increased substantially since 1989. These capabilities are being used currently to evaluate and plan dredging activities of the LTSM, as well as of other coastal engineering activities in the inlet vicinity.

4) Ongoing Engineering Research and Development Center (ERDC) monitoring and modeling efforts of the inlet area have greatly increased our understanding of sediment transport processes and wave energies in the area; future monitoring and modeling efforts are expected to further increase this knowledge base. The inlet is now among the best-studied in the world.

5) Oceanic shoals will be dredged for borrow; whatever is not taken from the ebb shoal will be taken from other shoals. Thus not dredging the anthropogenic, growing ebb shoal would require dredging of nonrenewable features believed to have greater habitat value for marine life.

6) The ebb shoal poses some hazard to navigation in and out of the inlet (the offshore shoals do not pose a navigation hazard).

It was unclear at this point whether or not dredging the ebb shoal would be cost-effective. The ebb shoal is closer on average to Ocean City than any of the four candidate offshore shoals (Table 4-1). This factor would serve to reduce costs. However, larger volumes of sand would have to be dredged because of the finer grain size. This would serve to increase costs. Difficulty in working in the ebb shoal's ambient shallow waters and dynamic surf/depth conditions, potentially negating ability to do dredging nourishment work with large dredges, could potentially also serve to increase costs.

4.3.7 Little Gull Bank

Little Gull Bank was considered as a potential source of sand for the short-term restoration of Assateague Island in the 1998 OCWR Study EIS. Little Gull Bank is the closest of the potential candidate offshore shoals to Ocean City for fishermen who dock on the bayside of Fenwick Island (Table 4-1). Largely as a function of its close proximity to Ocean City, this shoal is heavily used by recreational fishermen with smaller boats unwilling or unable to travel farther offshore to fish. Accordingly, in light of concerns expressed by fishermen during the 1998

OCWR Study, Little Gull Bank was rejected for dredging to provide sand for Ocean City over concerns of potential detrimental impacts to its recreational fishing value. The conclusion reached at that time was determined to be still valid, thus Little Gull Bank was rejected as a source of sand for this study.

4.3.8 Shoal "B"

Shoal B had previously been considered as a source of sand for Assateague Island in the 1998 OCWR Study. Shoal B was rejected from consideration at that time in favor of Great Gull Bank because of Shoal B's relatively great distance from shore that would render dredging less cost effective, as well as its importance as a fishing ground for surf clammers. Additionally, Shoal B has two artificial reef areas, the Bass Grounds, that are important recreational fishery areas (Section 2.6.12). Dredging in the vicinity of these could damage dredging equipment if the dredges accidentally encountered artificial reef materials.

Although the farthest offshore of the candidate shoals under consideration, the distance that would have to be traveled to obtain sand in the future for Ocean City would be greater in any case, other than for the ebb shoal, than the five mile distance traveled to Great Gull Bank from northern Assateague Island for the short-term restoration project. Thus, the rejection of Shoal B based on distance in 1998 did not apply at this time. Although the offshore reefs were recognized to be of importance as fishing grounds, it was anticipated that dredging could be conducted in such a manner as to avoid the artificial reefs. Although the shoal was previously determined to be of importance to commercial clammers, this factor was determined to warrant revisitation in light of the changing values of the shoals as fishing grounds, as was described above for Fenwick Shoal.

Shoal B was retained for consideration at this time because of the large volume of suitable sand it contains.

4.3.9 Great Gull Bank

As was described in Section 1.5, Great Gull Bank was dredged in 2001 and 2002 to obtain 2,034,000 cubic yards of sand for emergency sand placement on Assateague Island by USACE and the state. This was determined to be approximately 3 percent of the total shoal volume. Although a dredging plan had not yet been developed at this time for Ocean City's long-term sand needs, preliminary consideration of the total volume needs of Ocean City versus the volume of sand available in the candidate shoals (Table 4-1) indicated that ample sand could likely be obtained for Ocean City without removing greater than about 3 percent of the total volume of any shoal. (Note: Section 5 considers the topic of developing a dredging plan). Consistent with the dredging plan developed for the short-term restoration of Assateague Island that sought to maintain the geomorphic integrity of Great Gull Bank, it was determined to be preferable to avoid future impacts to Great Gull Bank for the foreseeable future until the state of its geomorphic integrity in response to the 2002 dredging could be determined. (MGS is currently studying this for MMS).

4.4 SELECTION OF BORROW AREAS

Based on this analysis, Fenwick Shoal, Shoal E, Little Gull Bank, and Great Gull Bank were eliminated from further consideration as sources of sand to meet Ocean City's long-term needs through 2044. The remaining offshore shoals, Weaver, Isle of Wight, A, and B, all have high potential to be able to provide beach-quality sand. The ebb shoal was determined to have some potential as a future source of sand, pending additional economic, engineering, and environmental analyses (Annex E).

As was noted in Section 2.1.4, storm wave energy from the northeast is focused along the shoal crests and diminished in the areas between the shoals. Dredging of closer shoals would thus perhaps be more likely to alter wave energies reaching the shore. However, because all the shoals being considered, other than the ebb shoal, are at least several miles offshore, and it was anticipated that dredging would not remove any shoal in its entirety and could be planned to minimize impacts to wave energies reaching the shore, this factor was not a consideration in shoal selection.

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SECTION 5

DEVELOPMENT OF A BORROW PLAN

5.0 INTRODUCTION

As was described in Section 4, four offshore shoal areas were selected for consideration as borrow sources for the project. The ebb shoal was also identified as a potential future source of increased volumes of sand for Ocean City over the 20,000 yd^3 per year currently authorized from the inlet vicinity. Criteria used for the selection included: proximity to the project area, potential for producing an adequate quantity of sand with an appropriate grain size distribution, previous use, and importance of shoal as fishing ground. Reports published by the Maryland Geological Survey (MGS) and previous U.S. Army Corps of Engineers (USACE) investigations were used in the initial screening. The areas selected by the study team included Shoal A, Shoal B, Weaver Shoal, and Isle of Wight Shoal. The location of the shoals is presented in Figures 2-3 and 2-4.

To develop the dredging plan, engineering, environmental, and economic factors required consideration. This section is subdivided into subsections that consider each of these disciplines. However, in reality, engineering, environmental, and economic considerations overlap substantially. The limits of what is technically practicable are set by the development of technology that is driven by cost considerations/limitations. What is environmentally acceptable is in part based on a judgment call as to what costs are acceptable to honor environmental constraints. Based on the relatively large volume of sand contained in the selected offshore shoals and ebb shoal in comparison with the long-term sand volumes needed by Ocean City (Section 4.2.1), it was expected that there would be substantial latitude in developing a plan that would be environmentally acceptable, technically sound, and cost-effective.

5.1 ENGINEERING

Engineering concerns focused on obtaining sand in suitable volumes and with a suitable grain-size distribution (gradation) to meet beach requirements as well as avoiding potential negative impacts of dredging on the project shoreline that could occur by increasing wave energy. Engineering limitations on where sand can be obtained are set by the water depths within which equipment can obtain sand and work practicably. Dredging technology has improved since beach nourishment work began at Ocean City. In the late 1980s, technically practicable and economical dredging depth was limited to a maximum depth of about 45 feet. As of the late 1990s, it became technically practicable and economically affordable for hopper dredges to dredge in water depths of as great as about 100 feet. Increased wave energy would be of concern if it threatened project functions of providing storm protection or if it increased substantially volume and or frequency of beach nourishment material required.

This SEIS summarizes engineering investigations undertaken in the course of this and previous studies. Several separate documents present more detailed information from current and previous investigations. Appendix D to the General Design Memorandum for the Atlantic Coast of Maryland Hurricane Protection Project, August 1989, contains results of investigations conducted in the late 1980s. Detailed information on results of investigations undertaken during the Ocean City Water Resources Study in the 1990s (Section 1.5), are contained in Appendix B of the June 1998 final report. The geotechnical appendix prepared for this current study contains details of 1993 pre-beach nourishment sand grain-size investigations as well as of investigations on samples collected in 2002. Copies of these documents are available by request from the Baltimore District.

5.1.1 Sand Grain-Size Requirements

The optimum grain size distribution of sand for beach nourishment from an engineering perspective typically approximates the grain size distribution of sand that naturally occurs on the beach. Distribution is the relative quantity of sands of different grain-sizes that together compromise the beach's sand (Section 2.1.2). If sand placed on the beach is finer than the native sand and/or has a significantly different distribution, a larger replenishment volume will be required. If sand of too coarse a grain size is placed, the beach may assume a steeper profile. USACE' engineering guidance applicable for the latter indicates that this may occur in this case where/when the median diameter of the borrow material exceeds the median diameter of the native material by more than 0.02 mm.

Grain-size data obtained previously from samples collected in 1986 and 1993 was used to determine a composite gradation to represent beach sand using standard USACE methods. Sands from the 1986 samples had a mean grain size of 0.36 mm (1.45 ϕ [phi]). Beach samples from 1993 had a mean grain size of 0.43 mm (1.22 ϕ). Materials collected in the 1993 sample were somewhat coarser and more uniform in texture (more poorly graded) than those collected in 1986. Poorly graded is an engineering term meaning that all the particles in the gradation are about the same size; geologists use the term well-sorted to describe this condition for sediments.

Assuming that mean sand grain size diameter is essentially equivalent to the median, then material with a mean diameter greater than 0.45 mm (1.16 ϕ) would be considered possibly too coarse when compared to the 1993 native material. Material with a mean diameter greater than 0.38 mm (1.39 ϕ) would be considered possibly too coarse when compared to the 1989 native material. Being too fine is directly related to the acceptable overfill ratio or factor. The overfill factor is an estimated measure of the number of cubic yards of borrow material required to produce one cubic yard of beach material when the beach profile reaches equilibrium. Overfill factors equal to or slightly greater than 1 are optimal. Too fine from a non-acceptable standpoint on the beach would be silt, but the beach would not be stable even with very fine stand or fine sand anyway so we should never get to that point.

5.1.2 Borrow Area Analysis

Several steps were involved in evaluating sands of the potential borrow areas. These steps were obtaining and processing sand samples, identifying sub-areas on the offshore shoals that possess somewhat consistent sands, and determining volumes of beachfill available in the sub-areas.

5.1.2.1 Obtaining and Processing Borrow Area Sand Samples

Drilling (vibracoring) was conducted to collect sand samples of potential borrow areas to determine their suitability for use as beachfill. Vibracoring for this purpose is typically done to 20 feet below the seafloor or to refusal. In most cases this coring depth allows for collection of samples within the shoal to about the depth of the ambient seafloor. Refusal at shallow depths can occur if gravels are intercepted that restrict further coring. Sand samples from Shoal B had been collected and analyzed during the OCWR Study when sand sources for the restoration of Assateague Island were being investigated. This data was considered adequate to characterize sands of Shoal B for this GR Study. Shoal B was vibracored during October and November 1995 on a grid at a spacing of approximately 3,000 feet, and 19 cores were collected. In contrast, data on sands of Shoal A, Weaver Shoal, and Isle of Wight Shoal was either unavailable or inadequate for the purposes of this GR Study. Vibracore drilling in Shoal A, Weaver Shoal, and Isle of Wight Shoal was accomplished in October 2002, also on a grid at a spacing of 3,000 ft. From Shoal A 14 cores were collected, from Weaver 17 cores, and from Isle of Wight Shoal 20 cores were collected. The location of the core sites for both 1995 and 2002 is depicted in Figures 5-1, 5-2, 5-3, and 5-4. Nine vibracores on the ebb shoal were collected between August and November 1986; an additional three ebb shoal vibracores were collected in January 1989. Since Fall 2003, grab samples of surficial materials from select areas of the ebb shoal have been collected biannually in monitoring conducted for the LTSM project

Vibracore samples from the potential offshore shoal borrow areas were transported to the District's Soils Laboratory at Fort McHenry for grain-size analysis. Grain-size analyses for vibracore samples collected in 1986 from the ebb shoal were conducted at Duck, North Carolina. Ebb shoal vibracores collected in 1989 were processed at Fort McHenry. Mechanical analyses were performed on selected sub-samples using screens corresponding to the Wentworth size designations to determine grain-size distributions. Gradations were determined for lengths of vibracore sample that contained visually similar material. Grab samples of surficial materials from select areas of the ebb shoal were visually inspected and mechanical analyses were performed on selected representative samples. Gradations for grab sample were determined for the entire sample.

5.1.2.2 Identification of Sub-Areas on Candidate Borrow Areas

The potential offshore shoal borrow areas show patterns of sediment grain-size distribution on the surface and interior of the shoal as a function of shoal evolution over

