REDUCING FLOOD DAMAGE POTENTIAL
AT OCEAN CITY, MARYLAND

Preliminary Draft
July 1983

Md. Dept of Natural Resources

PREFACE

This study is sponsored by the Maryland Department of Natural Resources, Coastal Resources Division, Tidewater Administration. The work is being performed by IEP, Inc. of Wayland, Massachusetts, L.R. Johnston Associates of Westport, Connecticut, and Dr. Stephen Leatherman of the University of Maryland, in cooperation with the Maryland Department of Natural Resources, other relevant state agencies, Worcester County Commissioners, the Mayor, City Council, and City Manager's office of the Town of Ocean City and other organizations and individuals.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Overview and Purpose

The Town of Ocean City, Maryland is located on a coastal barrier that stretches along the Atlantic coasts of Delaware and Maryland. Ocean City occupies all of the coastal barrier within Maryland -- from the Delaware line to Ocean City Inlet, which separates Ocean City from Assateague Island.

Ocean City has been a resort community since the 1800's, and during the last 15 to 20 years has undergone explosive growth. Although the permanent population of Ocean City is still less than 6,000, the transient population is now estimated to exceed 250,000 on peak summer weekends. To accomodate this large number of visitors, Ocean City has been extensively developed with individual homes, commercial businesses, motels, mobile homes, and high-rise motels and condominiums.

As part of a growing national awareness of the storm and flood hazards to which coastal communities are subject, the Maryland Department of Natural Resources has expressed increasing concern over the safety of the residents, visitors and property in Ocean City. It also recognized that Ocean City is already highly developed with a tremendous economic investment in new real estate, that there are only limited opportunities for reducing the flood loss potential of this existing development, and that Ocean City will continue to receive strong pressures for continued development and redevelopment because of its established position as a major east coast resort and its proximity to the major metropolitian areas of Washington, D. C. and Baltimore, Maryland.

To address these issues the Department of Natural Resources decided to sponsor a study that would evaluate the overall storm and flood hazard potential at Ocean City, and develop recommendations for actions that could be taken by the State, Worcester County and Ocean City to reduce the flood loss potential in the Ocean City area. The emphasis of the study would be on what should be done to prepare for recovery and redevelopment following a major natural disaster. In addition, the study was to examine the effectiveness of the several beach protection plans recently proposed for Ocean City and how those plans relate to other flood loss reduction measures.

Specific objectives of the study and the general approach to identifying additional hazard mitigation measures are described within the following five tasks:

1. Identify areas of greatest risk, areas likely to suffer heavy damage, areas of potential breaching and portions of the island that may be isolated due to major storm flooding and erosional processes;

2. Analyze four storm and beach protection alternatives regarding their effectiveness as beach protection and hazard mitigation measures, their costs and benefits and the implications of their implementation on other proposed hazard mitigation measures;

3. Identify approaches and criteria for flood hazard mitigation that have been used or considered in other areas that may also be applicable to the Ocean City area;

4. Determine what modifications may be appropriate to existing codes, ordinances, legislation, plans, programs and other land use controls; and

5. Develop performance criteria that can be used by the state, county, and city in guiding relocation/redevelopment decisions and actions after a major storm has occurred.

Use of the Report

The findings, conclusions and recommendations presented in this Preliminary Draft are conditional and subject to modification based on additional research to be performed and comments to be received during and following the public presentation of the Preliminary Draft. The final report will also be significantly expanded in several areas: (1) more information will be presented concerning potential flood impacts and hazard reduction measures for the shoreline areas of Worcester County along Assawoman and Isle of Wight Bays; (2) site-specific information concerning hazard mitigation actions will be discussed in more detail; (3) building codes will be reviewed and discussed in greater detail. Information regarding warning and evacuation plans for Ocean City will not be significantly expanded since that effort is outside the scope of this study.

This Preliminary Draft provides an opportunity for substantative review and comment by public officials and private interests who wish to have an input into the final conclusions and recommendations. While the overall relationship between hazard analysis and mitigation opportunities have been established in this Preliminary Draft, additional input from the public is needed before more specific actions are recommended. To aid the reader in reviewing the draft and making comments, a wide right-hand margin has been provided.

The final findings, conclusions, and recommendations of this report will provide the state, county and city with information they may use (1) to modify their existing regulations and programs in order to reduce the potential for flood losses during the next major storm, (2) to modify existing or adopt new regulations, programs and procedures that can be implemented following the next major storm to guide recovery and redevelopment efforts so that the resulting development will be less susceptible to storm and flood damages than is current development, and (3) as input to subsequent, related projects that will build on this study.

Relationship to Other Projects

The scope of this present study is not intended to address all of the flood hazard mitigation needs of the Ocean City area. Information is also needed to guide emergency management activities immediately before, during and after a major storm. Questions regarding the ability to evacuate Ocean City under different conditions, the determination of the probability of a hurricane or northeaster actually hitting the area, and other issues that could not be fully resolved as a result of the limited time and scope of this study also need to be addressed.

Subsequent to this study, the Department of Natural Resources, Water Resources Administration is proposing to undertake a comprehensive Flood Hazard Mmanagement Study to provide the information needed to address these questions. The Flood Hazard Management Study will utilize and build upon the results of this present study to provide the following products:

a) An assessment of the applicability of various flood hazard mitigation techniques to the Ocean City area, including an assessment of their costs, hydrologic impacts, and environmental, social, and economic implications.

b) Identification of management alternatives consisting of combinations of the mitigation techniques analyzed that can be used to mitigate flood hazards in the Ocean City area and an optimm schedule for their implementation.

These products will be used by Ocean City and Worcester County to develop flood management plans which will identify the management alternatives selected by them as most appropriate. Once the Flood Management Plan has been approved by the Water Resources Administration and adopted by the local governments, financial assistance may be available from the state to implement plan components on a cost-sharing basis.

The Flood Management Plan will be coordinated with activities of the State Office of Civil Defense and Emergency Preparedness which assists local governments in developing emergency preparedness plans and standard operating procedures to guide actions taken at the local level during a major storm event.

FLOOD HAZARD VULNERABILITY

UNDERSTANDING BARRIER BEACHES

Coastal barriers have been the subject of intense research over the past 15 years and, to date, three separate theories (DeBeaumont, 1845, and Price, 1963; Gilbert, 1885, and Fisher, 1968; and, Hoyt, 1967) have been accepted to explain their origin. Classification schemes, including subclasses by shape, have been presented (Leatherman, 1980). Regional variations as a function of tidal range have been described (Hayes and Kana, 1978). Ecologic and geomorphic descriptions of individual barrier components, beach erosion and barrier inventories, as well as geological atlases, have been compiled in the last 10 years to serve as useful baseline information (Humphries and Benoit, 1980). Currently, research on sea-level rise is being conducted in several barrier environments (Titus et.al., 1983). The overwhelming majority of this data demonstrates significant levels of flood hazard vulnerability, rates of landward movement or migration and degrees of sensitivity to man-induced modifications through construction, and development exists on most undeveloped and developed barrier beaches (which include islands).

Efforts to improve public awareness and education concerning the hazards and costs of living on barriers require translation of that scientific research. The National Flood Insurance Program and the Coastal Zone Management Act are two primary mechanisms for bringing about and improving the understanding of scientific research for the layman. Among many conferences and workshops where information on barriers was presented, the Barrier Islands Workshop in Annapolis, Maryland (1976) and the Barrier Island Forum and Workshop in Provincetown, Massachusetts (1980) were specifically devoted to expanding public awareness and changing management policies within the federal government. These educational efforts were rewarded with passage of the Omnibus Budget Reconciliation Act of 1981 and the Coastal Barrier Resources Act of 1982 which curtail federal expenditures which, in the past, have promoted unwise growth and development on previously undeveloped barriers.

Developed and highly urbanized barriers no longer have the natural environmental characteristics they once had in the undeveloped state. Instead, a large financial investment and population center has been substituted. The hazard vulnerability of the barrier, however, remains; and with expanded growth and development, the risk associated with potential damages increases. As a result, means by which damages can be reduced or mitigated need to be identified for these developed barriers.

Just as for undeveloped barriers, scientific and planning research must precede changes in governing policies and regulations for developed barriers. Baseline data needed to better understand the hazard vulnerability, erosion trends, and migration rate of a developed barrier should address the following: (1) onshore sediment movement; (2) storm activity; (3) equilibrium readjustment to sea level rise, and (4) construction activities along shore (Fisher, 1977).

OCEAN CITY: AN URBANIZED BARRIER ISLAND

Growth and Development

Northward progression of commercial and residential development from the south end of Fenwick Island to the Delaware state line has occurred since 1872 (see Figure 2B-1). Since that time, the small resort community of Sinepuxent Beach has evolved into the major east coast recreational center of Ocean City, Maryland.

In 1878 the railroad provided the first established means of transportation to Fenwick Island (Truitt and Les Calette, 1964). Today almost all transportation is by automobile. The opening of the Cheaspeake Bay Bridge in 1952 connecting Sany Point (on the Maryland western shore) with Kent Island (on the Maryland eastern shore) was probably the most significant factor affecting Ocean City's growth (Dolan et.al., 1980). This bridge reduced the travel time to Ocean City from Baltimore and Washington, D.C. to 2.5 hours. Three highways provide for easy access to Ocean City: U.S. Route 50 and Maryland Route 90 cross east to west over Isle of Wight and Assawoman Bays and the Coastal Highway (Maryland Route 528) extends north into Delaware.