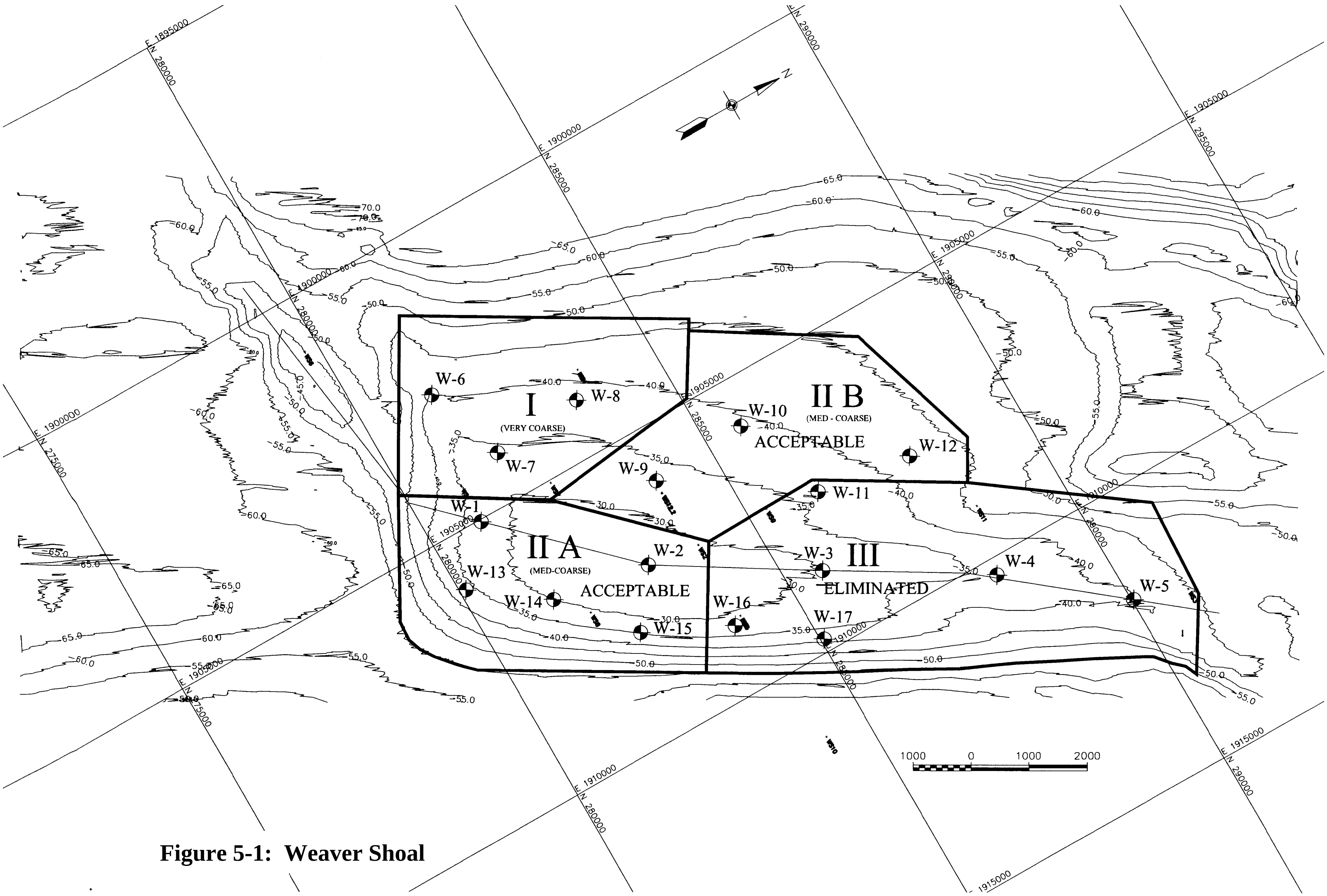

Figure 5-1: Weaver Shoal

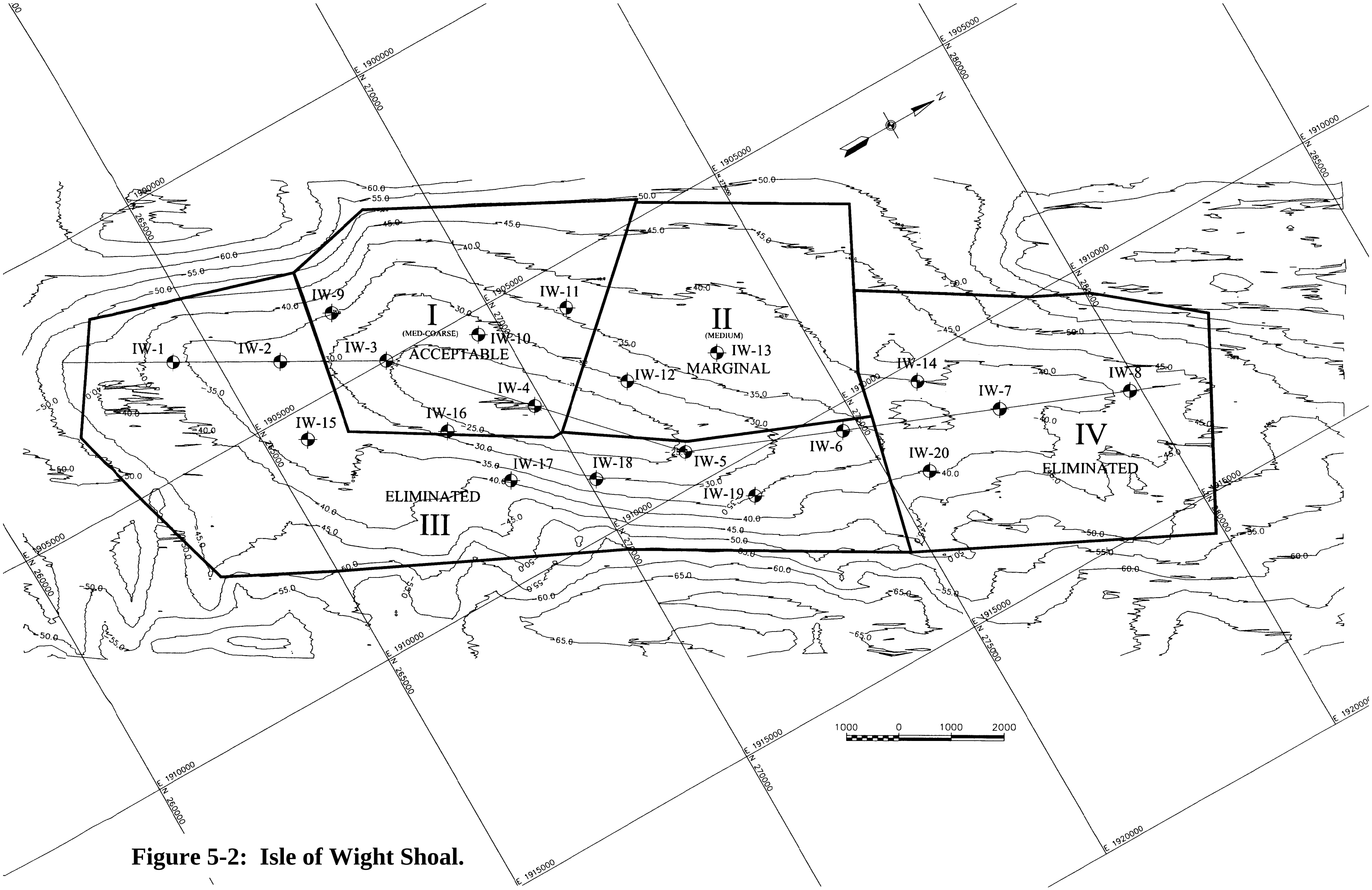

Figure 5-2: Isle of Wight Shoal.

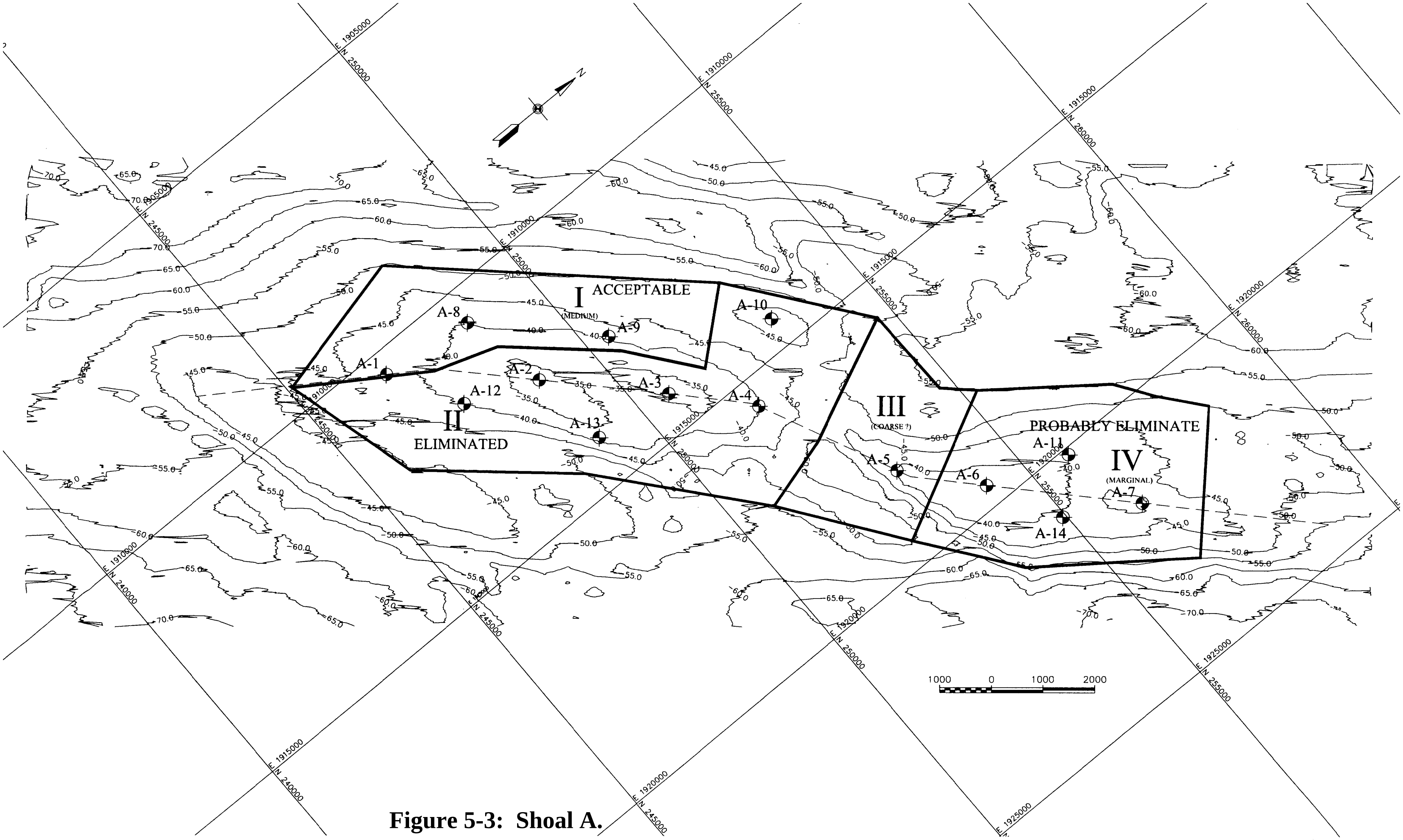

Figure 5-3: Shoal A.

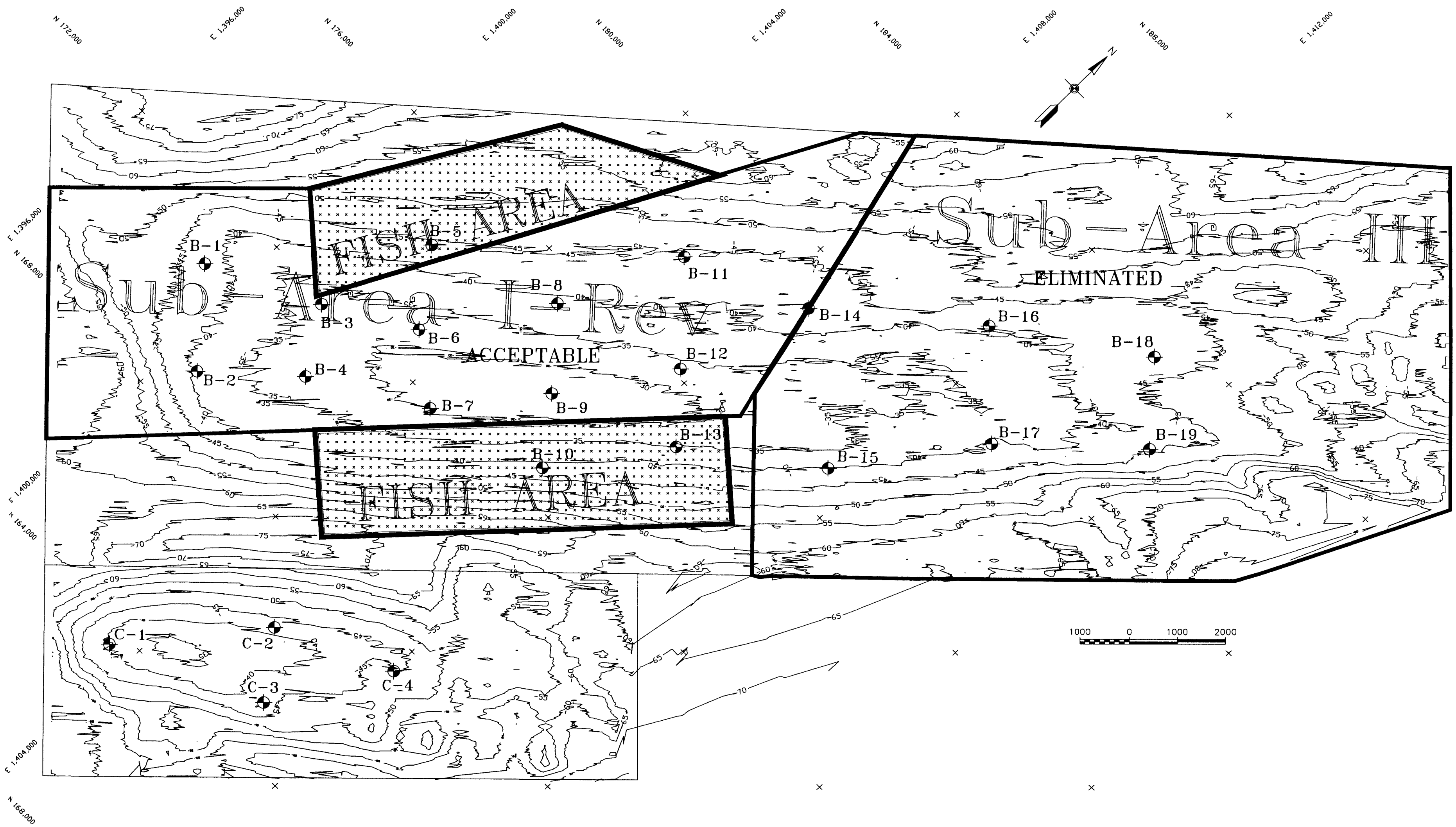

Figure 5-4: Shoal B.

its geologic history (Section 2.1.2). Composite gradations representing homogeneous vertical segments of the cores were determined. Vertical sub-segments were assigned for subsections of individual cores if they showed pronounced vertical change. Based on general mean grain size differences of these core site and interval gradations, the proposed offshore shoal borrow areas were divided into sub-areas over which grain-size distribution of subsurface sands was similar (Table 5-1). Artificial reef areas on Shoal B sub-areas were excluded from consideration when mapping sub-areas on Shoal B. Composite gradations representing each sub-area or combinations of sub-areas were calculated for various slice elevations, both cumulatively from the surface and for individual vertical slices in 5-foot increments. In calculating the composites, all samples were weighted in direct proportion to the length represented by each sample falling within the vertical increment being studied. These sub-areas are shown in Figures 5-1, 5-2, 5-3, and 5-4. In addition to grain-size data derived from samples collected in 1995 and 2002 (as described in Section 5.1.2.1), some drilling data from the previous study by MGS titled *Potential Offshore Sand Resources in Northern Maryland Shoal Fields* (September 1994), was also used to help define the areas. Detailed gradation data was not available from this older drilling to use in the analysis, however.

Table 5-1: Offshore shoal sub-area characteristics. (N/A is Not applicable).

Shoal	Sub-area	Surface Area (acres)	Elevation Evaluated to (ft)	Mean ϕ	Sand Size Class (Wentworth)	Over-fill Ratio	Number of Cores Collected
A	I	290	-55	1.42	Medium	1.09	3*
A	II	590		1.67	Medium	5.17	5*
A	III	200		0.62	Coarse	1.00	1
A	IV	380		1.49	Medium	1.57	4
A	III + IV			1.28	Medium	1.02	5
B	I (Rev)	1690	-55	1.08	Medium	1.05	11*
B	III	2720		1.57	Medium	16.9	6*
Weaver	I	320	-60	0.18	Coarse	1.00	3
Weaver	II (A&B)	680		0.85	Coarse	1.00	8
Weaver	III	570		1.55	Medium	2.28	6
Isle of Wight	I	530	-55	1.08	Medium	1.01	6*
Isle of Wight	II	500		1.29	Medium	1.17	2
Isle of Wight	I + II			1.13	Medium	1.02	8
Isle of Wight	III	1070		1.71	Medium	9.73	9*
Isle of Wight	IV	690		1.69	Medium	3.93	4
Total	N/A	10,230	N/A	N/A	N/A	N/A	N/A

*Includes cores collected on boundary between this and adjacent sub-areas.

Mean sand grain size of the ebb shoal was found to be 1.89 ϕ (0.270 mm) in investigations completed in 1989. This mean is 25 percent finer than that of the pre-nourishment beach in 1986, and 37 percent finer than that of the constructed Ocean City beach in 1993. The overfill factor for ebb shoal sands was calculated to be 2.8. Although the ability to directly compare modern data to historic data is limited as was discussed previously, it is possible that ebb shoal sand mean grain size is within the range of historic beach grain size median data from 1929 to 1954 recorded at the Maryland/Delaware border prior to major beach nourishment efforts. However, based on the 1989 data because of the greater overfill factor, the ebb shoal would not be a preferred source of sand for Ocean City from an engineering perspective.

5.1.2.3 Determination of Beachfill Volumes Available in Each Subarea

To determine the volume of beachfill material available in each subarea it is necessary to consider total volume and grain-size distribution. The overfill factor is multiplied as a correction factor to the total volume of material contained within a potential borrow area to determine volumes of suitable beachfill material. The Automated Coastal Engineering System (ACES) program was used to calculate the overfill factor, renourishment factor, and total volume of beachfill available in each of the proposed borrow areas and sub-areas as described in Section 5.1.2.2 (Tables 5-1 and 5-2). The renourishment factor is the ratio of the rate at which borrow material placed on the beach will erode to the rate at which natural beach material is eroding, thus providing an estimate of anticipated nourishment requirements. Any renourishment factor close to 1.0 is optimal; however, renourishment factors significantly less than 1.0 indicate that the material is likely too coarse. If it is significantly greater than 1.0, then the overfill factor is usually high enough to be a serious consideration. The greater the renourishment factor, the more frequently nourishment is required. Separate calculations were made for each of the two assumed native beachfill gradations previously mentioned in Section 5.1.1.

Table 5-2: Suitability of offshore shoal sub-areas as sources of beach sand.

Shoal	Sub-area	Status of Material as Beachfill	Quantity net beachfill (mcy)	Status Additional Notes
A	I	Acceptable to -55 NGVD	3.8	
A	II	Eliminated	0	Overfill ratio unacceptably large.
A	III	Combined Subareas III&IV Possibly Acceptable to –55 NGVD	6.8	III requires further consideration, has coarse material but based on only 1 core. IV is marginally acceptable. May consider combination of subareas - need additional core data to confirm
A	IV			
B	I	Acceptable to at least –55 NGVD	34.2	Somewhat coarse. Avoid artificial reef area.
B	III	Eliminated	0	Overfill ratio unacceptably large.
Weaver	I	Possibly Acceptable to -60 NGVD	7.4	Very coarse, probably unacceptable. Require additional drilling to confirm.
Weaver	II	Acceptable to -60 NGVD	18.9	Somewhat coarse
Weaver	III	Eliminated	0	Overfill ratio unacceptably large.
Isle of Wight	I	Combined Subareas I&II Acceptable to –55 NGVD	30.7	I acceptable. II marginal, but based on only 2 cores, need additional core data to confirm
Isle of Wight	II			
Isle of Wight	III	Eliminated	0	Overfill ratio unacceptably large.
Isle of Wight	IV	Eliminated	0	Overfill ratio unacceptably large.
			101.8	

5.1.3 Shoreline Impacts

Studies conducted for the Minerals Management Service (MMS) by Maa and others (2004) investigated potential shoreline impacts of dredging Fenwick and Isle of Wight Shoals under two scenarios. The first scenario modeled impacts to wave energy of a one-time mining of 2,600,000 cubic yards by dredging 10 feet from a 170 acre area on each, centered on the crest of each shoal. This study found no significant impacts to shoreline erosion rates would occur. The second scenario modeled the cumulative impact of mining 21,000,000 cubic yards from Fenwick Shoal and 11,000,000 cubic yards from Isle of Wight Shoal, each over a 10 to 20 year period and uniformly removing 10 feet of material from each shoal. At Fenwick, approximately 1,320 acres would be mined, whereas on Isle of Wight 700 acres would be mined under this modeling effort. In this cumulative impacts scenario, a significant increase in wave height might be realized at the shoreline that could result in increased erosion at the shoreline. For the 1998 USACE Ocean City Water Resources Study, impacts of dredging 13,000,000 cubic yards of sand from a 1,190 acre area borrow area that avoided the crest located on and adjacent to Great Gull Bank were modeled (Appendix A1 of that document). This modeling effort found that this mining would produce no adverse effects to the Assateague Island shoreline.

5.1.4 Engineering Recommendations

For now, the better assumption probably would be to use the comparison based on the 1993 native assumption since that data is probably more representative of what comprises the average condition of the beach now. Even so, material that appears too coarse may still be useable in some instances. For example, in the 1993 analysis, we actually divided the beach into two separate reaches since coarser material was more predominant to the north end of the island (mean ϕ=1.02, 0.49 mm) and finer material more predominant to the south (mean ϕ=1.45, 0.36 mm). Also, it may be desirable to use some of the coarser borrow material in some of the critical hot spot areas along the beach which are more prone to accelerated rates of erosion.

This will need to be considered in the final analysis and may be cause to eliminate portions of some of the areas. The final decision on what areas to use as sources of sand for beach nourishment will depend to a great extent on what native material to use as a comparison, how efficiently materials can be mixed in the borrow process, and how critical the beach steepness and textural properties of the sand are. In addition, during the final design, it is recommended that an analysis be conducted utilizing the equilibrium profile methodology in addition to determining overfill factors in assessing the final borrow area limits to be used for construction.

Sand material suitable for restoring the beach on Ocean City can be obtained from portions of each of the offshore shoal borrow areas studied. A significant quantity of material from each of these areas has a grain size distribution such that an overfill ratio of between 1.0 and about 1.3 would be realized. The renourishment factors calculated for these areas is sometimes less than 1.0, indicating that the beach retreat rate would be less than the existing rate. Theoretically, after the first nourishment cycle, nourishment would be required less often than the calculated retreat rate would indicate. In some areas the available material, although having an overfill ratio of 1.0, may be considered too coarse for consideration.

Based on the analyses, it is estimated that approximately 100 million cubic yards of beachfill material may be available from the four offshore shoal borrow areas proposed. However, some portions of the areas (sub-areas) are composed of material that may be too coarse for consideration as beachfill. Other sub-areas are marginally acceptable, but possibly could be considered if combined with another adjacent sub-area. Additional drilling and testing would be required during final design to better define the limits of acceptable borrow material. After selection of the proposed area, final design level drilling (vibracoring) should be conducted in this area (or areas) with core spacing at approximately 1,000-foot intervals during plans and specifications phase investigations conducted subsequent to finalization of this SEIS. A summary of the offshore shoal results and recommendations is presented in Table 5-2. Sand grain-size of sample means from sub-areas recommended for further investigation is presented in Table 5-3.

Table 5-3: Sand grain-size range of sample means from offshore shoal preferred sub-areas.*

Shoal	Sub-Area	Grain-size			
		Fine end of range (mm)	Coarse end of range (mm)	Fine end of range (ϕ)	Coarse end of range (ϕ)
A	I	0.295	0.451	1.76	1.15
	III	0.460	0.702	1.12	0.51
	IV	0.262	0.387	1.93	1.37
B	I	0.448	0.536	1.16	0.90
Weaver	II	0.463	0.574	1.11	0.80
Isle of Wight	I	0.304	0.678	1.72	0.56
	II	0.525	0.717	0.93	0.48

*Note that this table does not present the absolute range of grain-size of materials present, rather the range of the mean of composite samples from the sub-area.

The findings of Maa and others (2004) and the 1998 USACE study do not provide a means to determine maximum thickness of shoal material that could be safely dredged without risk to the shoreline. However, these findings indicate that thickness of material removed in the shallowest parts of the shoal should be minimized to minimize risk of increasing wave energy at the shoreline.

5.2 ENVIRONMENT AND FISHERIES

As was described in Section 3.2, because of environmental and fishery concerns, it was determined to be necessary to develop a dredging plan that would balance removal of sand for Ocean City with maintaining the long-term integrity and character of the offshore shoals as habitat features for marine life. The offshore shoals are irretrievable geomorphic features that provide large-scale structure for marine life that would otherwise be lacking on the largely flat seafloor plain of the study area. The offshore shoals are believed to be important features to which migrating finfish and mobile benthos orient to for navigational purposes or stage upon at various times (daily or perhaps seasonally). The offshore shoals may serve to maintain physical habitat diversity by contributing to maintenance of adjacent lows and seafloor flats. Future MMS studies are expected to address this issue.

In contrast, the ebb shoal in its current condition is an anthropogenic feature out of balance with the local environment. Ebb shoals by virtue of their location probably play a role in the ingress/egress of marine organisms to/from coastal bays. However, it is unknown how the ebb shoal in its current anthropogenic form compares in performance of this function to natural ebb shoals. Its known environmental values derive from the role the feature plays in maintaining the stability of Assateague and Fenwick Islands, rather than for any particular habitat functions the ebb shoal itself provides.

5.2.1 Dredging Guidelines

In accordance with the widely divergent attributes of the offshore shoals versus the ebb shoal, separate environmental objectives to direct development of more detailed constraints for dredging of each were formulated.

A) The offshore shoals should be mined in a manner that would not impair their long-term geomorphic integrity, assuming that this would maintain habitat functions of these features, and

B) The ebb shoal should be dredged in a manner that would not destabilize Fenwick Island, Assateague Island, nor mainland areas in the vicinity of the ebb shoal.

5.2.2. Dredging Constraints

The study team recognized that an array of potential alternative borrow plans could be formulated. In order to ensure that these potential plans would be formulated in a manner consistent with the dredging guidelines presented in Section 5.2.1, it was necessary to consider the plans that could be formulated and develop more detailed dredging constraints to ensure that plans met the dredging guidelines. These alternatives are presented in Table 5-4.

Table 5-4: Potential borrow plan alternatives that might differ in environmental and fisheries impacts.

Tally No.	Plan Alternative
1	Whether to dredge from all or just some of the five candidate shoals
2	How to apportion volume to be removed among shoals to be dredged (total volume that could be removed from each candidate shoal)
3	What shoals should be dredged during any given beach nourishment period
4	Location to dredge on any shoal and thickness of sand to be removed

The remainder of Section 5.3.2 is subdivided in accordance with the tally numbers presented in Column 1 of Table 5-4 to facilitate consideration of these variables important to formulating a borrow plan.

5.2.2.1 Consideration of Factors Warranting Exclusion of Candidate Shoals

Consideration was given in Section 4.3 to identifying major environmental and fisheries reasons that would be important enough to potentially warrant excluding any shoal from consideration using existing information. Several shoals were eliminated from further consideration based on these factors. Because of the recognized importance of environmental concerns identified in Section 3.2, it was necessary to conduct additional investigations to determine whether or not there would be any environmental or fishery reason to favor any of the candidate shoals as sand sources over others, or to potentially exclude any shoal from consideration.

Baltimore District coordinated with resource agencies to characterize the importance of the offshore shoals and ebb shoals as fishing grounds (Annex E). The U.S. Fish and Wildlife Service (USFWS) contacted commercial and recreational fishermen to characterize the importance of the four offshore shoals selected in Section 4.3 as fishing grounds. This work was undertaken as part of their study involvement conducted in accordance with the U.S. Fish and Wildlife Coordination Act.

The ebb shoal receives some use by recreational clammers who access the shoal by boat, but is otherwise not considered an important fishing ground (Section 2.6.11). This relative low importance is believed to be a consequence of the dynamic, high energy physical environment of the ebb shoal, and would thus be unlikely to change in the future. Consequently, need to avoid fisheries impacts was not determined to be an important consideration in developing a dredging plan that could include the ebb shoal.

The USFWS determined that Shoal B currently is of distinctly greater importance as a fishing ground than the other three offshore shoals (Annex C). Fishing effort occurs across the surface of Shoal B, although fishing efforts focus on the artificial reefs there (see Section 2.6.12). Fishermen contacted by USFWS expressed concern over potential indirect impacts to fish habitat that could occur from dredging large volumes of sand from anywhere on the shoal. In light of its importance as a fishing grounds, and likely controversy over dredging this shoal, the USFWS recommended against dredging Shoal B (Annex C). The USFWS expressed the opinion that the three other offshore shoals represented reasonable candidate borrow sites.

The USFWS recommendation did not specifically identify a period of time over which this recommendation for no dredging of Shoal B would be appropriate. The study team accepted the USFWS recommendation to avoid Shoal B, as long as the shoal maintains its status as being of particular importance as a commercial and recreational fishing ground. However, since its importance for this function could change over time, as occurred with Fenwick Shoal (Section 2.6.1.1), the study team decided that Shoal B would not be completely eliminated from consideration through the year 2044. Instead, it would be appropriate to periodically revisit this topic to determine the status of Shoal B as a fishing ground. In subsequent coordination, USFWS concurred that this approach met the intent of the recommendation regarding Shoal B.

Following this line of reasoning, it was recognized that any of the offshore shoals could in the future potentially be of far greater value as fishing grounds than they are currently. Accordingly, the study team recognized that the relative importance of all the candidate shoals should be periodically revisited to update the status of this determination through the year 2044.

In light of current (and likely near-future) fishing activity, the study team determined that shoals Weaver, Isle of Wight, and "A" would be used first, and no dredging would occur on Shoal B initially (6 to 10 years into the future). Since it is quite possible that fishing activity patterns will change in the future, all four of the candidate shoals' value as fishing grounds should be reevaluated periodically. If in the future any of the shoals are determined to be of great importance as fishery grounds, dredging should be shifted to those shoals of lesser value pending another reevaluation. Shoal "B" would be dredged in the future only if it is determined to be of relatively lesser value than at present. However, in light of the potential that Shoal B could become less important as a fishing ground over time as the status of populations of the fish species fished there changes, and importance of the other candidate shoals could increase, the study team determined that it would be appropriate to periodically revisit this issue in the future to reevaluate the importance of all the candidate shoals as fishing grounds.

Although the study team determined it to be appropriate to reconsider the ebb shoal, as was described in Section 4.3.6, it was determined that no plan could be developed that would ensure compliance with guideline C presented in Section 5.2.1 Several outstanding unresolved concerns were identified. These included magnitude of: 1) Impacts to northern Assateague Island environmental character and stability from increased wave energy and potential reduction in sediment delivered via natural bypassing. 2) Altered wave energies and bathymetries in the vicinity of the inlet and potential impacts to navigation. 3) Following placement of finer-grained sand dredged from the ebb shoal on the Ocean City beach, increased deposition of finer-grain sand could detrimentally impact the environment of inlet vicinity, with the coastal bays being of greatest concern. In light of these major concerns, the study team determined that the ebb shoal should be excluded from consideration for increased dredging for Ocean City until such time that these concerns could be satisfactorily addressed.

Increased mining of sand from the ebb shoal for Ocean City would require the acceptance of several stakeholders: USACE, the National Park Service (NPS), the Maryland Department of Natural Resources, Ocean City, and Worcester County. The NPS expressed by letter (Annex E) that at this time it can not support increased dredging of the ebb shoal for nourishment of Ocean City beaches because of concern over unknown impacts to Assateague Island. A substantial portion of the information that would ultimately be required to determine whether increased volumes of sand could be dredged from the ebb shoal for Ocean City is already being collected under the LTSM monitoring program. It is anticipated that it would take at least several years to perhaps a decade(s) to collect sufficient information and complete modeling to determine with a high level of certainty if the ebb shoal could be safely and economically mined to provide substantial quantities of sand for the Ocean City beach. It would be appropriate in the current stage of the study to identify information gaps of current monitoring efforts so that measures to address these deficiencies can be undertaken to facilitate future decision-making.

No other environmental or fishery reasons were identified that would warrant rejecting any of the three remaining shoals from dredging for borrow.

5.2.2.2 Apportioning Dredging Among Shoals

On the basis that the ebb shoal in its current form is largely an anthropogenic feature, while the offshore shoals are essentially natural features, it could be concluded that the ebb shoal is of less environmental value generally than the offshore shoals. As was discussed previously, the ebb shoal is not noted to be important habitat for marine life nor have particular value as a fishing grounds. Accordingly, no reason to restrict dredging of the ebb shoal to protect marine life or fisheries was identified. As a consequence of its size having been increased anthropogenically over natural ebb shoals characteristic of the mid-Delmarva peninsula, it has the potential to provide greater wave protection for Assateague Island from northeasters than would a small ebb shoal natural to this region. Given that the NPS objected to increased dredging of the ebb shoal, and it is not possible to formulate a dredging plan that would make increased use of the ebb shoal that would honor dredging guideline B from Section 5.2.1, the study team made no determination over how much sand could potentially be dredged from the ebb shoal at some time in the future if it is determined that this sand could be safely removed without threatening the geomorphic integrity of Assateague Island. This decision would be appropriately made after sufficient data are assembled from the LTSM to ensure that this could be done responsibly.

A clear distinction can be made among the offshore shoals with respect to their value as fishing grounds (Section 5.3.1). However, as was discussed above for Shoal B, it is quite possible that the relative importance of any given offshore shoal as a fishing ground could change in the future. Preliminary information indicates that the ecological importance of any given offshore shoal may be a function of relief off the seafloor and area of shallower water habitat that it possesses. (Distinction between ecological and fisheries perspectives was discussed in Section 2.6.12). Given that there has been a loss of offshore shoal habitat inside state waters associated with borrow actions from Borrow Areas 2, 3, and 9, it is prudent to assume that the relative value of the remaining shoals in close proximity to Ocean City has increased if any of the ecological and fishery functions formerly being performed by a greater number of shoals are now being performed by a fewer number of shoals. Following exhaustion of sand resources in state waters with consumption of remaining available sand in Shoal 9, this loss will be increased.

It is not known whether the geographic distribution of offshore shoals on the seafloor is of importance for marine life that orient to these or migrate along them. Accordingly, it was assumed that the most prudent course of action from an environmental and fisheries perspective would be to keep all the remaining offshore shoals geomorphologically intact, rather than risk losing one. This would effectively produce the consequence though of impacting more shoals and leave fewer in an unimpacted state. However, because of the mobile nature of shoals over time, it is anticipated that these impacts would be naturally erased as the shoal surface is reworked and the shoal migrates. Thus, as long as the shoals retain sufficient material to remain geomorphologically intact and are dredged in such a way as to promote this condition, impacts would be non-permanent.

The greater the proportion of material removed from any given offshore shoal, the more likely that that shoal's long-term geomorphic integrity would be threatened. Since these features are essentially irretrievable, it was determined to be appropriate to err on the side of caution to ensure greatest likelihood of compliance with Guideline A presented in Section 5.3 above. Following this rationale, in consultation with resource agency personnel and academic experts (Annex E) the study team determined that apportioning dredging among the candidate shoals such that no more than several percent of any individual shoal's total volume would be removed would be the best approach. In accordance with this judgment, the study team determined that the total volume that could be mined from any given offshore shoal should be less than five percent of its total volume (Tables 5-5 and 2-3). In each case, these total volumes are less than the identified volumes available that meet engineering requirements (Table 5-2). If 5% of each shoal's volume were dredged, the total volume would be 19,100,000 cubic yards. (However, it should be noted that the sub-area boundary delineations and estimated volumes available are preliminary in nature and will likely be revised over time.) No maximum permissible percent volume that could be removed from the ebb shoal was determined, although perhaps a theoretical maximum would be whatever volume a natural ebb shoal would likely have had in this setting (Table 2-7).

Table 5-5: Maximum volume of material permissible to dredge from individual offshore shoals meeting 5% environmental constraint.

	Weaver	Isle of Wight	A	B
Maximum volume (yd^3)	4,650,000	6,800,000	5,150,000	2,500,000

5.2.2.3 What Shoals Should be Dredged During any Given Beach Nourishment Period

Amelioration of potential negative impacts to the environment and fisheries that could be obtained by specifying the sequence of shoal dredging within any given beach nourishment effort as well as over the project life were considered. No mitigational benefits were identified that would reduce impacts to the environment or fisheries (independently of postponing dredging Shoal B and the ebb shoal [Section 5.2.2.1]). Accordingly, no environmental nor fishery guidelines or constraints that would direct the order in which shoals would be dredged nor how many shoals could be dredged during any given beach nourishment period were formulated.

5.2.2.4 Location and Thickness of Sand to Dredge on Individual Offshore Shoals

Three factors were identified that would likely have bearing from an environmental and fisheries perspective over where on any given offshore shoal dredging should or should not be conducted. 1) Artificial reefs constructed on the shoals. 2) Shoal values as habitat for seaducks and fish. 3) The long-term geomorphic integrity (and long-term habitat value) of the offshore shoals.

5.2.2.4.1 Artificial Reefs

Shoal B has two artificial reef areas on its flanks, the Bass Grounds, that are important recreational fishery areas (Sections 2.6.12, and 5.2.1.3). Dredging in these areas would be unacceptable to fishermen. Dredging in the vicinity of these could also damage dredging equipment if the dredges accidentally encountered artificial reef materials. Accordingly, these areas of Shoal B were restricted from further consideration. The Town of Ocean City and the Ocean City Reef Foundation have requested expansion of these existing reefs. A permit for this expansion has not been issued at this time, however it is likely that future improvements to the existing artificial reefs will be made, potentially increasing the value of the area as a recreational fishing grounds.