Other infrastructure which has promoted growth and development of Ocean City include water and sewer facilities. The Manokin Aquifer -- 33 feet thick and at a depth of 372 feet -- is the source of groundwater for Ocean City and other towns in the area (Corps, 1980). However, the groundwater supply is limited and the growing summertime demand for water could result in salt water intrusion or require additional sources to be located.

When Ocean City began its rapid growth in the late 1960's, sewerage facilities became necessary, and the Ocean City Treatment Facility was completed in 1968 to provide primary treatment for four million gallons per day. After expansions of the facility, a capacity of 12.4 million gallons per day with secondary treatment has been

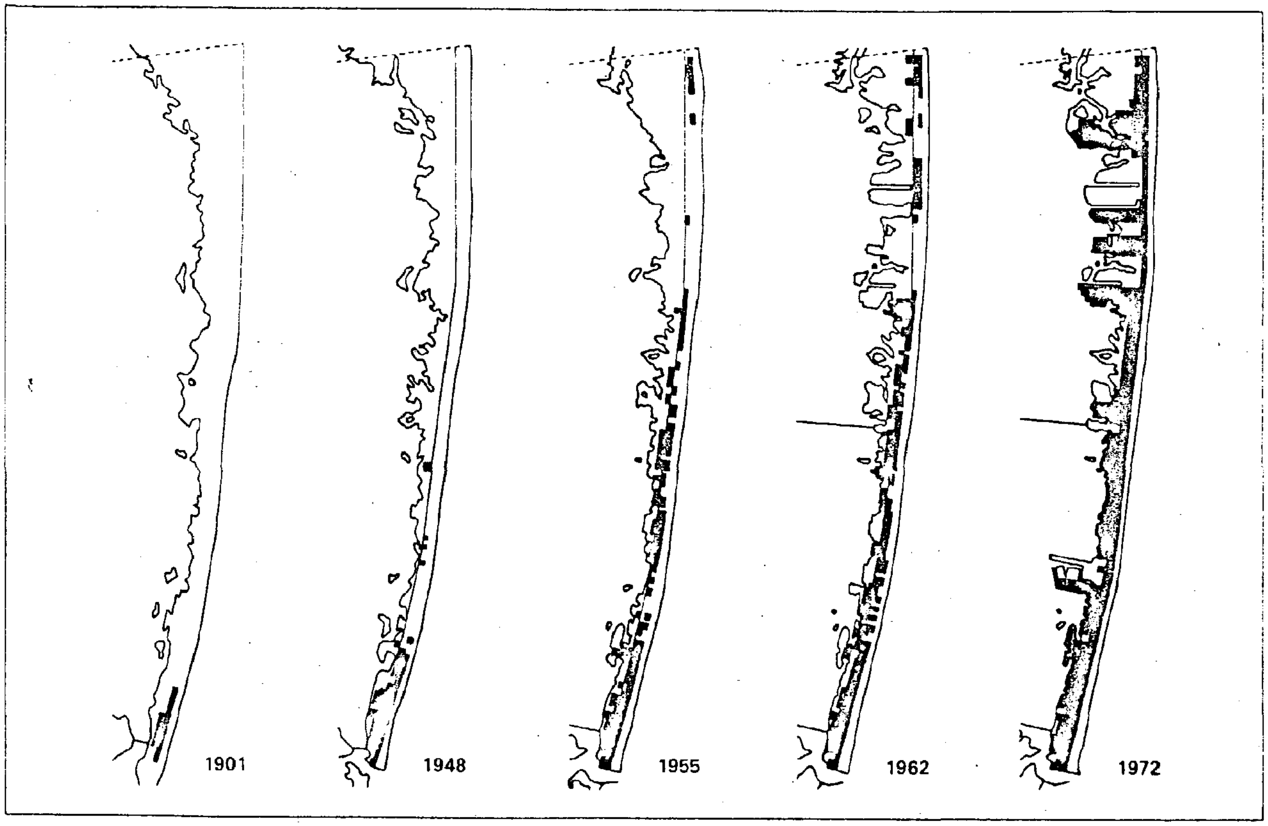


Figure 2B-1. **Northward progression of development between 1902 and 1970.**
(Source: Dolan et.al., 1980).

provided since 1981. A North Ocean City Interceptor Sewage Pipeline is currently under construction which will provide capacity to accomodate additional growth in this part of the City.

The close proximity of Ocean City to major metropolitian areas, the excellent access to the City, and the availability of adequate water and sewerage facilities have resulted in the rapid growth of Ocean City as a tourist resort. Although the permanent population was estimated in 1982 to be only about 5,700, over 250,000 people are estimated to be in the City during peak summer weekends. Mid-1970 statistics show the existence of 26,663 housing units of which over 75% were hotels, apartments and condominiums.

This large concentration of people and property occupies a coastal barrier, and they are vulnerable to the impacts of coastal storms and floods. The development also has an affect on the natural protective features provided by the barrier.

The Fenwick Island System

The barrier island which Ocean City occupies provides a storm damage prevention and flood control function which affects other barrier and mainland environments. The point of attachment for Fenwick Island lies within the state of Delaware to the north. During parts of the year, the southern coast of Delaware is affected by longshore sediment being transported north from Fenwick Island. To the south, the island terminates at the Ocean City Inlet, which separates it from Assateague Island. The obvious relationship betweed these two islands has been well documented (Leatherman, 1979) and is briefly described later in this report.

The mainland of Worcester County directly west of Fenwick Island, and separated from the island by Isle of Wight and Assawoman Bays, greatly benefits from the natural functions of the barrier island: bay tidal ranges are reduced, fetch distances are limited and the topography of Fenwick Island, although quite low, absorbs a major part of coastal wave and current damages. For this reason, the 100-year floodplain of Worcester County directly west of Ocean City will be addressed in this study as a hazard prone environment in the Ocean City Area.

Although Fenwick Island is no longer an undeveloped barrier in its natural state, this somewhat stabilized island is still characterized by low-lying, hazard prone areas subject to both gradual and sudden changes depending upon seasonal trends and storm occurrences. Within a relatively short distance perpendicular to shore, the geomorphic characteristics and hydrodynamic processes of Fenwick Island change rapidly. During major storms, deepwater waves exceeding 30 feet in height travel landward over a wide, flat nearshore zone, breaking on a steeper beach, running up the face of any dune or other elevated obstruction and overwashing onto higher ground with the possibility of joining calmer bay waters.

Three major storms have modified and damaged Ocean City on about a 30-year frequency since a 1902 hurricane. In 1933 a hurricane was responsible for the formation of Ocean City Inlet. On March 6-8, 1962, a northeast storm left an estimated damage of $11.3 million (1980 dollars) (Corps, 1980). Hurricanes that occurred in 1938 and 1944 and northeasters that occurred in 1960 and 1978 are considered to be minor storms.

The following section details each of the major hazard areas of the barrier island that collectively define the overall hazard vulnerability of Ocean City.

HAZARD PRONE AREAS

Hazard planning for barrier island resorts such as Ocean City, Maryland often fails to fully recognize the natural geologic and geomorphic processes that influence the built environment and island users. To summarize and assess the available data for Fenwick Island, five subenvironments were selected on the basis of their geomorphic characteristics and hazard vulnerability: (1) offshore zone; (2) nearshore zone; (3) coastal high hazard zone; (4) 100-year floodplain; and (5) Isle of Wight and Assawoman Bays. The compilation of data and information will provide a characterization of existing hazard prone areas, serve as a basis for evaluating existing erosion and flood control plans and indicate what additional information is needed to maintain and improve knowledge about Fenwick Island's flood hazard vulnerability.

The primary cause of coastal floods for the Ocean City area is the occurrence of hurricanes and northeasters. Both storm types generate winds and waves acorss the Atlantic Ocean that impact the shoreline and inland areas. Hurricanes have very high winds (74 mph or greater) and can generate large waves capable of massive destruction. They approach and pass through an area rapidly, usually affecting a relatively small portion of a shoreline. Their duration is usually one tidal cycle (less than 12 hours) and wave approach is from the southeast. The period of greatest hurricane threat extends from August through October. In contrast, northeasters are characterized by lower wind speeds and smaller wave heights, but they reside offshore for extended periods of time (up to three days or six tidal cycles) and affect a wider geographic area. Northeasters normally occur during the winter months.

Offshore Zone

The area between -20 and -30 feet mean high water (MHW) is the point at which most storm waves begin the breaking process that continues toward the beach. Knowledge of historical changes in the offshore bathymetry provides an understanding of the impacts which result from barrier island stabilization and the resultant increase in hazard vulnerability of the island.

A significant trend emerges from a review of historical bathymetric data of the waters offshore of Ocean City. The Corps of Engineers bathymetric profiles (confirmed by comparison with original Coast and Geodetic Survey boat sheets) clearly indicate that the shoreface has been steepening through time. The landward movement of the 20-foot depth contour has been greater than the 10-foot depth contour, which in turn has migrated further than the mean high water contour (Table 2C-1).