5.2.2.4.2 Shoal Habitats

The ebb shoal was not identified to have any particular habitat value in its anthropogenic condition. Thus, no guidelines or constraints related to maintaining ebb shoal habitat conditions were identified.

MMS studies (Section 2.5.2.3) found that finfish congregated at night from spring through fall on the two out of the four offshore shoals they studied that possessed greatest relief. The relatively greater relief of those two shoals was postulated to be one factor that could explain the observed distribution, although many other factors also influence species distributions that could have contributed to the observed pattern. In contrast, finfish did not appear to show this same behavior at two lower relief shoals nor adjacent seafloor flat reference areas. Dr. Doug Forsell of the USFWS (Annex C) stated that scoters (seaducks, Section 2.5.2.4) have been found to concentrate in waters of less than about 30 feet depth. (Note: water depths generally exceed 30 feet depth seaward of about 1,000 yards offshore. Farther offshore, waters less than 30 feet depth are only found over offshore shoals.) Accordingly, Dr. Forsell recommended that not removing the shallower areas of the offshore shoals might be an appropriate dredging guideline/constraint. Those areas of the shoals where depth is less than about 30 feet would probably be most valuable as foraging grounds for seabirds. Although this information is limited in scope, the study team determined that it would be prudent to minimize impacts to shoal maximum relief and shallow areas along the crest since shoal relief recovery time following dredging is unknown, and these areas likely have particular importance as habitat features. Given the apparent relationship between shoal total volume and relief off the seafloor (Section 2.1.1.), this constraint required consideration of whether the 5% constraint on total volume of shoal that could be removed would protect shoal relief. That topic is covered further in Section 5.2.2.4.3.

5.2.2.4.3 Geomorphic Integrity Maintenance

Implicit in Dredging Guideline A of Section 5.3 above for the offshore shoals is the need to understand how material dredged from these features might alter the geomorphic character of the individual feature. In contrast, Dredging Guideline B for the ebb shoal provides no clear reason, independent of avoiding destabilizing adjacent areas of Fenwick Island, Assateague Island, the mainland, or navigation channels, to maintain the ebb shoal in any particular geomorphic form or size, nor total volume of material.

Coordination with a number of seafloor experts was undertaken to identify guidelines and constraints that could be incorporated into a dredging plan to best meet the objective of maintaining geomorphic integrity of the offshore shoals. A summary of these discussions is presented in Table 5-6.

Table 5-6: Dredging guidelines and constraints for dredging individual offshore shoals to optimize for long-term geomorphic integrity maintenance.

	Dredging Guideline/Constraint	**Reasons (1)**
1	Avoid the crest	Maintain shallowest water wave-action processes which are likely important for long-term shoal maintenance (2); Maintain coarse-grained lag deposits in-place since these may serve to ensure crest stability (more wave-erosion resistant) (2);
2	Preferentially dredge sand from downdrift accreting (south*) (2) (3) or updrift eroding side (north**) (2)	Minimizing risk of interrupting sand recycling pattern/process
3	Dredge thin uniform thickness of material from a large area	Least disturbance to existing topography/geometry believed to offer least likelihood of substantial disturbance to physical processes that maintain shoal (3)(4)
4	Dredge no deeper than ambient seafloor depth (i.e., not below shoal)	To confine dredging to active portion of seafloor, and avoid creation of pits which could alter physical process patterns (3)(4)

(1) Reasons more specific than maintaining geomorphologic integrity which is assumed to be of long-term importance for biota
(2) Dr. Robert Nairn, Personal communication to Chris Spaur September 2004
(3) Dr. Randy McBride, Personal communication to Chris Spaur for planning dredging of Great Gull Bank for Short-Term Restoration of Assateague Island, March 2001
(4) Dr. Mark Byrnes, Personal communication to Chris Spaur April 2004

*Determined to be southerly based on Swift and Field (1981), McBride (personal communication), limited USACE monitoring conducted of nearby Great Gull Bank, and MGS monitoring work of Borrow Areas 2 and 3 conducted for this study.
**Assumed to be north based on MGS monitoring work of Borrow Areas 2 and 3 conducted for this study.

An absolute maximum of thickness of dredging that could be undertaken to meet Guideline/Constraint 3 from Table 5-6 above was not determined. However, other examples are available which offer some potential likely outcomes. Maximum dredging thickness of sand removed from Great Gull Bank to obtain sand for the Short-Term Restoration of Assateague project was restricted to six feet by USACE and MMS. Elsewhere on the Continental Shelf, MMS has included maximum dredging depths in some of its sand leases that have ranged from as little as 3 feet to as much as 10 feet. Accordingly, it is reasonable to assume that maximum thickness of material that would be removed for future Ocean City sand needs could be 10 feet. Minimum thickness of material removed would be what could be removed in a single pass of a hopper dredge, this would depend on the qualities of the material and the specifics of the dredge. Information received from MMS (Annex C) indicates that maximum thickness of material removed in a single pass by a trailer suction hopper dredge could be as much as 1.5 feet (50 cm) or more if the ship speed is slow and sand conditions suitable. However, in sand of medium density, removal of about 1 foot (30 cm) in a single pass would probably be more typical. In conditions where more compact sand occurs, as little as 2 to 4 inches (5 to 10 cm) of sand could potentially be dredged on a single pass by a trailer suction hopper dredge. The vertical distribution of suitable grain-size sand within each sub-area would be an important factor in determining the thickness to remove from each sub-area.

5.2.3 Preliminary Consideration of Environmental and Fisheries Impacts of Alternatives

It was recognized that the thinner dredging is done to obtain sand, the greater the surface area that would be impacted. Consequently, short-term detrimental impacts to benthos of this would actually be worse, since benthos would be destroyed over a wide area. However, since the benthos would likely recover to pre-project conditions within a several year period, the duration of this impact would be far shorter and presumably of less ecological consequence than if offshore shoal geomorphic character were substantially altered or stability undermined. Accordingly, it was determined that the short-term trade-off of greater seafloor impact on the offshore shoal would be less environmentally-damaging over the long-term.

Dredging guidelines formulated to avoid the crest to maintain geomorphic integrity of the shoals were also determined to be likely to effectively encompass the habitat/protection guidelines presented in Section 5.2.2.4.2.

It was necessary to attempt to forecast long-term relief impacts of mining the shoals under the various alternatives to determine whether the alternatives (or which of the alternatives) would likely meet the guideline to maintain shoal relief over the long-term. Utilizing the relationship presented in Section 2.1.1 (Figure 2-5), in which shoal relief positively correlates to total volume could be utilized to forecast long-term relief impacts of mining shoals, the with-project relief and elevation of the four offshore shoals candidates following dredging up to 5% of their total volume was forecast. None of the four candidate shoals would lose more than 1 foot of total relief (Annex B), assuming that the shoal evolved to a state of dynamic equilibrium. Accordingly, the study team determined that the any alternative removing less than 5% of total shoal volume and meeting the guidelines/constraints presented above would be acceptable.

5.2.4 Environmental and Fisheries Recommendations

For immediate future (~2010-2015)

1. Shoal B can't be dredged until such time as value as fishing grounds decreases substantially

2. Ebb shoal can't be dredged beyond current rate for Ocean City until such time that impacts of that dredging would be better understood and accepted by stakeholders and until better spatial and vertical characterization of sands contained within the shoal is obtained.

3. Individual offshore shoals should be dredged in accordance with the guidelines/constraints presented in Table 5-6 to the degree practicable.

4. Honor dredging constraints designed to minimize impacts to sea turtle populations.

5.3 ECONOMICS

Economic considerations focused on how to obtain sand cost-effectively, and maintain a favorable cost to benefit ratio. The latter would be effected by maintaining project storm protection economic benefits and avoiding substantial increase in costs that could result from need for increased volume or frequency of beach nourishment. Sand from any of the candidate shoals would be selected and combined as necessary to produce sand meeting the engineering grain-size requirements within the environmental guidelines and constraints presented above. Based on results of recent and ongoing dredging and sand placement work on Fenwick and Assateague Islands, it was anticipated that a plan could be developed utilizing new sources of sand that would have costs and benefits consistent with those of previous and ongoing efforts. Accordingly, no maximum cost per cubic yard that could serve as an upper cost ceiling beyond which alternatives should not be formulated was identified. No other economic guidelines or constraints requiring consideration in plan formulation were identified.

One factor was identified that systematically alters the transport costs from the general differences offshore presented in Table 4-1. Sand is generally not placed uniformly along Ocean City. Instead, nourishment volumes are placed predominantly in the northern half of the island. Thus, transport distances to the northern half of the island are reduced for shoals that are more northerly.

5.4 FORMULATION OF ALTERNATIVE BORROW PLANS

As was described previously, engineering requirements for suitable sand and avoidance of increased shoreline wave energy, environmental and fishery constraints that long-term impacts to the offshore shoals be minimized served to bound potential dredging plan alternatives that could be formulated. The study team determined that alternatives that could not meet these guidelines/constraints would not be formulated since they would effectively be non-viable. Table 5-4 provided a summary of variables that could be combined to produce alternative borrow plans.

The ebb shoal and Shoal B were determined to be unsuitable as borrow sources for the near-future (Section 5.2.2.1). Accordingly, it was necessary to formulate alternatives that would provide sufficient sand from the three other offshore shoals over the near-future. It would be possible that neither the ebb shoal nor Shoal B would prove to be available for the remainder of the project life as well. This possible scenario required formulation of alternatives for the entire project life that obtain sufficient sand from the other three identified offshore shoal sources. Or, either or both the ebb shoal and Shoal B would potentially be acceptable to dredge in the future, pending findings of additional studies.

Given this possible scenario, it is also appropriate to formulate alternatives that also obtain sand from the ebb shoal and or Shoal B in the future.

5.4.1 Sand Volume Needs

Sand needs through the year 2044 can not be forecast with absolute certainty (Section 3.1). The study team determined that it would be appropriate to formulate a borrow plan that would be flexible to meet the range of likely sand need scenarios. Minimum potential total needs, based on project performance from 1998 through the present, would be 6,800,000 cubic yards. Maximum total potential needs, based on project performance over the total project life from 1988 through present, would be approximately 15,000,000 cubic yards. In addition to these minimum and maximum volume need scenarios, intermediate volume need scenarios would also be possible. Thus, the borrow plan must accommodate a range of scenarios spanning 8,600,000 yd^3.

5.4.2 Shoals to Dredge Over Project Life

The most simple borrow plan alternative would obtain all sand from a single shoal. As was described previously, neither Shoal B nor the ebb shoal could be considered as sole sources of sand given that dredging of these features would be postponed for a decade or more into the future. Of the remaining three shoals, neither Weaver Shoal nor Shoal A could alone meet the minimum potential borrow needs scenario through the year 2044 without violating the guideline that no more than five percent of shoal volume be removed (Table 5-7). Accordingly, neither Weaver Shoal nor Shoal A could be considered a viable alternative as the sole source of sand under the minimum volume needs scenario. Isle of Wight Shoal could meet the minimum borrow needs scenario. This would remove approximately 4.7% of its total volume and be towards the upper limit of what would be geomorphically acceptable (Section 5.2.2.2). It is uncertain whether this volume could be removed in accordance with the dredging constraints presented in Table 5-6. Isle of Wight Shoal could not alone provide sufficient sand to meet any scenario requiring more than 6,800,000 yd^3 of sand (Table 5-5) which only 400,000 yd^3 above the minimum volume needs scenario, however. However, in the event Isle of Wight Shoal is dredged first, sand needs prove to be substantially less than the minimum potential future need presented herein, and the constraints presented in Table 5-6 could be honored, then Isle of Wight Shoal could possibly meet the entirety of sand needs for Ocean City out to the year 2044 in accordance with the dredging constraint focused on maintaining shoal volume.

Table 5-7: Percent total shoal volume removed via dredging only one offshore shoal to provide sand through 2044. Minimum and maximum scenarios: 6,400,000 and 15,000,000 cubic yards, respectively.

	Weaver	Isle of Wight	Shoal A
Minimum Borrow Needs Impact (% Loss)	6.9	4.7	6.2
Maximum Borrow Needs Impact (% Loss)	16	11	15

a) Volumes determined by MGS.

The study team then considered alternatives that would involve dredging from multiple shoals. As was presented in Table 5-4, there are several variables requiring consideration that could be combined to produce alternative borrow plans. These variables could be combined in numerous potential grouping to produce an immense number of potential alternatives. Initially, the study team considered just which shoals could be dredged at any time over the project life to see whether this would constrain the field of potential alternatives. Subsequent to this exercise, it would be necessary to consider the sequence in which they are dredged and whether one or more than one shoal would be dredged in any given nourishment event.

For the near future, sand could be dredged from any combination of Isle of Wight, Weaver Shoal, and Shoal A. Over the long-term (decade plus), sand could also potentially be dredged from Shoal B and the ebb shoal pending findings of further investigation. The volume of material cumulatively dredged from any individual offshore shoal could not exceed 5% of the total shoal volume (Table 5-5), the maximum volume that could potentially be dredged from the ebb shoal has not been determined. No minimum volume that might be dredged from an individual shoal was identified (although a practicable minimum useful volume would perhaps be one dredge full).

If Shoal B and the ebb shoal continue to be restricted, there would be 7 potential combinations of shoals that could be dredged; 5 of these combinations could meet the minimum sand need scenario (Table 5-8). If Shoal B (but not the ebb shoal) is later determined to be suitable for dredging, there would be 15 potential combinations of shoals that could be dredged over the project life (Table 5-8); 12 of these combinations could meet the minimum sand needs scenario. If the ebb shoal (but not Shoal B) is later determined to be suitable for dredging, there would be 12 potential combinations of shoals that could be dredged over the project life (Table 5-8); 10 of these combinations could meet the minimum sand needs scenario. An additional two combinations that include dredging the ebb shoal might meet sand needs, depending on maximum permissible volume to dredge from the ebb shoal over the project life. If Shoal B and the ebb shoal become available, there could be 27 potential combinations of shoals that could be dredged over the project life. Of this, 24 combinations could meet the minimum sand need scenario (Table 5-8); an additional 3 combinations might also meet sand needs.

Table 5-8: Alternative combinations of shoals that could be dredged to meet minimum volume need (6,400,000 yd3) scenario. W=Weaver, I=Isle of Wight; NA= Not Applicable; ?=Not Determined.

Tally	Shoals	Combined maximum permissible total dredging volume (yd3)	Scenarios: Eligible shoals			
			W, I, A	W, I, A, B	W, I, A, Ebb	W, I, A, B, Ebb
1	W	4,650,000	No	No	No	No
2	I	6,800,000	Yes	Yes	Yes	Yes
3	A	5,150,000	No	No	No	No
4	B*	2,500,000	NA	NA	NA	NA
5	Ebb*	Not Determined	NA	NA	NA	NA
6	W, I	11,450,000	Yes	Yes	Yes	Yes
7	W, A	9,800,000	Yes	Yes	Yes	Yes
8	W, B	7,150,000	NA	Yes	NA	Yes
9	W, Ebb	>4,650,000	NA	NA	?	?
10	I, A	11,950,000	Yes	Yes	Yes	Yes
11	I, B	9,300,000	NA	Yes	NA	Yes
12	I, Ebb	>6,800,000	NA	NA	Yes	Yes
13	A, B	7,650,000	NA	Yes	NA	Yes
14	A, Ebb	>5,150,000	NA	NA	?	?
15	B, Ebb	>2,500,000	NA	NA	NA	?
16	W, I, A	16,600,000	Yes	Yes	Yes	Yes
17	W, I, B	13,950,000	NA	Yes	NA	Yes
18	W, I, Ebb	>11,450,000	NA	NA	Yes	Yes
19	W, A, B	12,300,000	NA	Yes	NA	Yes
20	W, A, Ebb	>9,800,000	NA	NA	Yes	Yes
21	W, B, Ebb	>7,150,000	NA	NA	NA	Yes
22	I, A, B	14,450,000	NA	Yes	NA	Yes
23	I, A, Ebb	>11,950,000	NA	NA	Yes	Yes
24	I, B, Ebb	>9,300,000	NA	NA	NA	Yes
25	A, B, Ebb	>7,650,000	NA	NA	NA	Yes
26	W, I, A, B	19,100,000	NA	Yes	NA	Yes
27	W, I, A, Ebb	>16,600,000	NA	NA	Yes	Yes
28	W, I, B, Ebb	>13,950,000	NA	NA	NA	Yes
29	W, A, B, Ebb	>12,300,000	NA	NA	NA	Yes
30	I, A, B, Ebb	>14,450,000	NA	NA	NA	Yes
31	W, I, A, B, Ebb	>19,100,000	NA	NA	NA	Yes
	Total no.		7	15	12	27
	Combinations meeting sand needs.		5	12	10	24
	Not Determined				2	3

*Shoal B and Ebb Shoal are NA for these rows because they can not be dredged until some undetermined time in the future, thus they are ineligible for consideration. .

The study team then considered what alternative combinations of shoals could meet the maximum volume needs scenario of 15,000,000 yd^3. (The sequence in which they are dredged nor whether one or more than one shoal would be dredged in any given nourishment event was not considered at this time.) The total number of potential combinations for each alternative group of shoals considered is the same as that of the minimum volume needs scenario.