It appears that the shoreline has remained in approximately the same location, but the adjacent shoreface has steepened. Although it is not known what angle of shoreface inclination is the natural equilibrium position, the current steepened condition cannot be considered at equilibrium since recent bathymetric data have shown that the steepening trend has continued.

Table 2C-1. Contour Shifts from 1929-1965 (Trident Engineering, 1979)

	Over 36 Year Period	Average Per Year
MHW Contour	86 feet	2.4 feet
-10 Foot Contour	252 feet	7.0 feet
-20 Foot Contour	350 feet	9.7 feet

It is a well established geologic principle that most geomorphic work is accomplished in quantum steps. Therefore, a major coastal storm would provide the impetus for a decrease in the angle of inclination by shifting and redistributing nearshore sands to reverse the steepening trend of the shoreface. At this point the shoreface inclination will return to its minimum angle and then continue to again slowly steepen through time until the next major storm.

Wave refraction analysis for Maryland and Virginia (Goldsmith et.al., 1975) predicts areas of wave concentration along the coastline for various storm conditions. As reported by the Corps of Engineers (1981), offshore dredging can also alter the characteristics of the incoming storm waves, perhaps causing abnormal concentrations of wave energies along certain stretches of the coastline.

The wave refraction data indicate wave concentration in the northernmost portion of the study area, near the Maryland-Delaware line, and also a secondary concentration at the Ocean City Inlet area. These data are not clearly reflected by the shoreline recession information, possibly because of the pulsaic nature of barrier island retreat and downdrift migration of low amplitude, very long period sand waves.

Nearshore Zone

For purposes of this discussion, the nearshore zone is located between the offshore zone and the approximate seaward extent of development (the Ocean City Building Limit Line) and includes the beach and berm areas. Sand moves alongshore as well as on and offshore in this zone. The gross rates of sand movement are believed to be about 450,000 cu.yd. per year northerly, and 600,000 cu.yd. per year southerly, resulting in a net drift of 150,000 cu.yd. of sand per year to the south (Dolan et.al., 1980).

National Ocean Survey quantitative shoreline change data since 1849 was used to analyze historical shoreline erosion. Automated techniques of processing the data and plotting maps from these historical sources, specifically using stereoplotters and metric mapping techniques, can be used to obtain highly accurate information concerning historical shoreline movementy trends

(Leatherman, 1983). For Ocean City, a computerized procedure was developed by which transects were drawn across the barrier at predetermined distances along the island and shoreline changes between certain time periods for these locations determined. Forty-two transects 1000 feet apart were used to determine shoreline changes from periods 1850-1980; 1850-1908; 1908-1929; 1929-1980; 1929-1942; 1942-1962; and 1962-1980.

Figure 2C-1 represents the shoreline changes between 1929 and 1980, the longest period of record for all stations. From 21st Street (Station 37) north, the shoreline has been eroding at an average rate of 2.7 feet per year. From 21st Street south to the Inlet, the shoreline has been accreting at an average rate of 7.0 feet per year.

Mean High Water (MHW) datum has been used extensively in past studies of shoreline movements in Ocean City (Trident Report, 1979). Most efforts to better understand beach changes are concentrated seaward of MHW and little analysis has been done immediately landward of MHW. Nevertheless, the area between MHW and existing development is an important indicator of hazard vulnerability. Using a 1981 photogrammetric survey of the Beach Erosion Control District, linear measurements between MHW and the Building Limit Line (BLL) were taken at 150 street locations from Ocean City Inlet to the Maryland-Delaware line and plotted (see Figure 2C-2). The average distance from MHW to the BLL is 135 feet; the average height above MHW at the BLL is 9.7 feet (11.9 feet NGVD); and the average slope is 7.2% or 1:14. A trend north of approximately 50th Street seems to indicate an equilibrium slope has been established. Note that where the distance is large, the elevation is high, and conversely, when the distance is small, the elevation is low.

The least amount of erosion and flood control protection, as a function of beach width and height, exists between 73rd and 91st Streets, and between 119th and 132nd Streets, approximately.

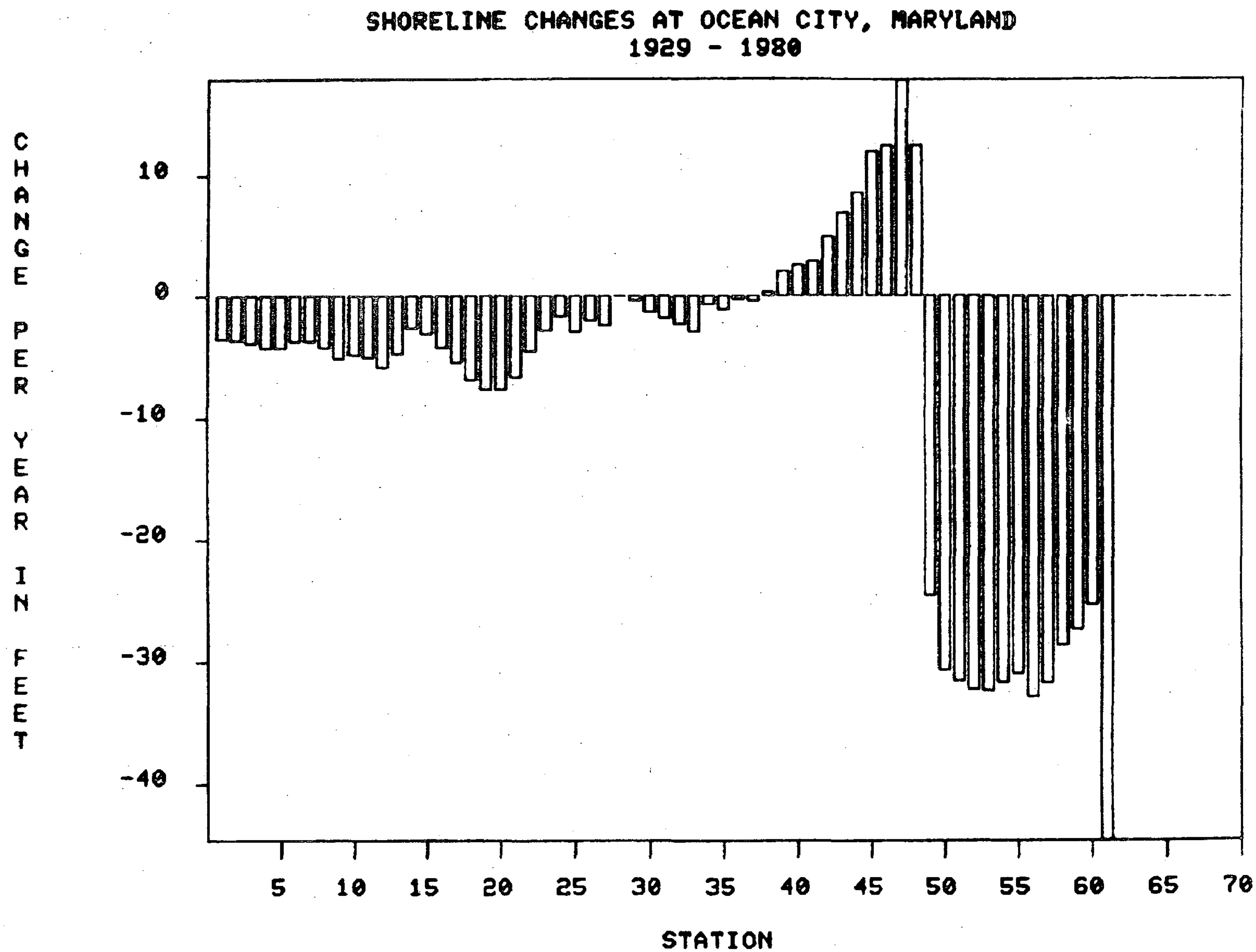


Figure 2C-1. Shoreline Change Between 1929 and 1980.

Note: The station numbers begin at the Maryland-Delaware line and end on Assateaque Island.