For the maximum volume need scenario, in the event that Shoal B and the ebb shoal continue to be restricted from dredging, there is only one potential combination that could meet Ocean City's sand needs: dredging from all of the other three offshore shoals (Table 5-9). This situation occurs because the constraint limiting dredging to no more than 5% of the total volume of any individual shoal effectively forces dredging from more shoals, and eliminates consideration of alternatives that would make use of fewer shoals.

In the event that Shoal B is determined to be acceptable at some time in the future but the ebb shoal is not, there would be two potential combinations of shoals that could be dredged that could meet Ocean City's maximum sand needs (Table 5-9). In this scenario, because of the comparatively small maximum volume that could be taken from Shoal B while meeting the 5% volume limit (2,500,000 yd^3), Shoal B could only be dredged if material is also taken from Weaver, Isle of Wight, and Shoal A.

If the ebb shoal is determined to be acceptable at some point in the future but Shoal B is not, only the potential combinations including Weaver, Isle of Wight, and A could meet the maximum need scenario (Table 5-9); 6 other potential alternative combinations exist for which it is not possible to determine whether or not they could meet maximum volume sand requirements. Since a minimum acceptable volume that the ebb shoal should remain following any dredging has not been determined, it is not possible to state what maximum volume could be dredged from the ebb shoal. Accordingly, it is unlikely that even if the ebb shoal is determined to be suitable for increased dredging to maintain Ocean City that it alone or it in combination with any single other offshore shoal alone could supply the total sand needs of Ocean City because of concern over impacts of dredging the ebb shoal described previously. However, as the total known volume of sand available from any given alternative including the ebb shoal increases, the more likely it is that it would prove acceptable.

If both Shoal B and the ebb shoal become available, four combinations could meet the maximum sand need scenario (Table 5-9). An additional 13 combinations including the ebb shoal that might meet the maximum volume needs scenario exist for which the total volume that could be dredged can not be determined at this time. Those alternatives with a permissible dredging volume most closely approaching 15,000,000 yd^3 even without the ebb shoal would be most likely to be determined to be suitable, since these would require the least volume of sand to be dredged from the ebb shoal. Those alternatives borrow from the ebb shoal in addition to Weaver, Isle of Wight, and Shoal B, or the ebb shoal in addition to Isle of Wight, Shoal A, and Shoal B.

Table 5-9: Alternative combinations of shoals that could be dredged to meet maximum volume need (15,000,000 yd3) scenario. W=Weaver, I=Isle of Wight; NA= Not Applicable; ?=Not Determined.

Tally	Shoals	Combined maximum permissible total dredging volume (yd3)	Scenarios: Eligible shoals			
			W, I, A	W, I, A, B	W, I, A, Ebb	W, I, A, B, Ebb
1	W	4,650,000	No	No	No	No
2	I	6,800,000	No	No	No	No
3	A	5,150,000	No	No	No	No
4	B*	2,500,000	NA	NA	NA	NA
5	Ebb*	Not Determined	NA	NA	NA	NA
6	W, I	11,450,000	No	No	No	No
7	W, A	9,800,000	No	No	No	No
8	W, B	7,150,000	NA	No	NA	No
9	W, Ebb	>4,650,000	NA	NA	?	?
10	I, A	11,950,000	No	No	No	No
11	I, B	9,300,000	NA	No	NA	No
12	I, Ebb	>6,800,000	NA	NA	?	?
13	A, B	7,650,000	NA	No	NA	No
14	A, Ebb	>5,150,000	NA	NA	?	?
15	B, Ebb	>2,500,000	NA	NA	NA	?
16	W, I, A	16,600,000	Yes	Yes	Yes	Yes
17	W, I, B	13,950,000	NA	No	NA	No
18	W, I, Ebb	>11,450,000	NA	NA	?	?
19	W, A, B	12,300,000	NA	No	NA	No
20	W, A, Ebb	>9,800,000	NA	NA	?	?
21	W, B, Ebb	>7,150,000	NA	NA	NA	?
22	I, A, B	14,450,000	NA	No	NA	No
23	I, A, Ebb	>11,950,000	NA	NA	?	?
24	I, B, Ebb	>9,300,000	NA	NA	NA	?
25	A, B, Ebb	>7,650,000	NA	NA	NA	?
26	W, I, A, B	19,100,000	NA	Yes	NA	Yes
27	W, I, A, Ebb	>16,600,000	NA	NA	Yes	Yes
28	W, I, B, Ebb	>13,950,000	NA	NA	NA	?
29	W, A, B, Ebb	>12,300,000	NA	NA	NA	?
30	I, A, B, Ebb	>14,450,000	NA	NA	NA	?
31	W, I, A, B, Ebb	>19,100,000	NA	NA	NA	Yes
	Total no.		7	15	12	27
	Combinations meeting sand needs.		1	2	2	4
	Not Determined				6	13

*Shoal B and Ebb Shoal are NA for these rows because they can not be dredged until some undetermined time in the future, thus they are ineligible for consideration. .

Intermediate volume need scenarios between the minimum 6,400,000 yd^3 and maximum 15,000,000 yd^3 would also be possible (and probably most likely). Proceeding from the minimum volume need towards the maximum volume need more shoals need to be dredged to honor the 5% maximum volume constraint.

It is not possible at this time to conclusively determine that the proposed dredging work could be conducted in full accord with all of the dredging constraints presented in Table 5-6 since the volumes of suitable sand available (Table 5-2) and delineations of sub-area boundaries are somewhat preliminary at this time. However, the preliminary total estimate of 67,600,000 yd^3 available from the combined identified sub-areas on Isle of Wight, Weaver, and Shoal A provide an indication that there would likely be latitude in use of sub-areas such that the dredging constraints could be largely honored. If Shoal B also becomes available, then the total sands preliminarily identified increases to 101,800,000 yd^3 available, further increasing the likelihood that constraints can be honored for the most part.

5.4.3 Sequence of Dredging

As was discussed previously, the ebb shoal and Shoal B are restricted from dredging until such time that further information indicates that dredging these shoals would pose no undue risk of harming Assateague Island or fisheries, respectively. Among the three remaining shoals, there is no preferred order of dredging from an environmental and fisheries perspective.

From an economic perspective, over the project life it is advantageous to use sand from as close to Ocean City as possible because transport costs from the borrow site to Ocean City are a major cost component. Other factors being equal and ignoring potential impacts to costs that the environmental and fisheries constraints might incur, it would be cheapest to bring sand in from the closest source(s). As was presented in Table 4-1, among the four candidate offshore shoals, Isle of Wight is the closest on average to the center of Ocean City. Accordingly, unless costs change over time in a manner that would cause dredging from farther offshore shoals to be cheaper now than in the future (such as from future accelerated increase in fuel costs), it would make sense from an economic perspective to mine the offshore shoals to the maximum suitable volume preferentially from inshore first and then proceed further offshore as sand is exhausted. (Note, however that this would give no consideration to future needs beyond the project life; this scenario could actually increase future project costs beyond the project life compared to what they might be otherwise because of fuel cost escalation or other factors.) Given the uncertainties in total sand needs, this would hedge towards spending money on the least expensive sand first. In the event it is not necessary to go further offshore for sand because the volume needs prove to be towards the minimum anticipated needs, then less money would have been spent on sand.

5.5 EVALUATION AND COMPARISON OF PLANS

5.5.1 Estimating Costs

Costs of beach nourishment are a function of a number of fixed and variable costs that combine to produce the total cost. The fixed costs remain the same regardless of the volume of sand to be placed on the beach. Mobilization and demobilization of the floating plant and land-based equipment comprise the fixed costs. The floating plant includes dredge, pipeline, and booster pumps. Land-based equipment includes bulldozers and front-end loaders. Variable costs in contrast depend upon cubic yards of sand nourished and include dredging cost and beachfill costs. The dredging cost includes dredging sand off the seafloor and transporting to the beach. Beachfill costs cover shaping the material once it reaches the beach. The baseline estimate for this project is at an October 1st, 2006 price level. Current dredging costs and historical data for the placement plan were used to develop the estimate. The total current working estimate includes all construction costs, contingency and escalation to cover future inflation. Based upon previous Baltimore District experience, it was assumed that application of a 15% contingency would cover cost estimate uncertainties independent of inflation. Contingencies represent allowances to cover unknowns, uncertainties, and/or unanticipated conditions that are not possible to adequately evaluate from the data on hand at the time the cost estimate is prepared but must be represented by a sufficient cost to cover the identified risks. Inflation factors are applied in the estimate to predict future costs.

This section summarizes the results of cost engineering efforts conducted to estimate costs of dredging either Isle of Wight Shoal, Weaver Shoal, or Shoal A. Costs of dredging sand from Shoal B were not estimated at this time because of the expectation of postponing any dredging of this shoal to some unknown point in the future. Additional detail is contained in a Cost Engineering Appendix available by request from the Baltimore District.

For future nourishment cycles that would take place every four years after 2010, escalation costs would have proportionally the same impact for each shoal. Thus, for this exercise escalation costs were not considered. Costs could potentially be affected by measures undertaken to minimize environmental impacts. However, dredging guidelines comparable to those presented in Table 5-6 had been applied during dredging conducted on Great Gull Bank to obtain sand for the Short-Term Restoration of Assateague Island project in 2002 (Section 1.5). These guidelines had no impact on dredging costs over what they would have been had dredging been conducted without environmental guidelines and constraints in place. Accordingly, it was assumed in this current analysis that no further consideration of environmental guidelines/constraints was required in estimating costs of alternatives.

Baseline cost estimates of beach nourishment for each nourishment cycle were prepared assuming the first dredging occurs during 2010 (Table 5-10). The mobilization/demobilization costs are equal for use of any of the offshore shoals because all involve the use of the same floating plant in the same manner. Dredging costs vary among the offshore shoals because of difference in transport distance. Although beachfill costs vary as a function of cubic yards of sand placed, they are the same among alternatives because the same land-based equipment would be used to shape the material regardless of source.

Table 5-10: Fixed and variable dredging costs for Weaver Shoal, Isle of Wight Shoal, and Shoal A individually in Federal Fiscal Year (FY)* 2010. Costs do not include contingency.

Shoal Borrow Source	Mobilization/ Demobilization $	Dredging Cost $/cy	Beach Fill $/cy
Weaver	2,200,000	7.18	2.42
Isle of Wight	2,200,000	7.23	2.42
Shoal A	2,200,000	7.89	2.42
Average of Three	2,200,000	7.43	2.42

*The Federal 2010 FY runs from October 1, 2009 to September 30, 2010.

Among the many potential dredging scenarios presented in Tables 5-8 and 5-9, the greatest difference in cost during any given nourishment cycle would be expected between those scenarios that make use of either borrow area individually. In contrast, use of more than one shoal during any individual nourishment cycle would tend to reduce differences in costs. Accordingly, to estimate the maximum difference in costs among the alternative sources to provide input towards selection of a preferred borrow plan, total baseline and contingency costs for dredging any one of these three sources individually were estimated. Table 5-11 presents costs for a routine nourishment volume of 800,000 cubic yards that is expected to be applied every four years in FY2010 dollars.

Table 5-11: Baseline and contingency costs of dredging 800,000 cubic yards from either Weaver Shoal, Isle of Wight Shoal, or Shoal A individually in FY2010 dollars. All costs rounded to the nearest $1,000.

Shoal Borrow Source	Baseline Costs				Maximum Contingency Cost (15%) $	Baseline Plus Contingency Maximum Cost $
	Mobiliza-tion/ Demobiliza -tion $	Dredging $	Beach Fill $	Total $		
Weaver	2,200,000	5,744,000	1,936,000	9,880,000	1,482,000	11,362,000
Isle of Wight	2,200,000	5,784,000	1,936,000	9,920,000	1,488,000	11,408,000
Shoal A	2,200,000	6,312,000	1,936,000	10,448,000	1,567,000	12,015,000
Average	2,200,000	5,947,000	1,936,000	10,083,000	1,512,000	11,595,000

The cost differences in dollars and percent difference in cost between dredging either Weaver or Isle of Wight Shoal individually is measured in only tens of thousands of dollars; the percent difference in costs is well below 1% (Tables 5-12 and 13). The difference in cost between dredging Shoal A versus either Weaver or Isle of Wight Shoal individually is more substantial at 5.75%, but still well-within the contingency estimate (Table 5-11).

Table 5-12: Difference in total baseline and baseline plus contingency costs of dredging among Weaver Shoal, Isle of Wight Shoal, and Shoal A. Comparison is to lower cost shoal.

Shoal to Shoal	Total Baseline Cost $			Baseline Plus Contingency Cost $		
	Weaver	Isle of Wight	Shoal A	Weaver	Isle of Wight	Shoal A
Weaver	0			0		
Isle of Wight	40,000	0		46,000	0	
Shoal A	568,000	528,000	0	653,000	607,000	0

Table 5-13: Difference in total baseline and baseline plus contingency costs of dredging among Weaver Shoal, Isle of Wight Shoal, and Shoal A. Comparison is to lower cost shoal.

Shoal to Shoal	% Difference in Total Baseline Cost $			% Difference in Baseline Plus Contingency Cost $		
	Weaver	Isle of Wight	Shoal A	Weaver	Isle of Wight	Shoal A
Weaver	0.00%			0.00%		
Isle of Wight	0.40%	0.00%		0.40%	0.00%	
Shoal A	5.75%	5.32%	0.00%	5.75%	5.32%	0.00%

5.5.2 Benefits and Impacts

Dredging of any given shoal could be conducted in a manner such as to minimize alteration of shoreline wave energy that could otherwise reduce project benefits. Sand from any of the alternative sources would provide the same storm protection benefits, so there would be no anticipated difference in economic benefits among various alternative dredging plans.

Environmental impacts among any alternatives formulated would be equivalent since all alternatives would be formulated to meet the same guidelines and constraints (Table 5-6). The value of long-term damages to habitat avoided would be equivalent among any alternatives formulated.

5.5.3 Cost-Benefit Analysis

Sand can be obtained most cost-effectively from Weaver Shoal because it has the least transport distance. However, it alone can not meet even the minimum volume scenario need of 6,400,000 cubic yards. Accordingly, it will be necessary to use an additional shoal to meet Ocean City's needs. Given the very minor increase in cost over Weaver of dredging Isle of Wight Shoal, this shoal in combination with Weaver Shoal would be the most cost-effective means of obtaining sand. Considering only costs, it would be appropriate to dredge up to the 5% volume of sand from Weaver and then progress to dredging Isle of Wight Shoal. Weaver and Isle of Wight Shoal are the most cost-effective means of obtaining sand up to a total volume need of 11,450,000 cubic yards. In the event that volume needs exceed 11,450,000, then considering only costs it would be appropriate to dredge 5% of the volumes each of Weaver and Isle of Wight Shoal before proceeding to dredge the remainder of needs from Shoal A. Although a cost estimate of dredging Shoal B was not determined, based on the greater transport distance, this shoal would be a less cost effective source of sand than Shoal A.

5.6 RECOMMENDED BORROW PLAN

There is a maximum of 5.75% difference in cost between dredging any of the three candidate shoals evaluated economically. There is substantial uncertainty over total future sand volume need and the volume of suitable beach sand actually contained within each of the identified borrow sub-areas. These realities warrant proposal of a flexible borrow plan as the recommended plan. Accordingly, it is recommended that Weaver, Isle of Wight, and Shoal A all be utilized as borrow sources for Ocean City for the remainder of the project life, pending maintenance of current fishery values of Shoal B and uncertainty over detrimental impacts to Assateague of increased dredging of the ebb shoal.

In order to verify that impacts of dredging are not detrimental to shoal geomorphology, it would be prudent to allow for passage of a substantial amount of time between redredging the same borrow area. Accordingly, it is recommended that borrow areas within the shoals be dredged generally in progression such that any given sub-area be given the maximum amount of recovery time possible between dredging. In light of the four year routine cycle and current determination of seven sub-areas that each possess greater than 800,000 cubic yards on Isle of Wight Shoal, Weaver Shoal, and Shoal A, it could potentially be possible to dredge the majority of the borrow subareas only once through the end of the project life in 2044. Individual shoals should be dredged in accordance with the guidelines and constraints presented in Table 5-6.

Whether or not the ebb shoal and Shoal B should be dredged would be most appropriate for reconsideration in the event that the environmental or fishery value of Weaver, Isle of Wight, or "A" increases with respect to Shoal B. Shoal B would not be appropriate for dredging unless it can be determined in coordination with other resource agencies and fishermen that it no longer has high importance as fishing ground. The ebb shoal would not be appropriate for additional dredging until such time that major concerns over potential negative impacts to Assateague Island are resolved. It is anticipated that information garnered under the auspices of the LTSM monitoring program would facilitate conducting appropriate analyses to make such a determination in the future.