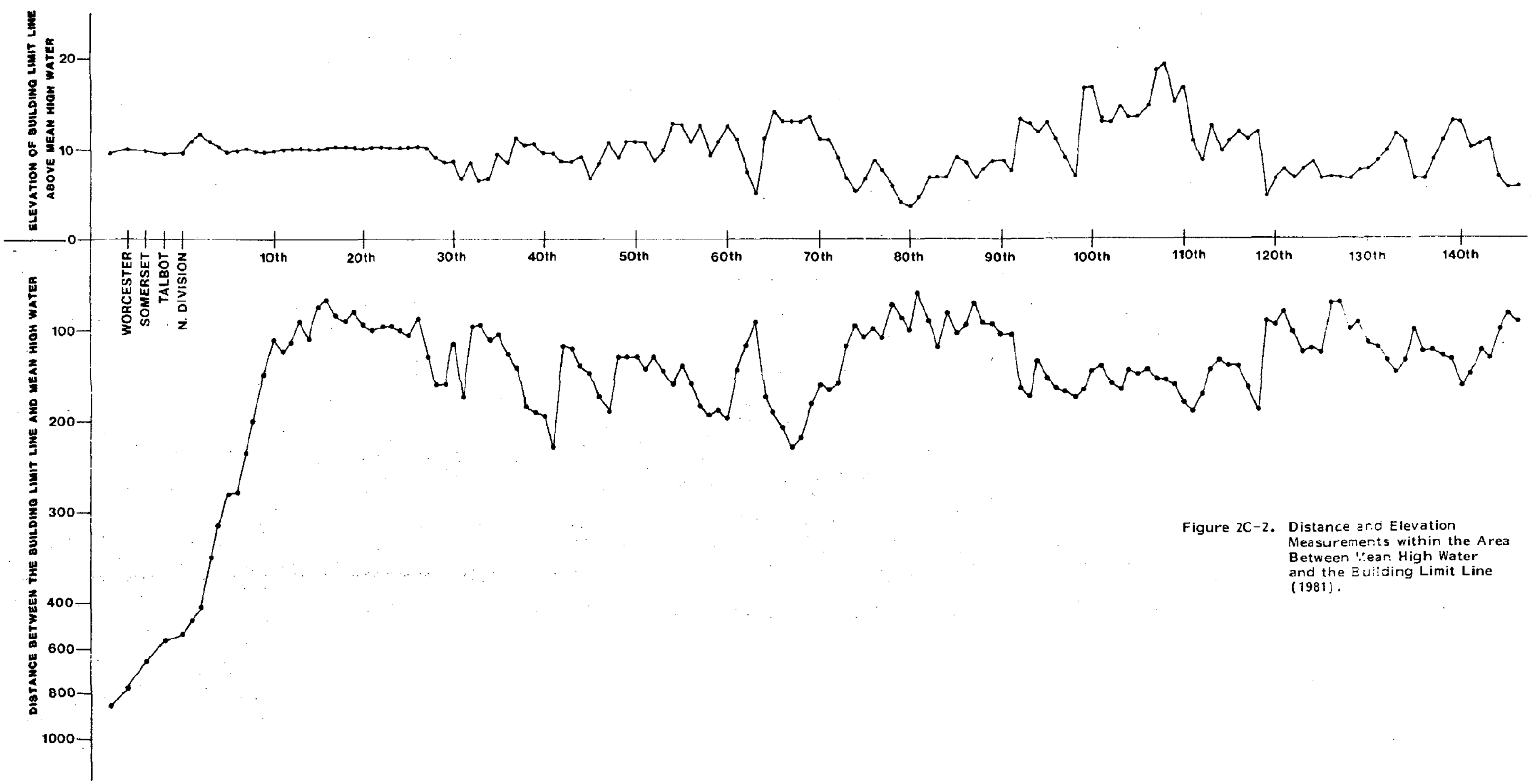


Figure 2C-2. Distance and Elevation Measurements within the Area Between Mean High Water and the Building Limit Line (1981).

The greatest protection exists between 50th and 60the Streets and between 92nd and 118th Streets, approximately. South of 7th Street, where beach widths are greater than 200 feet because of updrift accretion at the North Jetty, development is protected to the largest degree.

The existing average beach profile from MHW to BLL is lower than what is currently represented in other work. Figure 2C-3 shows the recommended plan for beach and dune restoration proposed by the Corps of Engineers referenced to an existing profile. The new profile for the upper beach has been located on this Figure 2C-3. Extension of the profile lower than mean low water (MLW) is not represented. The effect of a lower profile means a landward shift of the 100-year tide line and increased hazard vulnerability. It also indicates a revision is needed for the Corps Plan and the amount of beach and dune fill required. The Corps Plan is discussed later in the report.

Using the average elevation of the beach at the Building Limit Line of 9.7 feet MHW and assuming four feet of erosion would occur during a storm (as assumed during the most recent Flood Insurance Study), the resultant 5.3 foot elevation would be exposed to waves during a very minor event. Using the Corps of Engineers storm frequency distribution curve (COE, 1981; Figure D-16), the current level of beach protection afforded by an average number of shoreline areas in Ocean City is the 2-year frequency storm event. Given the possibility of error at the lowest end of the distribution curve, it would be more accurate to state that less than 5-year storm protection exists.

Development in the nearshore zone is limited to coastal engineering structures, including the North Jetty, a timber pile pier and 52 timber and stone groins (Table 2C-2). The impact of the North Jetty is obvious. Approximately 150,000 cu.yds. of sand have been trapped and have covered 11 groins rendering them ineffective.

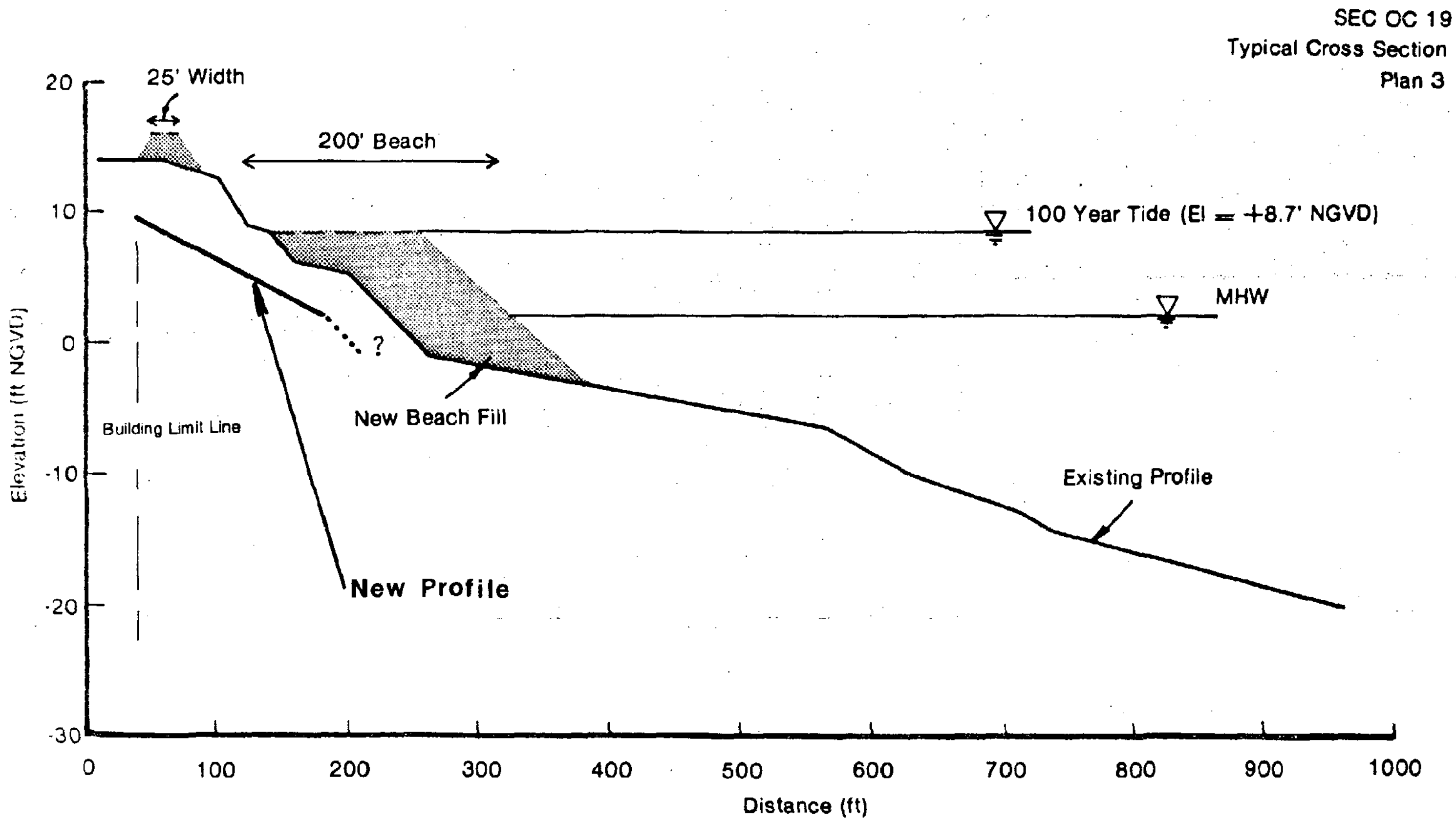


Figure 2C-3. New Profile Between Mean High Water and the Building Limit Line.

Table 2C-2. Inventory of Existing Groins.