SECTION 6

PROJECT IMPACTS

6.0 INTRODUCTION

This section assesses direct, indirect, and cumulative impacts of the proposed borrow actions described in the recommended plan as presented Section 5.6. The formulation of the borrow plan was provided in Sections 4 through 6. The impacts of not taking any action (the no-action alternative) and of dredging the rejected alternative borrow sites were discussed in Sections 3 through 5. Because sand would be transported to and placed on Ocean City beach in a manner consistent with sand placement practices utilized from the late 1980s through 2006, impacts of sand transport and placement on Ocean City beach, the inlet, coastal bays, and Assateague Island would be equivalent to those of current practices. Impacts of beach nourishment on these sites were assessed in the 1980 EIS, 1989 EA, and 1993 GDM EA (Section 1.6) and are hereby incorporated by reference. Accordingly, this section does not assess impacts of sand transport or placement since there would be no change in impacts. Although new borrow sites would be dredged, social and economic impacts of dredging would for the most part be the same as those of past and current dredging conducted for periodic beach nourishment. Accordingly, this section addresses social and economic impacts of dredging only where future impacts would be different from those of past impacts. This section does not assess impacts of potential future increased dredging of the ebb shoal to up to 20,000 cubic yards per year since impacts of this were evaluated previously in the 1998 EIS. Any future increased dredging of the ebb shoal at greater volumes would require completion of supplemental environmental studies and preparation of additional environmental documentation.

Direct impacts are those impacts that will occur at each borrow site at the time of dredging as a result of borrow activities. Borrow activities associated with the proposed dredging are described in the 404(b)(1) Analysis contained in Annex A. Indirect impacts are those impacts that occur after dredging and/or are removed in distance from the direct impact locations. Indirect impacts can be minor or in some cases, of even greater concern than the direct project impacts. Cumulative impacts result 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 actions. Cumulative impacts are discussed separately in Section 6.12. In order to provide a fair and comprehensive context for decision-making, the cumulative impacts section considers activities and conditions over a broader geographic region than is considered for each individual topic for which direct and indirect impacts are discussed.

Impacts that are likely to be important and issues of particular concern to the community and decision-makers are addressed at length; impacts that are likely to be negligible or minimal are addressed generally to limit the length of this document. A summary of project impacts is provided in Table 6-1. A Clean Water Act 404(b)(1) analysis for

Table 6-1 Summary of project impacts.

	Per Dredging Cycle						Entire Project Life (to 2044)					
	Direct			Indirect			Direct			Indirect		
	Type of Impact (1)	Range of Impact (2)	Duration of Impact (3)	Type of Impact (1)	Range of Impact (2)	Duration of Impact (3)	Type of Impact (1)	Range of Impact (2)	Duration of Impact (3)	Type of Impact (1)	Range of Impact (2)	Duration of Impact (3)
Physical Environment												
Physiography, Topography, and Bathymetry	C	WS	Y	C	WS	Y	C	WS	Y	C	WS	Y
Geology	C	WS	Y	C	WS	Y	C	WS	Y	C	WS	Y
Soils	N/A	N/A	N/A	*	N/A	N/A	N/A	N/A	N/A	*	N/A	N/A
Hydrology	*	N/A	N/A	*	WS	Y	*	N/A	N/A	*	WS	Y
Air Quality	A	L	M	N/A	N/A	N/A	A	L	Y	N/A	N/A	N/A
Water Quality	*	L	M	N/A	N/A	N/A	*	L	M	N/A	N/A	N/A
Habitats	A	WS	Y	*	WS	Y	A	WS	Y	*	WS	Y
Living Things												
Phytoplankton	*	N/A	N/A	N/A	N/A	N/A	*	N/A	N/A	N/A	N/A	N/A
Submerged Aquatic Vegetation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Wetlands	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Upland Vegetation	N/A	N/A	N/A	*	N/A	N/A	N/A	N/A	N/A	*	N/A	N/A
Zooplankton	*	N/A	N/A	N/A	N/A	N/A	*	N/A	N/A	N/A	N/A	N/A
Invertebrates	A	WS	Y	*	WS	Y	A	WS	Y	*	WS	Y
Finfish	*	WS	M	A	WS	Y	*	WS	M	A	WS	Y
Wildlife (4)	*	WS	M	A	WS	Y	*	WS	M	A	WS	Y
Rare, Threatened, and Endangered Species	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Community and Socioeconomic Setting												
Cultural and Historical Resources	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Population	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Economics	*	WS	Y	B	WS	Y	*	WS	Y	B	WS	Y
Transportation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Navigation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Infrastructure	*	WS	Y	B	WS	Y	*	WS	Y	B	WS	Y
Land Use	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Public Health and Safety	*	WS	Y	B	WS	Y	*	WS	Y	B	WS	Y
Visual and Aesthetic Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Noise	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Recreation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Commercial and Recreational Fishing	A	WS	M	A	WS	Y	A	WS	Y	A	WS	Y
Parks	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HTRW, FUDS, MEC	*	L	M	N/A	N/A	N/A	*	L	M	N/A	N/A	N/A

1 A = Adverse
B = Beneficial
* = Negligible
C = Change that is neither + or -
N/A = Not Applicable

2 L = Local
WS = Wide Spread
N/A = Not Applicable

3 D = Days
M = Months
Y = Years

4 Does not include endangered/threatened species

activities that involve discharge of dredged or fill material into waters of the United States is contained in Annex A.

New dredging will occur several miles offshore and cause no direct impacts to Fenwick and Assateague Islands. Based on the nominal volume to be removed compared to each shoal's total volume, avoidance of the crest, dredging conducted uniformly over a wide area such that no major bathymetric changes are produced, and relatively great distance offshore, it is not anticipated that the proposed dredging would alter energy of waves striking the shore during normal or storm conditions (see Annex C5 for additional information). Accordingly, direct and indirect impacts to Fenwick and Assateague Islands are not considered further in this section. Provided that funding for the authorized Atlantic Coast and Long-Term Sand Management (LTSM) Projects is received, the shorelines of Fenwick and Assateague Islands will be periodically monitored through the years 2044 and 2029, respectively. In the unlikely event that anomalously high wave energy and or shoreline retreat occurs at Fenwick or Assateague Islands that could potentially be attributed to the proposed dredging described in this SEIS, data collected under these projects would be interrogated to determine the cause and formulate alternative strategies to mitigate this risk. Additionally, in the event additional monitoring or data collection efforts were determined to be necessary, additional monitoring could be supported from Atlantic Coast Project continuing construction funds.

The discussion of environmental impacts of the project is based on ERDC hydrodynamic and beach response modeling (additional information this can be found in engineering appendices listed in the Table of Contents that are available by request from the Baltimore District); consultation with environmental resource agency personnel, scientists and engineers from academia and private firms, and the general public (Annex E); and previous U.S. Army Corps of Engineers (USACE), other agency, and scientific/engineering reports and studies.

6.1 PHYSICAL ENVIRONMENT

Project impacts to non-living components of the physical environment are reported in this section. Value judgments over whether these impacts are positive or negative are included for water quality and air quality (Sections 6.1.1 and 6.1.3, respectively) based on how these impacts relate to established criteria to protect human beings and aquatic life, but are not included for the other physical environment topics considered in Section 6.1. Value judgments over whether project impacts are positive or negative to environmental quality, living resources, and people are contained in remaining subsections of Section 6.

6.1.1 Physiography, Topography, and Bathymetry

Direct Impacts
In accordance with the borrow plan (Section 5.2.2.4.3), dredging will be conducted in a manner to remove a uniform thickness of material from within the identified borrow areas. The shoal crests will be avoided, thus no direct impact to shoal maximum relief is

anticipated. Dredging would deepen the borrow sub-areas on each shoal by one to several feet during each beach nourishment cycle. It is possible that dredging within one beach nourishment cycle could lower borrow area relief by as much as 10 feet. Within the borrow areas, if a hopper dredge is used, dredging may create a series of parallel furrows in the seafloor up to several feet deep the length of the borrow area, with remnant un-disturbed ridges left between the furrows. In all cases though, total thickness dredged over the project economic life until 2044 would be no more than about 10 feet from initial shoal height at any location. At each borrow site, minor slumping from adjacent areas may occur during dredging. The remainder of each shoal outside of the borrow areas would be left in its existing condition. Following dredging, each offshore shoal's general profile will be maintained, although at a lower elevation within the borrow area than pre-project conditions.

The bottom area impacted within each sub-area during a typical anticipated borrow action would be a function of volume of sand needed and thickness of material dredged, but would be significant environmentally each borrow cycle. For a typical anticipated beach nourishment cycle in which 800,000 cubic yards of sand is dredged, bottom area impacted would range from a maximum of 500 acres if an average of 1 foot of material is dredged to a minimum of 50 acres if 10 feet of sand is dredged (Annex B). Approximate bottom area that would be impacted through 2044 if the entire surface area in each preferred sub- area is dredged is presented in Table 6-2. In any given beach nourishment dredging effort, impacts could potentially occur over the entirety of any of the identified subareas. It is also possible that dredging could occur in more than one subarea during any given beach nourishment event. Accordingly, it is probably reasonable to assume that approximately 500 acres (0.8 square miles) of bottom would be dredged every four years. In the event major rehabilitation is necessary to repair severe storm damage (Section 1.0), volume need could perhaps be as much as 1,600,000 cubic yards based on project history, and dredging during rehabilitation efforts could perhaps impact as much as 1,000 acres. The total bottom area that would be impacted over the project life to 2044 if all sub-areas are dredged would be significant and would be approximately 4,600 acres (7.2 square miles).

Table 6-2: Borrow area impacts.

Shoal	Sub-area	Impact Area (acres)	Impact Area (mi2)	Volume of Suitable Material Present (cubic yards)	Maximum Volume of Material to be Removed (cubic yards)*
A	I	290	0.45	3,800,000	5,150,000
A	III&IV	580	0.90	6,800,000	
B	I-Rev	1690	2.64	34,200,000	2,500,000
Weaver	I	320	0.50	7,400,000	4,650,000
Weaver	IIA&B	680	1.06	18,900,000	
Isle of Wight	I&II	1030	1.61	30,700,000	6,800,000
Total		4,590	7.16		

*See Section 5.2.2

Indirect Impacts
Conducting dredging according to the borrow plan would be expected to maintain the general bathymetric character of the offshore shoals into the future. Over a period of years to decades following dredging, it is likely that some infilling of the borrow area will occur as natural processes transport material from adjacent areas of the shoal to the borrow area. Over centuries to millennia, as the shoals continue to evolve, the shoal elevation and total area will likely be reduced somewhat as the condition of each shoal adjusts into a new dynamic equilibrium with respect to the reduced volume of sand retained within the feature. It is anticipated that the ultimate loss of elevation when the feature attains a new dynamic equilibrium with its reduced volume will be less than 1 foot (see Figure 2-5 and Annex B for additional information on relationship between shoal volume and relief). Impacts to each offshore shoal's total area, length, or width would not be as readily predictable from the change in volume, given that there does not appear to be a close correlation between these attributes of these features to volume. However, in accordance with the volume removals being no more than about 5% of the features' total volume, it is not anticipated that feature width, length, or total area will change substantially.

6.1.2 Geology

Direct Impacts
In accordance with the borrow plan (Section 5), dredging volumes to be removed will be apportioned among the shoals proportionally to each shoal's total volume such that no more than about 5% of any one shoal's volume would be removed. This excavated volume will not be replaced in the foreseeable future by natural processes and can be considered a permanent loss (see irretrievable losses 6.7). Sand underlying the material to be removed is similar in grain size to the sand to be removed; so the post-project shoal surface substrate is expected to be similar in character to the pre-project surface.

Indirect Impacts
Some post-construction movement of material into the borrow areas by slumping from adjacent areas is expected. Currents and waves will transport sand into the borrow areas from adjacent shoal areas. Sand slumping into or transported into the borrow areas from adjacent areas of the shoal over time would be similar in grain size to the sand to be removed; so the post-project shoal surface substrate is expected to be similar in character to the pre-project surface.

6.1.3 Soils

No direct or indirect impacts to soils would occur since dredging of the offshore shoals would take place several miles offshore. No impacts to prime farmland would occur since none occur on the seafloor of the continental shelf.

6.1.4 Hydrology/Hydrodynamics

No direct impacts are anticipated during dredging because of the vastness of the ocean. Since dredging will avoid the crests, wave energies that typically concentrate along the crests during northeaster storms would be expected to continue. However, since dredging would increase water depths in adjacent areas, there may be some minor reduction in wave energies at the ocean surface in the shallowest areas that are dredged.

6.2 AIR QUALITY

Operation of dredges, tugboats, bulldozers, trucks, and other heavy equipment will release air pollutants into the project area where equipment is operated. Notable air pollutants released will include nitrogen oxides (NOx), with smaller amounts of SO2, volatile organic compounds (VOC), carbon monoxide (CO), and particulate matter. During construction occurring during any period of time when winds are light, relatively high air pollutant concentrations may temporarily occur in localized areas. Because a greater transport distance will occur to bring sand ashore than under previous practices, the quantity of air pollutants generated will increase.

In accordance with the Clean Air Act, a determination must be made as to whether proposed Federally sponsored or approved projects conform to state air quality improvement plans. In coordination with Maryland Department of the Environment MDE (Annex C), it was determined that because Worcester County is in attainment with EPA air quality standards, there are no air pollution emission thresholds that must be met for this project, and MDE requires no formal air quality impacts analysis. Accordingly, this project is in compliance with stipulations of the Clean Air Act. Over the project life through 2044, it is likely that air quality regulations and air quality will change. In that event, this issue may need to be revisited in the future to reassess that this conclusion is still valid.

6.3 WATER QUALITY

Direct Impacts
There will be short-term turbidity increases to ocean waters in the area of the new offshore shoal being dredged at the time of dredging. However, the shoals contain primarily sand with only minimal silts and clays present. Accordingly, sediments that are stirred up would be expected to be predominantly sands and rapidly resettle to the bottom. No substantial detrimental impacts to water quality are expected. All work will be performed in accordance with the State of Maryland Water Quality Certificate.

Indirect Impacts
No long-term impacts are expected since water quality impacts would only occur at the time of dredging and this will only occur only during project construction. No long-term increase in the rate of erosion or sediment re-suspension from the offshore shoal surface is expected.

6.4 HABITATS

Habitat conditions on the offshore shoals would be impacted as described in Section 6.1. These impacts are expected to be significant and pronounced over the short-term at each borrow site by virtue of the shear magnitude of area impacted, but are expected to become progressively less over the long-term. A significant area of benthic habitats would be destroyed during dredging on each new borrow area. It should be noted that the borrow plan described in Section 5 designed to reduce the risk of permanently altering shoal geomorphic character would cause dredging impacts to be spread out over a large area during each dredging cycle, effectively causing an increase in direct impacts to benthic habitats over alternative rejected borrow plans that would remove material from a smaller area. However, over time it is anticipated that comparable habitat conditions to those destroyed would be restored by natural processes and that long-term benthic habitat impacts would thus be minimal. Short-term impacts to the shoals as habitat for finfish would also be significant as a consequence of the scale of bottom area that would be impacted. However, long-term impacts are anticipated to be minimal since the overall geomorphologic integrity of each shoal is expected to be maintained. USACE has completed an Essential Fish Habitat (EFH) impacts analysis pursuant to the requirements of the Magnuson-Stevens Fishery Conservation and Management Act that provides more detailed information on likely consequences of these habitat alterations to commercial fish species. USACE has determined that the proposed project will adversely affect EFH, but that the project complies with the provisions of the Magnuson-Stevens Act, as amended, because the proposed borrow plan incorporates appropriate mitigation measures. A copy of the EFH analysis is included in Annex D.

6.5 LIVING THINGS

This subsection covers impacts to animals and plants; impacts to people are covered in Section 6.6.

6.5.1 Plants

6.5.1.1 Phytoplankton

No significant impacts are expected because phytoplankton are widely dispersed throughout the study area and no notable concentrations would be anticipated in the project area. No notable change in water quality which could cause change phytoplankton concentrations is anticipated.

6.5.1.2 SAV and Wetlands

No impacts to these resources are expected because none occur in study area ocean waters.

6.5.1.3 Upland Vegetation

No impacts to upland vegetation is expected because none occurs in study area ocean waters and no beach impacts are expected.

6.5.2 Animals

6.5.2.1 Zooplankton

No significant impacts are expected. Zooplankton are widely dispersed throughout the study area and no notable concentrations would be anticipated in the project area that could be impacted by project activities. No notable change in water quality which could cause changed zooplankton concentrations is anticipated.

6.5.2.2 Invertebrates

Direct Impacts
Dredging will destroy relatively nonmotile benthic invertebrates that occur at each borrow site at the time of dredging. During dredging efforts associated with a typical beach nourishment volume need of 800,000 cubic yards, up to approximately 500 acres of relatively nonmotile benthic invertebrates would be destroyed. However, in the event rehabilitation is necessary to repair damage from a severe storm (Section 1.0), impacts during a single dredging season could perhaps be as great as 1,000 acres. Total impact area over the project life would likely be on the order of about 4,600 acres, or 7.2 square miles. This would be almost 10% of the total 75 square mile area of large shoals surveyed by Maryland Geological Survey up to 13.1 miles offshore. Destruction of benthic invertebrates will be significant locally at each borrow area at the time of dredging by virtue of shear size of the area that will be impacted. Underlying sands lacking benthic populations will be exposed and will become the new shoal surface following dredging. Some relatively nonmotile benthic invertebrates will survive on remnant undisturbed habitats within the borrow areas (such as on ridges between dredging furrows). As was described in Section 6.4, reducing the risk of altering shoal geomorphic character to minimize indirect impacts to benthos and finfish that use the shoals as habitat over the long-term requires the trade-off of spreading out dredging over a larger area with concomitant increases in direct impacts to benthic invertebrates.

Juveniles and adults of highly mobile benthic invertebrates such as crab species and swimming invertebrates such as squid should be able to relocate to avoid disturbance or destruction. Egg of squid would not be impacted because they would not be expected to be present on the bottom in the dredging areas. Crab eggs would be destroyed if adult crabs on which they are carried are destroyed. Planktonic larvae of these organisms would be widely dispersed and although individuals could be entrained in the dredge and destroyed, no population impacts would be expected.

Indirect Impacts
The substrate remaining at the shoal after dredging will consist of sediment of the same character as the pre-project surface substrate. Recovery time of the benthic animals within the borrow areas is expected to be relatively rapid for many organisms because of the relatively high energy nature of the site, mobile sand substrate, relatively depauperate benthic community that occurs on the shoals, and proximity of the borrow area to remnant undisturbed and adjacent habitats containing sources of propagule material. Based on research conducted by Newell and others (1998), colonization of the borrow area by benthic organisms from residual unimpacted areas and adjacent areas is expected within several months to a year following dredging. Because the existing benthic invertebrate community is thought to be low in species richness, faunal density, and biomass, the community that recolonizes would be expected to achieve levels at least as great as pre-project conditions. Although short-term impacts will be locally significant, long-term impacts are expected to be insignificant. The dredging plan developed for the project should serve to minimize impacts to shoal character, thus promoting recolonization of the area by benthos comparable to those that occur at the site under pre-project conditions, and minimizing long-term detrimental impacts to benthos.

6.5.2.3 Finfish

Direct Impacts
Direct impacts to the offshore shoals include a short-term increase in turbidity during dredging and destruction of bottom habitats. These activities may disturb finfish, which would be expected to relocate to adjacent undisturbed areas. Individual bottom-dwelling finfish may be entrained into the dredge and destroyed during dredging. Finfish incurring greatest impacts would be for bottom-dwelling species with a high degree of affinity to the offshore shoals. Among these, sand lance would perhaps be the finfish species most greatly impacted since they are highly associated with shoals although they also occur over/in sand elsewhere. However, no detrimental impacts to the populations of any finfish are expected from the proposed project because the number of finfish that will be destroyed will be nominal compared to the total numbers of individuals of finfish that inhabit the mid-Atlantic. Impacts to finfish species regulated under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act are described in Annex D.

Indirect Impacts
The dredging plan developed for the project is expected to maintain the shoal crest, general shape, and sand grain-size of each shoal. Consequently, the shoal is expected to maintain its habitat functions for finfish and minimal long-term impacts to finfish are expected.

6.5.2.4 Wildlife

This section only includes amphibians, reptiles, birds, and mammals not recognized to be endangered, threatened, or rare by the Federal government or the State of Maryland.

Potential impacts to these special status species are considered in *6.5.3 Rare, Threatened, and Endangered Species*.

Direct Impacts
Wildlife using the shoals may relocate to other areas as a result of disturbance caused by dredging. Since comparable shoal habitats are available elsewhere in adjacent waters that wildlife can relocate to, this impact would not be expected to be significant. Because of their great mobility, collisions with dolphins would be highly unlikely.

Indirect Impacts
Since shoal geomorphologic integrity is anticipated to be maintained, it is anticipated that the fundamental habitat attributes of the shoals will be maintained and consequently that the shoal habitat functions performed today will continue to be performed into the future. Increased water depths on the flanks of the shoals may reduce the quality of the shoals as foraging areas for seabirds that dive to feed on the shoals.

6.5.3 Rare, Threatened, and Endangered Species

Direct Impacts
Direct impacts to sea turtles could be avoided either by restricting dredging from the end of March through November or by modifications to dredging equipment and methods. Unfortunately, weather conditions (primarily northeasters) often make it unsafe to dredge from October through March; therefore, it is not possible to complete the project during the time of year when sea turtles would be absent from the project area. Instead, mitigation measures required by the National Marine Fisheries Service (NMFS) under the tenets of the Endangered Species Act to protect sea turtles would be utilized. These measures include outfitting dredges with sea-turtle deflectors, conducting dredging operations in a manner to minimize risk of sea turtle entrainment, crew training, and the use of NMFS-approved observers. These protective measures are stipulated in a November 2006 Biological Opinion (BO) prepared for the study by NMFS (Annex C).

No turtle takes were incurred from the time of preparation of the BO in 1998 through 2006 periodic nourishment work of Ocean City. Although it can be hoped that no turtle takes would occur for the remainder of the project life, this is probably unrealistic. Accordingly, NMFS issued a species-specific incidental take statement for fresh dead sea turtles (takes) as a function of volume of sand dredged (Table 6-3) that exempts destruction of one Kemp's ridley sea turtle for every 10 loggerheads over the project life. (Under the Endangered Species Act, an incidental take statement allows for the destruction of individuals of a Federally-endangered or threatened species incidental to the pursuit of the otherwise lawful action, without the project violating the Endangered Species Act). Destruction of Kemp's ridely sea turtles at greater than this ratio is not exempt. No take of green sea turtles is exempted. If incidental take is exceeded then consultation will be reinitiated with NMFS to determine how to proceed.

Table 6-3: Incidental take exempted in November 2006 BO.

Volume to be Dredged Per Cycle (cubic yards)	Number of Sea Turtle Takes Exempted
Up to 500,000	1
More than 500,000 up to 1,000,000	2
More than 1,000,000 up to 1,500,000	3
More than 1,500,000 up to 1,600,000	4

It is unlikely that any whales will be in the project area during dredging or placement of material. To date, there have been no known collisions between marine mammals and dredges on the continental shelf in Federal waters according to the Minerals Management Service (MMS). NMFS in its BO determined that these actions are not likely to adversely affect whales.

Indirect Impacts
None are expected to any of the rare species occurring in project area waters. Open water and seafloor habitat conditions will largely recover to those of pre-project conditions within months to years of dredging. Abundant comparable habitat that will not be disturbed will remain in adjacent waters and availability of benthos forage is not currently limiting to the populations of any of these species.

6.6 HUMAN ENVIRONMENT / COMMUNITY SETTING

6.6.1 Cultural and Historic Resources

In accordance with Section 106 of the National Historic Preservation Act (NHPA), Dr. Susan Langley of the Maryland State Historic Preservation Office (SHPO) was contacted by telephone on January 27, 2003. Because the four candidate borrow areas are located outside of the three-mile limit controlled by the State of Maryland, the SHPO does not regulate activities in these waters. However, the SHPO requested that they be provided due notice and permitted opportunity to monitor the placement of sand in an attempt to identify any offshore artifacts which might have been entrained into the dredge. A Memorandum for the Record regarding this telephone consultation is included in Annex E.

The Federal government is required to comply with the NHPA in Federal waters, however. No shipwrecks are known to exist on Weaver Shoal, Isle of Wight Shoal, Shoal A, or Shoal B, other than for purposefully-placed artificial reef materials. However, to conclusively determine whether historic shipwrecks are located within sand borrow areas in Federal waters, MMS policies require side-scan sonar and magnetometer surveys be conducted prior to issuance of a permit for dredging. MMS guidelines require 30 meter or closer spacing of these survey lines. Accordingly, these investigations will be conducted in the future prior to dredging of the new offshore shoal sites. Additionally, cultural resource investigation would include review of future core data in the event materials are recovered during further geotechnical investigations. In the event culturally or historically significant materials are documented to exist, a mitigation plan would likely be developed to ensure that further disturbance to the site containing these materials is presented.

6.6.2 Population

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no impacts to people are expected.

6.6.2.1 Environmental Justice

No adverse impacts to minority or low income communities are expected since no new impacts to people are expected.

6.6.3 Economics

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no economic impacts are expected.

6.6.4 Transportation

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no impacts to transportation are expected.

6.6.5 Navigation

Direct Impacts
Dredging of the new borrow areas will require limits to navigation in the new borrow areas during dredging, but would otherwise have no direct impact on navigation. These areas have not previously been dredged, thus navigation restrictions in these areas will be new to mariners and boaters. Measures currently employed to minimize navigation hazards during dredging and during dredge transits from the borrow areas to pumpout stations will be utilized at the new borrow sites and new routes. Notice to mariners will be given prior to new dredging. Other than for the change in routes and borrow sites, direct impacts to navigation from the new work will be comparable to that of impacts from dredging the previously used sites.

The floating plant used to transport material to the beach from the pumpout station will be equivalent to those currently used, thus no new direct or indirect impacts to nearshore navigation will occur.

Indirect Impacts
Dredging of the new sites will increase water depths on the shoal flanks and may locally change wave energy. Noindirect impacts to navigation are expected since regional waves and bathymetry is not expected to be changed.

6.6.6 Infrastructure

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no impacts to infrastructure are expected.

6.6.7 Land Use

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no impacts to land use are expected.

6.6.8 Public Health and Safety

Since all new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands are expected, no impacts to public health and safety on land are expected. Risks to mariners will be minimized through measures discussed in Section 6.6.5.

6.6.9 Visual and Aesthetic Values

All new dredging will occur several miles offshore and no new direct or indirect impacts to Fenwick or Assateague Islands aesthetic values are expected. Physical presence of dredges at the new borrow sites will temporarily alter aesthetics at those sites during dredging. No indirect impacts are expected following completion of dredging.

6.6.10 Noise

New dredging noise will be produced at the new borrow sites during dredging. Noise impacts are expected to be temporary and insignificant. Noise is not expected to significantly impact wildlife.

6.6.11 Recreation (Other than Fishing)

All new dredging will occur several miles offshore and no new direct or indirect impacts to recreation on Fenwick or Assateague Islands are expected. Impacts to recreational boaters are covered under Navigation.

6.6.12 Fishing: Commercial and Recreation

Direct Impacts
No dredging of Shoal B will occur unless it is determined that the relative value of that shoal as a fishing grounds declines. Consequently, impacts to fishermen on Shoal B would be postponed until such time as dredging impacts would be minimal. In the event Shoal B's value as a fishing grounds declines and dredging is conducted there, no dredging would occur in the fish havens (artifical reefs) there to minimize impacts to these recreational fishing areas. If the fishing value of Isle of Wight, Weaver, or A are determined to increase in the future in coordination with resource agencies, borrow actions would be modified to minimize impacts to the fishery.

Dredging will generate turbidity; however, sediments are expected to rapidly settle out of suspension because of the coarse grain size of the material, and minimal impacts are expected to the fish havens. During construction, recreational and commercial fishermen would suffer a temporary loss of fishing opportunities in the areas to be dredged since they will need to stay out of areas to be dredged to avoid collisions with the dredge.

Surf clam, whelk, and other slow-moving or relatively non-motile commercially valuable benthos inhabiting each borrow area are likely to be destroyed during dredging. It is anticipated that it would take months to years for populations of these organisms to recover in any given borrow area following dredging. While this would also effectively prevent these organisms from being commercially harvested and thus constitute a loss to fishermen, commercial fishing pressure on Isle of Wight, Weaver, and "A" appears to be limited, and it is likely that commercial fishermen could instead succeed equally well at other sites in the vicinity during the dredging and recovery period following.

Indirect Impacts
No long-term impacts are expected since following dredging commercial and recreational finfish are anticipated to readily return to dredged areas, although benthos that provide forage for these species would take months to recover to pre-dredging conditions. Thus, there would a several month period of reduced forage base for any finfish strongly associated with the seafloor of the dredged areas. No substantial alterations to the character of the offshore shoals are expected; the surface and overall configuration of the shoal will only be slightly altered from pre-project conditions, and hydrodynamic conditions will not be altered. Consequently, fishing opportunities are expected to be similar in the future to those of today.

6.6.13 Parks

No direct impacts to Assateague Island National Seashore, Assateague State Park in Maryland, or Fenwick Island State Park in Delaware are anticipated since no work would occur within these areas, and no environmental alterations that could affect these areas would occur.

6.6.13.1 Wild and Scenic Rivers

There are no federally designated wild or scenic rivers within the project area. Consequently, no impacts are expected.

6.6.14 Hazardous, Toxic, and Radioactive Waste (HTRW); Formerly-Used Defense Sites (FUDS); and Munitions and Explosives of Concern (MEC)

Because of their remote location offshore, lack of industrial activity in close vicinity, and coarse-grained sand composition, the offshore shoals are not likely to contain hazardous or toxic contaminants. Consequently, no impacts to the environment that could occur from liberating such materials or safety risks to dredging crews or beach-users would be anticipated.

However, there is a moderate probability that munitions and explosives of concern (MEC) occur on or within the offshore shoals. To mitigate for the chances of encountering and dredging MEC from the borrow area it is anticipated that one or both of the following courses of action would be followed:

1. Place a screening mechanism on the intake of the dredging apparatus to restrict the smallest of the potential MEC items from entering the dredging process. If this process is used, a quality assurance process should be used to ensure the screening mechanism is effectively removing MEC from the dredged sand.

2. Screen the sediment as it is pumped to the beach. The screen would need to be sized to the smallest MEC item expected. A quality assurance process should be used to ensure the screening mechanism is effectively removing MEC from the dredged sand.

By utilizing one or both of these measures, it is anticipated that MEC would be prevented from being dredged and pumped onto the Ocean City beach.

6.7 IRRETREIVABLE USES OF RESOURCES

The sand contained in the new offshore shoals proposed for dredging is essentially irretrievable because it is not anticipated that these features would accrete equivalent volumes of sand via natural processes for many human lifetimes, if at all. Mitigation measures proposed with the objective of maintaining the geomorphic integrity of these features are anticipated to ensure the continued existence of the shoals though, albeit at a lower elevation off the seafloor and covering a lesser area. Thus, although the sand will be an irretrievable loss the features themselves will not be.

Transport of sand to Ocean City from the proposed new borrow sources would consume a greater quantity of fossil fuel per shipload compared to the previously-used borrow areas because the proposed new borrow sites lie farther offshore (Tables 2-3 and 4-1) and the travel distance would increase. The average distance traveled from Weaver Shoal, Isle of Wight Shoal, and Shoal A to the Ocean City beach would generally be more than twice as far per shipload of sand. The average distance traveled from Shoal B to the beach would generally be more than three times as far as the previously-used borrow areas.

6.8 CUMULATIVE EFFECTS

Borrow material for the Atlantic Coast of Maryland Project through 2044 has been identified in this study. Since the LTSM project now provides sand for Assateague Island to compensate for jetty-induced losses from the inlet vicinity, it is presumed that no additional sand from detached nearshore or offshore sources will be needed to maintain the geologic integrity of Assateague Island.

The proposed dredging of offshore shoals to supply sand for the Atlantic Coast of Maryland Project through the year 2044 will contribute cumulatively to past impacts already incurred as a result of state and Federal dredging of sand from Maryland detached nearshore and offshore shoals from the late 1980s through present (Table 6-4 and Annex D). Past borrow actions to obtain sand for Ocean City altered the geomorphic character of Borrow Areas 2, 3, and 9; measures to minimize impacts of dredging on the shoals as habitat were not specifically considered in advance. In contrast, dredging of Great Gull Bank for Assateague Island was conducted in accordance with guidelines to minimize impacts to shoal geomorphic character, and information available to date indicates that dredging did not substantially impact the geomorphic character of that shoal (Appendix B). Future dredging of Isle of Wight Shoal, Weaver Shoal, and Shoal A (and possibly Shoal B) by USACE would be conducted with mitigation measures effectively and or purposefully incorporated into the borrow plan. Consequently, of the 22 large detached nearshore and offshore shoals inventoried by Maryland Geological Survey (MGS) within 13.1 miles of the shoreline (Section 2.1.1), it is expected that the geomorphic character of only the three shoals previously dredged for borrow for Ocean City would potentially be substantially altered by the cumulative impacts of Federal and state actions. The remainder would incur minimal or no impacts. Additional smaller shoals and other large shoals farther offshore not surveyed by MGS occur off Maryland. Accordingly, although cumulative impacts of the proposed dredging combined with past dredging are substantial, it is not expected that this dredging would have other than a minor detrimental cumulative impact on habitat functions for marine life of the Continental Shelf off Maryland.