Location	Year Completed[1]	Type[2]	Exposed[3] Length	Groin[4] Work	Spacing[5]
Between S. Division and S. 1st Streets	1922-24		0	-	
Worcester Street	1922-24		0	-	
Somerset Street	1931		0	-	
Talbot Street	1928		0	-	
N. Division Street	1931		0	-	
N. 1st Street	1930		0	-	
2nd Street	1931		0	-	
Between 3rd and 4th Streets	1932		0	-	
Between 4th and 5th Streets	1931		0	-	
Between 5th and 6th Streets	1932		0	-	
Between 6th and 7th Streets	1932		0	-	
8th Street	1932	T	20·	-	400·
9th Street	1934	T	30·	-	400·
Between 10th and 11th Streets	1934	T	70·	-	500·
12th Street	1938	T/S	100·	-	370·
13th Street	1962	T/S	90·	-	370·
14th Street	1930			-	
- repaired	1973	T	100·	DNR	400·
15th Street	1933,1960	T		-	
- extension	1978	S	170·	DNR	450·
16th Street	1938	T/S	140·	-	520·
18th Street	1949	T	140·	-	490·
Between 19th and 20th Streets	1962	T	140·	-	480·
21st Street	1951	S	150·	-	320·
22nd Street	1962	T	90·	-	450·
23rd Street	1951	T	100·	-	600·
- repaired outboard end	1978			DNR	
25th Street	1974	T	110·	DNR	370·

Location	Year Completed	Type	Exposed Length	Groin Work	Spacing
26th Street	1951	T	120·	-	[illegible]
29th Street	1973	S	170·	DNR	[illegible]
31st Street	1975	T	140·	DNR	[illegible]
- revision	1978			DNR	
34th Street	1978	T	240	DNR	[illegible]
41st Street		S	220		[illegible]
47th Street		S	200		[illegible]
51st Street	1975	T	20	DNR	[illegible]
58th Street	1978	T	100·	DNR	[illegible]
60th Street		S	120·		[illegible]
71st Street	1975	T/S	100·	DNR	[illegible]
73rd Street	1961	T	180	-	[illegible]
Between 74th and 75th Streets	1961	T	180	-	[illegible]
76th Street	1961	T	130·	-	[illegible]
77th Street	1974	T/S	180·	DNR	[illegible]
80th Street		S	230·	DNR	[illegible]
83rd Street		S	180·		[illegible]
86th Street	1975	T	170·	DNR	[illegible]
89th Street	1975	T	190	DNR	[illegible]
91st Street	1973	T	150	DNR	[illegible]
93rd Street		S	150·		[illegible]
98th Street		S	150·		[illegible]
102nd Street	1975	T	140	DNR	[illegible]
112th Street		S	150·		[illegible]
118th Street		S	180·		[illegible]
125th Street		S	120·		[illegible]
128th Street	1975	T/S	100·	DNR	[illegible]
130th Street	1978	T	40·	DNR	

1 Where no date is entered, it is presumed completion occurred between May 14, 1979 and May 3, 1981.

2 S = Stone; T = Timber

3 Length in feet.
(·) indicates totally exposed surface; otherwise, there is intermittent exposure.
standard Ocean City groins between South 1st Street and 130th Street are approximately 200 ft in length.

4 DNR indicates work done by Maryland Department of Natural Resources.
(-) indicates work done by "others" (presumably Department of Transportation).
no entry indicates unknown work responsibility.

5 Distance to next (higher street number) groin in feet.
(·) indicates spacing meets Corps of Engineer standards.

The impact of the remaining groins is less obvious. Using the May 1981 photogrammetric survey maps, a quantitative analysis at each groin revealed that no definitive trend exists regarding updrift accretion and downdrift erosion. The differences in position of MLW north and south of each groin at a distance equal to the length of each groin averaged about 25 feet. Beach slopes (MLW to MHW) near the groins were approximately 9.7% or 1:10.

Coastal High Hazard Zone

For this discussion, the coastal high hazard zone is considered to extend from the Building Limit Line landward to the western edge of the V-zone as delineated on the Flood Insurance Rate Map (FIRM). This zone extends from 27th Street north to the Delaware line (about seven miles). Existing and future development within this area is the most vulnerable to flood damages during a 100-year flood because it is exposed to the direct effects of waves and high velocity water.

For the most part, dunes and open space which once acted to buffer the effects of storm waves, currents and overwash have now been replaced with single family residences, high rise condominiums, motels and parking lots. The most recent FIRM -- effective May 16, 1983 -- predicts 100-year frequency storm surge elevations with waves to reach 11 feen NGVD. This estimate is two feet above the previous FIRM predections which did not include wave heights. The methodology employed in the revised FIRM assumed four feet of shoreline erosion would occur north of 15th Street. Six transects were used to determine the landward boundary of the V-zone. They were located at approximately 6th, 20th, 44th, 81st, Purnell and Franford Streets.

Consideration of flood elevations for the 10-year and 50-year frequency storm events is also important for a better understanding of the overall flood hazard vulnerability. Using storm frequency data from the Corps of Engineers (1980) and Flood Insurance Studies

(FIS 1983), the 10-year and 50-year flood elevations for the V-zone and several A-zones were derived (Table 2C-3). Based on the FIS 100-year elevations, the difference between the stillwater level (8.1 feet) and the V-zone elevation (11.0 feet) is 2.9 feet. This differential was used to obtain values for the 10- and 50-year V-zones. The differences between the stillwater level and the A-zones are +0.9, -0.1, +1.1, and -2.1 feet, and they were used to obtain values for the 10-year and 50-year A-zones.

The stillwater elevations from the Corps of Engineers are 0.6 feet higher than those used in the FIS. The Corps value is considered more conservative in that it represents a higher level of hazard. Using the Corps data, a summary of the estimated 10-year, 50-year and 100-year storm elevations based on a MHW datum are shown in Table 2C-4. This summary information provides an easier means of evaluating other maps and charts that use MHW or MLW datums. A factor of 3.4 feet should be added to values in Table 2C-4 to obtain elevations above MLW (common datum for Ocean City).

By comparing the V-zone elevations in Table 2C-4 with the Building Limit Line elevations shown in Figure 2C-3, an analysis of hazard vulnerability during the 10-year, 50-year and 100-year storm events was made for the coastal high hazard zone north of 27th Street. Since beach erosion is related to both storm intensity and duration and is, therefore, somewhat independent of the storm frequency event, a four foot erosion value is assumed as it was in the May 16, 1983 FIS. Figure 2C-4 identifies those areas which are higher in elevation than the predicted storm levels, and which are not expected to receive direct wave damage during the three storm frequency events. In terms of which areas could be expected to receive more damage, 75%. 90% and 92% of the shoreline north of 27th Street is vulnerable to the 10-year, 50-year and 100-year events, respectively. Variations in beach width, not considered in this analysis, are an important factor which would control wave processes and impact. Qualitatively, the wider the beach is, the more seaward waves will break, and the less impact there

Table 2C-3. Comparison of the 10-year, 50-year and 100-year Ocean Storm Elevations (NGVD in feet)

	STILLWATER	V-ZONE	A-ZONES							
			COE				FIS			
100-year	8.7/8.1[1]	12/11	10	9	8	7	9	8	7	6
50-year	8.0/7.4	11/10	9	8	7	6	8	7	6	5
10-year	6.4/5.8	9/9	7	6	5	4	7	6	5	4

[1] Corps of Engineers (COE)/Flood Insurance Study (FIS)

Table 2C-4. Summary of the Estimated 10-year, 50-year and 100-year Ocean Storm Elevations (MHW in feet)

	STILLWATER	V-ZONE	A-ZONES			
100-year	6.5	9.4	7.4	6.4	5.4	4.4
50-year	5.8	8.7	6.7	5.7	4.7	3.7
10-year	4.2	7.1	5.1	4.1	3.1	2.1

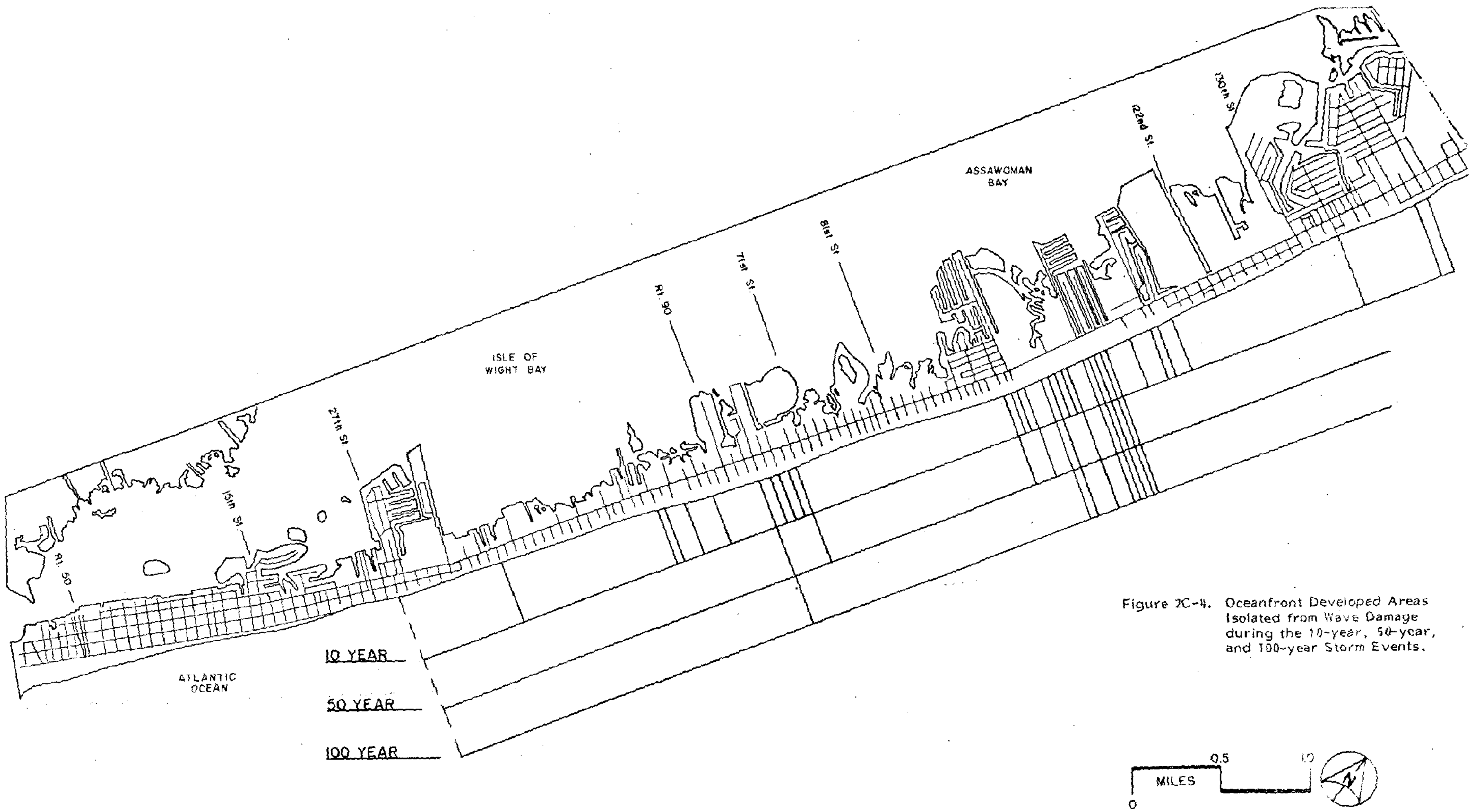


Figure 2C-4. Oceanfront Developed Areas Isolated from Wave Damage during the 10-year, 50-year, and 100-year Storm Events.

IEP, Inc. JOB NO. 83-10

will be at a certain elevation. A qualitative analysis of beach height and width was presented in the previous section.

Flood elevations were delineated on the FIRMs according to upland topography without considering differential vulnerabilities to flooding and erosion except at the six transects. Several of the factors one must consider in defining differential vulnerabilities include man-made and natural obstructions such as seawalls and dunes, other human modifications such as buildings and pavement and the extent of natural vegetation.

Human modification in the coastal high hazard zone has had a profound affect on the storm susceptibility of Fenwick Island. The built environment affects the barrier's ability to respond naturally to storm conditions in many ways. Among these are: 1) interference with aeolian (wind) and overwash transport processes through paving and other construction; 2) removal of the natural dune line which increases backbarrier susceptibility to storm waves; and 3) construction of tall buildings and seawalls which can force highly erosive currents through gaps in the structures.

On a barrier island that is in its natrual state, sand is often transported from the beach to the barrier flats during storms. This transport occurs by both aeolian and overwash processes. During periods of quiescence following storms, some of this sand is transported back to the beach by the wind. This aids in natrual beach restoration and dune formation.

Human intervention by development of barrier islands, such as Ocean City, have diminished the effectiveness of this process. Sand is prevented from moving to the backdune areas during storms by the tall buildings and other structures which block and funnel the wind and water. These buildings may also diminish the occurrence of overwash, but more likely, will actually concentrate the flow into discrete areas between the buildings. Following a coastal storm, the recent practice in Ocean City has been to use bulldozers and showplows to remove beach sand that has accumulated on streets and parking lots, and dump the sand on unused land, into the bay, or push it onto the beach. It is difficult to evaluate the short-term ramifications of this interference with the natural migrational processes, but clearly the barrier surface has not been allowed to increase in elevation, as would occur in a natural setting. Meanwhile, sea level is continuing to rise, resulting in a net decrease in elevation of the barrier.

An inventory of man-made obstructions located in the coastal high hazard zone included the identification of the number and extent of walls (as shown on 1981 photogrammetric survey), and the number of structures (as shown on 1981 photogrammetric survey and May 1983 aerial oblique photos). A total of 18 walls having a cumulative length of 3,690 feet or 10% of the beach exist between 27th Street and the Maryland-Delaware line (see Figure 2C-5). A count of 336 habitable structures was made without a distinction of size, and any portion of a structure in the V-zone was regarded as a total structure (see Appendix A). Sixteen new structures were identified as completed or under construction since 1981. Eighteen buildings are over ten stories high. Only eight of the 119 blocks inventoried are currently vacant in the V-zone. The areas previously identified as having the least amount of erosion and flood control protection seaward of the BLL are occupied by 119 structures in the V-zone. The areas previously identified as having a greater amount of protection have 71 structures associated with them. One reason for the lower number of structures in these areas is that many of them are high rise condominiums.

The present position of the shoreline is rapidly becoming determined more by the extent of development and encroachment toward the Building Limit Line than the natural process of erosion, at least for this current period of low storm activity. If more seawalls and bulkheads are constructed, their effect on beach erosion and storm overwash will become even more difficult to determine.

1983 AUG 15 AM 10:00

MAIL ROOM

Torrey C. Brown, M.D.
[redacted]
SECRETARY

LOUIS N. PHIPPS, JR.
DEPUTY SECRETARY

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES
TIDEWATER ADMINISTRATION
TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401

(301) 269-2784

August 10, 1983

Dear Interested Person:

The purpose of this letter is to remind you of the workshop we are holding on August 18, 1983, to discuss the contents and recommendations of the draft and the final report of the Post-Disaster Planning Study in the Ocean City area entitled "Reducing Flood Damage Potential in Ocean City, Maryland." The workshop will be held in the City Council Chambers in City Hall, Baltimore Avenue and 3rd Street, Ocean City, Maryland and will start at 1:30 P.M. I hope you will be able to attend since we want to be sure that your concerns are addressed in the final report and its recommendations. If you have not already sent us your written comments on the report, please bring them with you to the meeting. It is presently planned that discussions at the workshop will focus on the following points:

1) Are the report's recommendations appropriate and comprehensive? Is there a need to further clarify or discuss in more detail certain issues? Is there a need to modify some of them? If so, for what reasons?

2) What barriers do you foresee in the city, county and state implementing the report's recommendations?

3) Is there a need to further clarify or discuss the technical subject matter in the report? (As noted previously, the question of sea level rise will be discussed in further detail in the final report)

4) What subject areas not covered by this study need further analysis in the follow-up watershed management study that the Water Resources Administration is proposing to undertake for the area?

There will be an opportunity at the workshop for discussion of any additional concerns you may have concerning flood hazards in the Ocean City area.

Thank you for your involvement in the study and I hope to see you the afternoon of the 18th of August.

Yours sincerely,

Earl H. Bradley, (Local) Technical
Assistance Program Manager

EHB/dk

REC'D.

1983 AUG -3 PM 12:05

JAMES B. COULTER
SECRETARY

LOUIS N. PHIPPS, JR.
DEPUTY SECRETARY

STATE OF MARYLAND
DEPARTMENT OF NATURAL RESOURCES
TIDEWATER ADMINISTRATION (301) 269-2784
TAWES STATE OFFICE BUILDING
ANNAPOLIS 21401

July 25, 1983

Dear Interested Person:

Enclosed for your review and comment is a copy of the draft report of the Post-Disaster Planning Study for the Ocean City area entitled "Reducing Flood Damage Potential in Ocean City, Maryland." It should be noted that additional work will be done in some sections, particularly those dealing with management options. While comments on any portion of the work are welcome, those dealing with subjects that need further analysis or clarification and any inaccuracies you note will be particularly welcome.

We would like to receive your comments in writing or by phone (301-269-2784) by August 12 or sooner if possible. The reason for the relatively short comment period is that we are planning to hold a workshop in Ocean City on the afternoon of August 18, 1983 to discuss the contents of the report; additional information the consultants have developed; the comments we have received; the relevance of the management options presented, including what steps should be taken in the near future by the State government, local government, and the private sector; and additional areas that need to be studied in a followup watershed management study proposed to be undertaken by the Water Resources Administration. Further details on the workshop will be sent to you as theyare developed.

Thank you for taking the time to review the document and I hope to see you on the 18th of August.