Table 6-4: Detached Nearshore and Offshore Shoal cumulative impacts history

Project	Completion Date	Sand Placed (Cubic yards)*	Sand Source
Ocean City State Recreational Beach Fill	Sep-1988	2,700,000	Borrow Areas 2 & 3
Atlantic Coast Storm Protection Beach Fill	Oct-1991	3,800,000	Borrow Areas 2 & 3
Atlantic Coast Rehabilitation #1	Sep-1992	1,600,000	Borrow Area 3
Atlantic Coast Rehabilitation #2	Oct-1994	1,200,000	Borrow Area 9
Assateague National Seashore Emergency	Sep-1998	134,000	Great Gull Bank
Atlantic Coast Renourishment #1	Oct-1998	1,300,000	Borrow Area 9
Atlantic Coast Renourishment #2	Jun-2002	745,000	Borrow Area 9
Assateague State Park Sand Placement	Summer 2002	95,000	Great Gull Bank
Assateague Island Short-Term Restoration	Dec-2002	1,800,000	Great Gull Bank
Atlantic Coast Renourishment #3	Nov-2006	932,000	Borrow Area 9
Total		14,306,000	

Dredging conducted for Ocean City and Assateague Island has placed 14,306,000 cubic yards of sand from detached nearshore and offshore shoals on the beach. In the event that future frequent severe storms occur, Atlantic Coast of Maryland Project sand needs out to 2044 could potentially be as great as 15,000,000 cubic yards (Section 3.1). Total cumulative volume of sand dredged from Continental Shelf detached shoals in Federal and state actions by 2044 would then exceed 29,000,000 cubic yards. While this is a substantial volume of sand, the total volume of sand known to occur in the 22 large shoals inventoried by MGS exceeds 1,236,000,000 cubic yards (Section 2.1.1). Additional sand occurs within smaller shoals and in other large shoals farther offshore not surveyed. Accordingly, it is anticipated that cumulative effects of dredging for Ocean City and Assateague Island will only consume a small fraction of the total volume of sand contained in the detached nearshore and offshore shoals.

The proposed dredging work would also contribute cumulatively to impacts of commercial fishing trawling gear. Churchill (1989) determined that as much as about 1/3 of the seafloor off the Maryland coast out to about 30 miles offshore was disturbed by commercial trawling activity in the single year 1985. This is roughly about 300 square miles of bottom disturbance in this 900 square mile area in that year. Assuming that the 1985 estimate would still apply today, and dividing the 0.8 square miles of bottom dredging impact every four years by four to produce an annual estimate of bottom disturbed by borrow dredging, then the proposed dredging for sand would cumulatively add about 0.25 square miles of additional seafloor bottom disturbance annually to that caused by commercial fishermen. However, it should be noted that the magnitude of bottom habitat disturbance within the dredged areas could be nearly complete (other than missed patches and ridges) and extend to as much as 10 feet below the current surface, whereas bottom disturbance caused by trawling although causing substantial disturbance to surface dwelling organisms and habitat structure is likely to have minimal subsurface impact.

No other future large-scale dredging to obtain sand independent of its use for beach nourishment on Ocean City is proposed at this time. However, it is possible that future demand for gravel and sand for construction purposes on land may drive additional seafloor mining, including on the offshore shoals. In that event, those impacts would act cumulatively with those described above. Geomorphic integrity of any of these shoals and their habitat functions may be jeopardized if repeated large-scale borrow actions beyond those formulated in this project are undertaken in the future.

6.9 COMPLIANCE WITH ENVIRONMENTAL STATUTES

Tables 6-5 and 6-6 outline the statutes and executive orders that are potentially applicable to the project, including the level of compliance. This section provides an overview of major potential relevant compliance concerns. Although the proposed dredging would be conducted under the auspices of the existing Atlantic Coast Project, it represents a substantial modification in the project since new dredging sites and methods are proposed. Accordingly, this proposed work requires reevaluation for compliance with environmental statutes.

In coordination with the Baltimore District Office of Counsel, it was determined early in the General Reevaluation Study (Section 1.2) that an SEIS would be the appropriate National Environmental Policy Act (NEPA) document for the proposed new dredging work in light of the magnitude of new potential seafloor impacts. Information on coordination undertaken to meet NEPA requirements is provided in Section 7.

Table 6-5: Compliance of the proposed action with relevant Federal environmental protection statutes.

Federal Statute	**Level of Compliance[1]**	**Notes**	**Report Section**
Abandoned Shipwreck Act of 1987	Full	2, 3	6.6.1
Archeological and Historic Preservation Act	N/A		
Clean Air Act	Full		6.2, Annex C
Clean Water Act	Full	2	6.3, 6.9, Annex A
Coastal Barrier Resources Act	N/A		
Coastal Zone Management Act	Full	4	6.9
Comprehensive Environmental Response, Compensation and Liability Act	N/A		
Endangered Species Act	Full		6.5.3, 6.9
Federal Water Project Recreation Act	N/A		
Fish and Wildlife Coordination Act	Full		7.2, Annex C
Fish and Wildlife Conservation Act	N/A		
Magnuson Fishery Conservation and Management Act	Full	5	6.9, Annex D
Marine Mammal Protection Act	Full	2	6.5.2.4, 6.5.3, Annex C
Marine, Protection, Research, and Sanctuaries Act	N/A		
National Environmental Policy Act	Full		Table of Contents, 6.9
National Historic Preservation Act	Full	3	6.6.1
National Invasive Species Act of 1996	N/A		
Nonindigenous Aquatic Nuisance Prevention and Control Act	N/A		
Outer Continental Shelf Lands Act	Full	6	6.9
Resource Conservation and Recovery Act	N/A		
Rivers and Harbors Act	Full		6.6.5
Submerged Land Act	N/A		
Water Resources Development Acts of 1976, 1986, 1990, and 1992	Full	2, 7	7.2
Wild and Scenic Rivers Act	N/A		

1 Levels of Compliance
a. Full Compliance: having met all requirements of the statute, E.O., or other environmental requirements for the current stage of planning.
b. Partial Compliance: not having met some of the requirements that normally are met in the current stage of planning.
c. Non Compliance: violation of a requirement of the Statute, E.O., or other environmental requirement.
d. Not Applicable: no requirements for the statute, E.O., or other environmental requirement for the current stage of planning.
2 Not specifically addressed in report section.
3 Compliance will be complete following completion of field surveys and coordination with MMS and SHPO.
4 Will be completed after MDE concurrence with USACE determination.
5 Will be completed following NMFS review of EFH Impacts Assessment
6 Will be completed following development of MOA with MMS
7 Mitigation measures for fish and wildlife incorporated into plan formulation.

Table 6-6: Compliance of the proposed action with relevant Federal Executive Orders.

E.O. No.	Name	Compliance[1]	Report Section
11514	Protection and Enhancement of Environmental Quality	Full	2, 7
11593	Protection and Enhancement of Cultural Environment	N/A	
11987	Exotic Organisms	N/A	
11988	Floodplain Management	N/A	
11990	Protection of Wetlands	N/A	
12088	Federal Compliance with Pollution Control Standards	Full	2
12898	Environmental Justice	N/A	
12962	Recreational Fisheries	Full	2, 7
13045	Protection of Children From Environmental Health and Safety Risks	N/A	
13112	Invasive Species	N/A	
13158	Marine Protected Areas	N/A	

Coordination with NMFS and the U.S. Fish and Wildlife Service (USFWS) focused on sea turtles and whales was undertaken to ensure compliance with the Endangered Species Act. NMFS prepared a BO in April 1998 that considered the Atlantic Coast of Maryland Project for the remainder of its 50 year project life using Borrow Areas 2, 3, and 9, and also included consideration of the Short-Term and Long-Term Assateague Restoration projects. This BO did not consider use of Weaver Shoal, Isle of Wight Shoal, Shoal "A," or Shoal "B." NMFS prepared a second BO for the project for proposed new dredging of these offshore shoals dated November 30, 2006 (Annex D). In the likely event Atlantic sturgeon is Federally-listed in the future, then coordination with NMFS would need to be undertaken for this species.

An assessment of impacts to EFH was prepared to ensure compliance with the Magnuson-Stevens Fishery Conservation and Management Act (Annex D). NMFS reviewed the assessment and stated that among the species evaluated, their concerns focus on surf clam. NMFS recommended that future coordination be undertaken to monitor the health of surf clam populations on the shoals. In the event surf clam numbers reach commercially harvestable levels, USACE would need to consult with NMFS on measures to mitigate impacts to the surf clam fishery.

Through coordination with USFWS, NMFS, MMS, DNR, and academic experts, the borrow plan that strives to maintain geomorphologic integrity of the shoals was developed in order to maintain the fishery habitat functions of these features. Coordination with agencies undertaken during formulation of the proposed borrow plan is summarized in Annex C.

USACE and MMS must enter into a Memorandum of Agreement (MOA) regarding the proposed use of mineral resources from the outer continental shelf (i.e., area of

Continental Shelf within Federal waters) for use in the project. Additionally, the sponsors (Section 1.0) must negotiate a noncompetitive lease with the MMS (USACE Engineer Regulation 1105-2-100, 22 April 2000). Federal, state, and local government agencies are exempt from the assessment of fees for the use of Outer Continental Shelf sand, gravel, and shell resources for shore protection and beach restoration.

Because new dredging impacts will be restricted to Federal waters, it is not expected that a new Water Quality Certificate (WQC) will be required from the state of Maryland for the dredging. However, a WQC and Tidal Wetlands License would be required and obtained for placement of sand on the beach. The state of Maryland has issued WQCs and Tidal Wetlands Licenses (Annex C) for previous work, and it is anticipated that these would be sought and obtained for future beach nourishment work. The state of Maryland previously determined that the Atlantic Coast Project is in compliance with the state's Coastal Zone Management program. The proposed dredging of the new borrow sites would represent no changes occurring within state waters other than cessation of dredging at Borrow Areas 2, 3, and 9 within state waters. Accordingly, USACE has determined that the proposed new dredging is in compliance with the State of Maryland's Coastal Zone Management Program.

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SECTION 7

PUBLIC INVOLVEMENT AND AGENCY COORDINATION

7.0 INTRODUCTION

Water resources development studies conducted by the U.S. Army Corps of Engineers (USACE) address problems and evaluate solutions that will provide benefits to the general public. The National Environmental Policy Act of 1969 (NEPA) and USACE' planning regulations require public involvement. Coordination with appropriate Federal, state, regional, and local agencies is also a required part of the planning process. The intent of public involvement and agency coordination efforts undertaken during the study was to identify interested agencies and groups; encourage constructive interaction between the study team, representatives of the public, and agency representatives; and elicit and incorporate ideas, issues, and concerns important for the study area into the decision-making process. This section summarizes the public involvement and agency coordination actions undertaken during this study.

7.1 COOPERATION WITH MINERALS MANAGEMENT SERVICE

During the course of the study, Minerals Management Service (MMS) was apprised of upcoming important meetings related to borrow area selection and chose to attend/participate or not attend/participate at MMS's discretion. USACE representatives attended a workshop organized by MMS and the Delaware Geological Survey on offshore sand resources in October 2003. A USACE representative participated in an MMS workshop on environmentally-friendly dredging technologies in April 2004. MMS was requested by letter in July 2004 to participate in the study as a cooperating agency and agreed to this request in response by letter in August 2004 (see Annex C). USACE was the lead agency. MMS was provided a preliminary draft version of an integrated feasibility report and SEIS for review in February 2005 and provided comments back to USACE on that document. Revisions to the document were made to address these comments. Subsequent to this, USACE determined that a stand-alone SEIS would be prepared instead. MMS was provided a preliminary draft version of the stand-alone SEIS in October 2006. MMS provided comments to USACE in November 2006 and revisions were incorporated into the draft SEIS to address these comments. An MMS representative attended the public meeting held in Ocean City in July 2007 (see Section 7.2). MMS sent a letter to USACE in December 2007 stating that the draft SEIS had addressed all MMS comments and concerns.

7.2 COORDINATION WITH RESOURCE AGENCIES, NON-FEDERAL SPONSORS, AND PUBLIC

A USACE representative gave a presentation coauthored with a U.S. Fish and Wildlife Service (USFWS) staff member in August 2002 at the American Fisheries Society annual symposium in Baltimore regarding the approach USACE used to minimize habitat impacts at Great Gull Bank during dredging to obtain sand for the short-term restoration of

Assateague. Use of this as a model for future dredging for Ocean City for the Atlantic Coast Project was discussed.

USACE prepared an initial coordination letter announcing the study and soliciting relevant information and input in January and February 2004. Coordination letters were sent to Congressional interests, resource agencies, state and local governments, and identified interested citizens and citizens groups.

Additional agency coordination conducted during the study included formal written communication, informal verbal and e-mail communication, and interaction at meetings. A summary of this coordination and copies of the letters, comments, and records of other communication are included in Annex C.

Coordination with Federal and state resource agency personnel and academic experts was undertaken to formulate the proposed borrow plan (Sections 4.0 and 5.0; Annex C). The USFWS coordinated with commercial and recreational fishermen to facilitate inclusion of their concerns during plan formulation and prepared a planning aid report for the study summarizing these findings in July 2004 (Annex C3). The USFWS voiced support for the approach proposed to minimize long-term habitat impacts to the offshore shoals in its subsequent Fish and Wildlife Coordination Act report, dated January 11, 2007 (Annex C3).

During the study, Maryland Department of Natural Resources (DNR), and the Town of Ocean City (Ocean City) have been involved and participated in planning and decision-making. DNR and Ocean City representatives participated in team meetings and reviewed correspondence with resource agencies. DNR and Ocean City were provided a preliminary version of the stand-alone draft SEIS for review in October 2006.

A notice of availability informing the public and agencies that the draft SEIS was available for review was mailed out on June 25th, 2007 to agency representatives, the public, and media. Newspaper articles about the project referencing the proposed meeting were published in the Maryland Coast Dispatch on July 20th. Legal notices announcing the public meeting were published in two local newspapers, the Coast Dispatch and Salisbury Daily Times, prior to the meeting.

A public meeting was held on July 25, 2007 during the public review period of this DEIS in Ocean City. Following the public meeting, the Dispatch published an article summarizing the meeting on July 27, 2007. On August 4th, the Daily Times also published an article about the meeting.

7.3 FEDERAL REGISTER NOTICES

A Notice of Intent that USACE would prepare a *General Reevaluation Report and Draft Environmental Impact Statement* for the Atlantic Coast of Maryland Shoreline Protection Project to document the findings of a general reevaluation study of the existing project was published in the Federal Register on October 21, 2003. The notice stated that the study would evaluate new sand borrow areas for the continued replenishment of the beach at Ocean City, Maryland. The notice also stated that potential modifications to the existing project to better protect Ocean City at areas of high erosion would be evaluated. As was noted in Section 1.2 however, investigations conducted during the study found that existing protection provided by the project met the original goals of the project, and no modifications were identified that would increase the benefit to cost ratio of the project. Accordingly, no modifications were proposed.

The U.S. Environmental Protection Agency (USEPA) listed the draft SEIS among its weekly receipts in the Federal Register on July 6, 2007. A Notice of Availability was published in the Federal Register on July 10, 2007 by the Department of the Army announcing release of the draft SEIS for public and agency review (Annex C4). The announcement stated that comments needed to be received by August 28, 2007.

7.4 AGENCY AND PUBLIC REVIEW OF THE DRAFT SUPPLEMENTAL EIS

During the public meeting held on July 25, 2007, a commercial fishermen provided verbal comments on the proposed borrow plan described in the May 2007 Draft SEIS. The fishermen generally accepted the proposed dredging plan, but preferred that Weaver Shoal not be dredged, and noted that Atlantic sturgeon have been caught there. He inquired over why additional dredging of sand from the Coastal Bays is not conducted. Written comments were received from two citizens who both recommended that additional sand be dredged from the Coastal Bays. A summary of these public verbal and written comments and responses to them is provided in Annex C5.

Comments on the draft SEIS were received from the USEPA, National Marine Fisheries Service (NMFS), and the U.S. Department of Interior (USDI). USEPA stated that it had environmental concerns over the proposed project because of potential impacts to irretrievable resources (the shoals), but that appropriate mitigation measures had been formulated. NMFS noted that future potential recovery of surf clam in numbers sufficient to support a fishery on the shoals is possible. In this event, USACE must consult with NMFS to consider mitigation measures for surf clam populations and the fishery. NMFS recommended that Shoal B be avoided to protect commercial and recreational fishing interests. NMFS also recommended that the ebb shoal continue to be considered as a greater sand source in the future, pending findings of additional monitoring. USDI stated that it had concerns over potential impacts to Assateague Island resulting from altered sediment transport and wave energy resulting from changes to the offshore shoals and identified several minor errors and deficiencies in the report text. A summary of these agency written comments and responses to them is also provided in Annex C5.

7.5 FUTURE AGENCY COORDINATION

Detailed planning of new dredging from 2010 through 2044 shall be undertaken in coordination with resource agencies. At this time, it is anticipated that coordination and detailed planning for future Atlantic Coast Project dredging through the year 2029 could be undertaken concurrently with efforts to plan dredging for the Long-Term Sand Management Project (Section 1.5).

Findings of periodic bathymetric surveys of the individual shoals conducted by USACE and other physical and biological monitoring information that becomes available from other investigators shall be reviewed in formulating detailed dredging plans. It is anticipated that future USACE bathymetric surveys would range in geographic coverage from localized borrow area surveys to more comprehensive surveys of entire offshore shoals, depending on information needs. The borrow plan presented in this SEIS (Section 5) shall be periodically reevaluated and adjusted as necessary to best meet environmental, economic, and engineering concerns. It will be necessary to assess the relative value of each shoal as a fishing grounds, with particular attention to surf clam. In the event that commercially harvestable populations of surf clam are determined to be present on any given shoal, it will be necessary to reinitiate EFH consultation with the NMFS to determine best measures to minimize impacts to surf clam and the local surf clam fishery (Annex C). In the event that Atlantic sturgeon is Federally-listed as a threatened or endangered species, it will be necessary to consult with NMFS regarding whether mitigation measures are necessary to protect individuals of this species.

SECTION 8

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