Sincerely,

Sarah J. Taylor / for

Earl H. Bradley, Jr.
(Local) Technical Assistance Program
Manager, Coastal Resources Division

EHB:ps

Enclosure

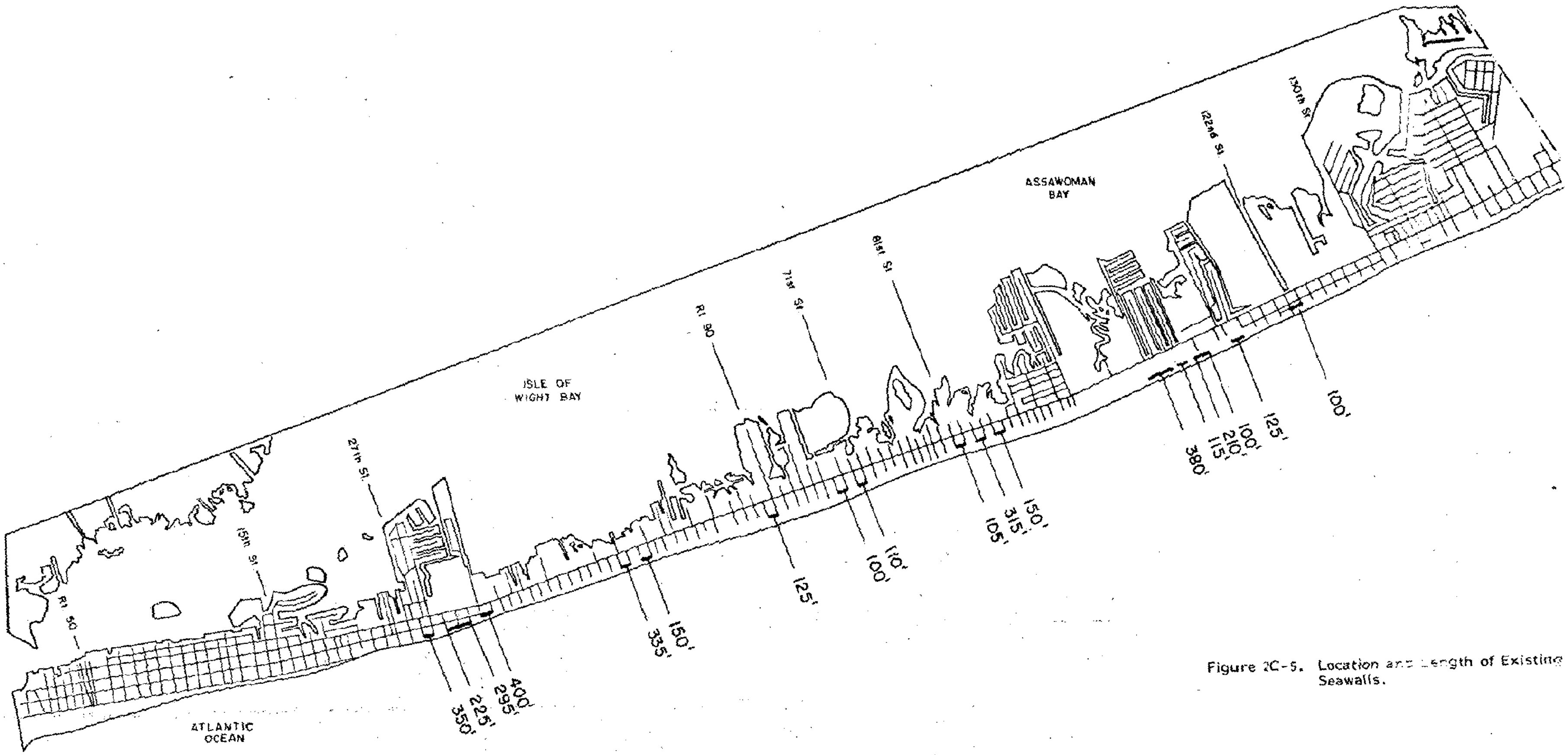


Figure 2C-5. Location and Length of Existing Seawalls.

IEP, Inc. JOB NO 83-10

Fenwick Island 100-Year Floodplain

For all practical purposes, according to the recent FIRM, the entire city north of 27th Street is within an area which will be inundated by water associated with the 100-year flood. Two isolated areas located along the Coastal Highway between 63rd and 67th Streets and between 119th and 124th Streets are slightly higher in elevation and are designated as 500-year floodplains. A two block wide area between the inlet and 27th Street also has this designation. Even within the areas designated as a 500-year floodplain, shallow flooding less than 1.0 foot may occur.

Flood elevations of the 100-year storm decrease west of the V-zone toward the bay from nine feet to six feet, respectively. This updated information broadly contrasts with information presented in the 1976 FIRM. In the 1976 FIRM, most of the area east of the Coastal Highway was designated as the 500-year floodplain and remaining areas to the west had 100-year flood elevations of nine feet. Two primary reasons are responsible for the revisions that resulted in higher beachfront elevations and lower bay elevations: 1) wave heights were incorporated on the storm surge, and 2) lower tidal ranges were recognized in the upper reaches of Assawoman Bay.

It should be understood, however, that the information provided by the FIRM was obtained using a methodology that could be used at all coastal locations for the purposes of defining hazard prone areas and properly rating structures for insurance purposes. Only six transects were used along the nine mile stretch of Ocean City, and information was interpolated between these transects in order to produce a hazard map for the City. Nevertheless, this is the most current hazard map available.

Historical data from the March 1962 storm is particularly helpful in defining the type of hazard to which a majority of the island is exposed. Accounts in the newspapers and Corpos of Engineers reports note the deposition of up to six feet of sand on the streets. Flood currents were strong enough to move sand across the entire island in certain locations (see Figure 2C-6). For proper perspective, it must be remembered that the March 1962 storm was a 45-year event in the Ocean City area.

A qualitative comparison of the March 1962 storm with the 1983 FIRM based on the extent of overwash shown in Figure 2C-6 was made for 10 segments in Ocean City and briefly described as follows:

1. between the Inlet and 14th Street, no overwash occurred in the B-zone.
2. between 14th and 27th Streets, an area between one and two blocks wide was overwashed and is currently delineated as a B-zone.
3. between 27th and 34th Streets, overwash extended across the Coastal Highway and into the A-zone (elevation six feet).
4. between 34th and 41st Streets, overwash generally did not reach the Coastal Highway and would have been maintained within the A-zone (elevation nine feet).
5. between 41st and 52nd Streets, overwash generally extended across the Coastal Highway and reached the bay;
6. between 52nd and 67th Streets, overwash generally did not cross the Coastal Highway and would have folowed the A-zone (elevation nine feet) delineation remarkably close;
7. between 67th and 85th Streets, overwash entirely crossed the Coastal Highway and generally extended into the A-zone (elevation six feet);
8. between 85th Street and Channel Buoy Road (approximately 112th Street), overwash entirely crossed the Coastal Highway and generally followed the A-zone (elevation nine feet) delineation.
9. between Channel Buoy Road (approximately 112th Street)

and 118th Street, two extensive washovers crossed what would have been A-zones (elevation eight feet and elevation six feet); and

10. between 118th Street and the Maryland-Delaware line, overwash generally did not cross the Coastal Highway and generally followed the A-zone (elevation nine feet) delineation.

Note: Using Tables 2C-3 and 2C-4, Azone elevation difference for the 110-year and 50-year events are estimated to differ by approximately 1 foot.

Summarizing the comparison (see Figure 2C-7), there was a good correlation between the extent of 1962 overwash and the 1983 delineation of the A-zone (elevation nine feet) for 60 percent of the shoreline. There was a poor correlation between the extent of overwash and any A-zone delineations, and overwash primarily extended into the back barrier (A-zone, elevation six feet) for 40% of the shoreline. This relatively poor correlation emphasizes the variability and unpredictable nature of overwash processes and flood hazard delineation.

The most dramatic overwash and threat of inlet formation during the 1962 storm occurred in the vicinity of 71st Street (see Figure 2C-8). Bulldozing of sand into the breach prevented the formation of a new inlet.

The island is quite narrow in many areas, particularly between 32nd and 61st Streets. The island is widest north from 87th Street to the Maryland-Delaware line, except in areas where canals have been dredged. In this area, 14 man-made canals and two natural tidal channels are present, nine of which are less than 500 feet from the Coastal Highway. Overall, the barrier varies in width (from the Coastal Highway) between 4,900 feet at 133rd Street and 230 feet at 36th Street, and 37 canals and channels exist. Island widths and data relating to man-made canals and natural

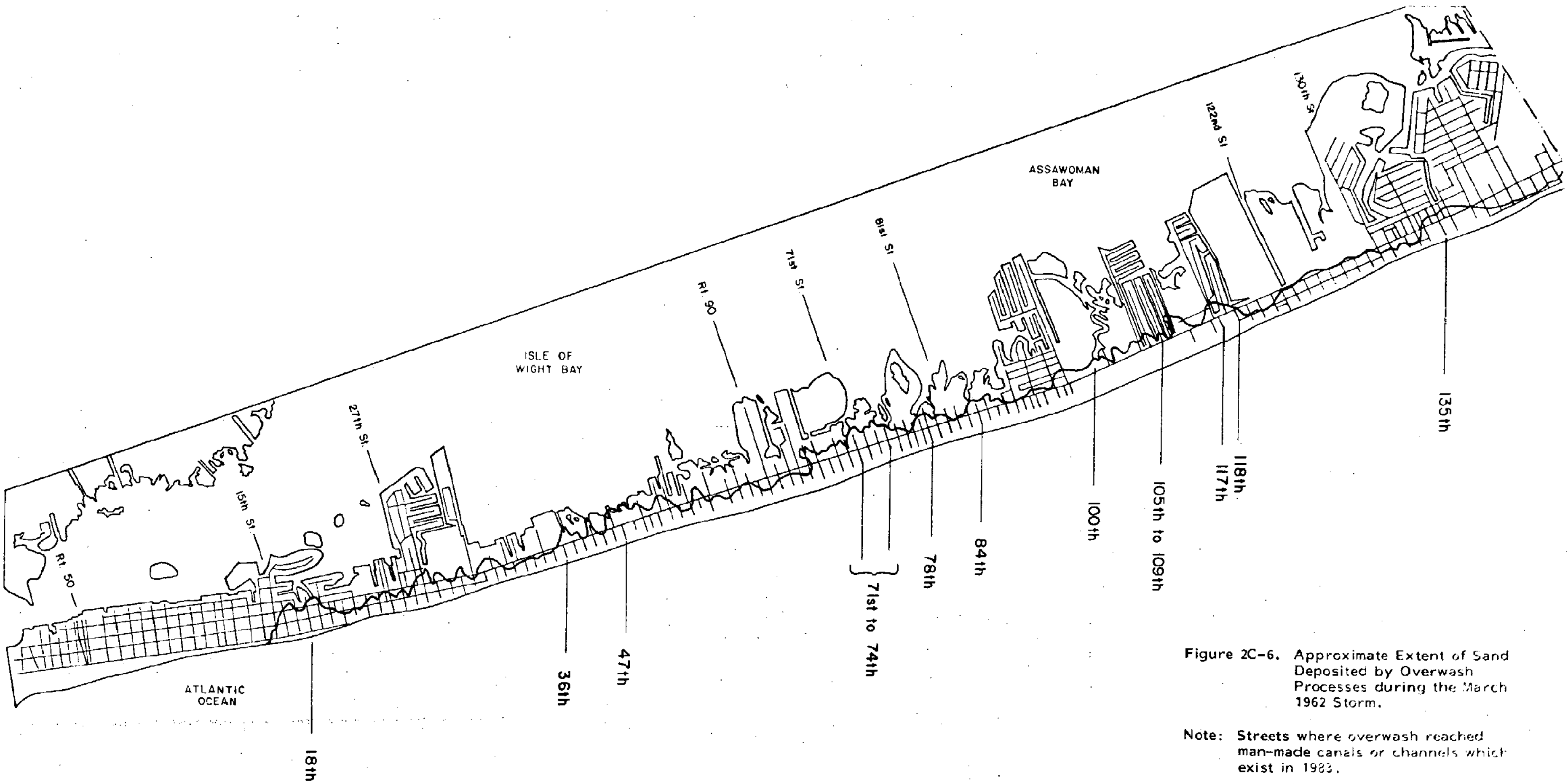


Figure 2C-6. Approximate Extent of Sand Deposited by Overwash Processes during the March 1962 Storm.

Note: **Streets where overwash reached man-made canals or channels which exist in 1983.**

IEP, Inc. JOB NO 83-10

Key

(+) Overwash correlated with delineation of A-zone (EL9)
Overwash generally was contained with A-zone

(-) Overwash did not correlate with any delineations
Overwash generally extended into A-zone (EL6)

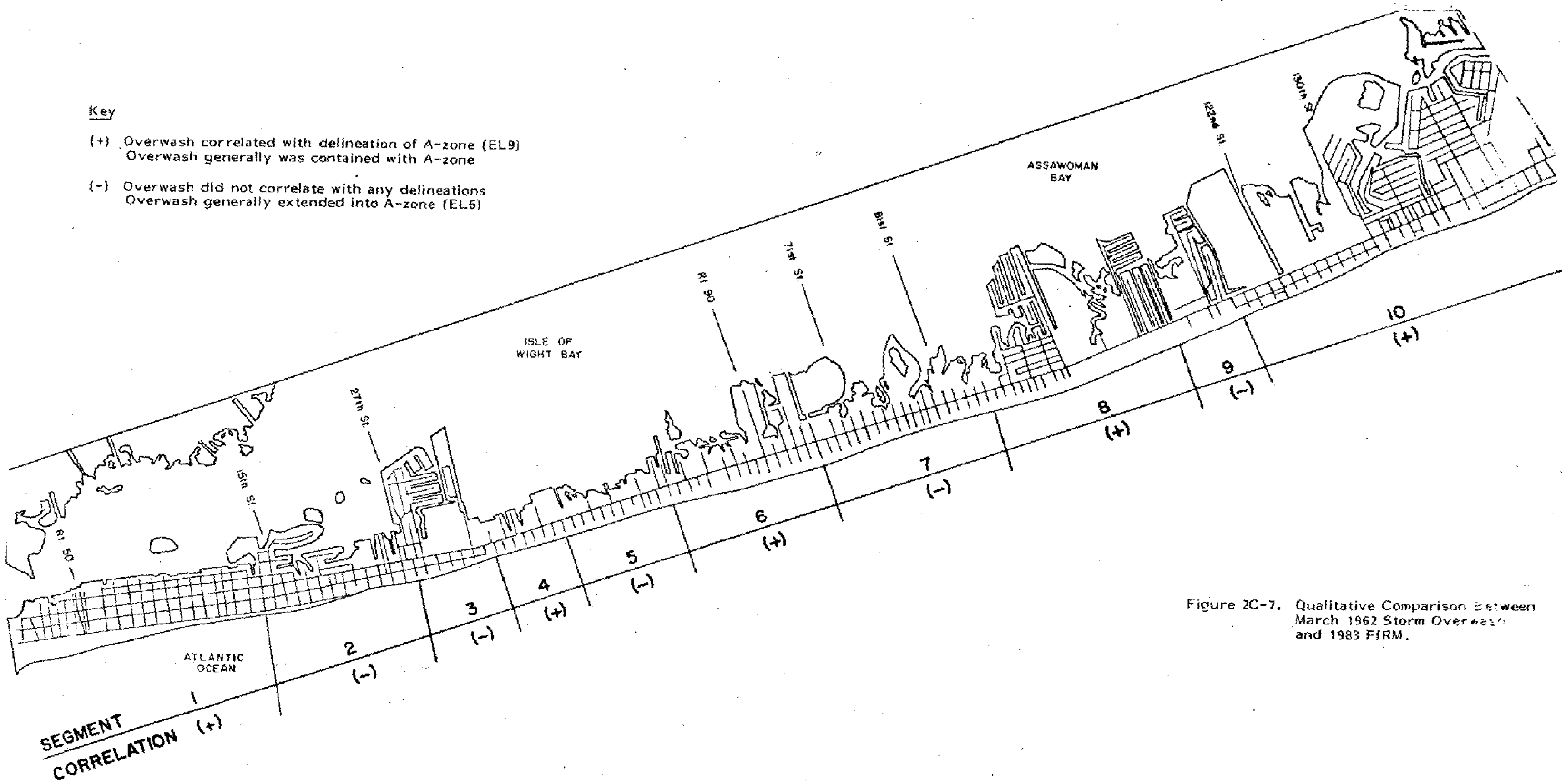
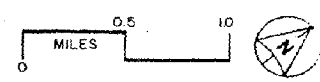
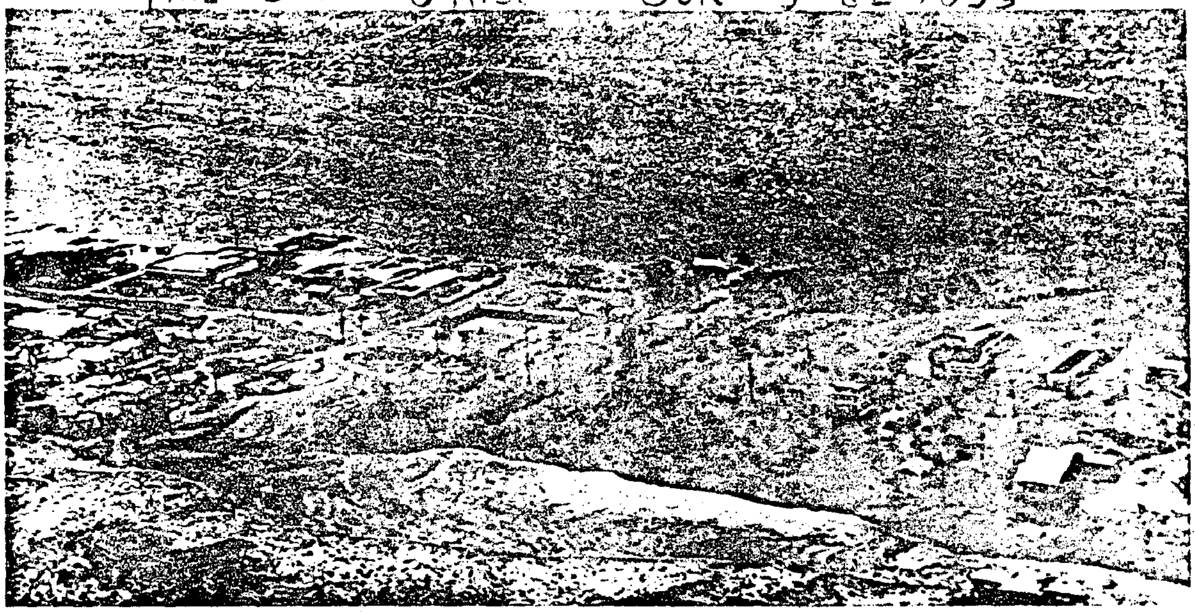


Figure 2C-7. Qualitative Comparison Between March 1962 Storm Overwash and 1983 FIRM.

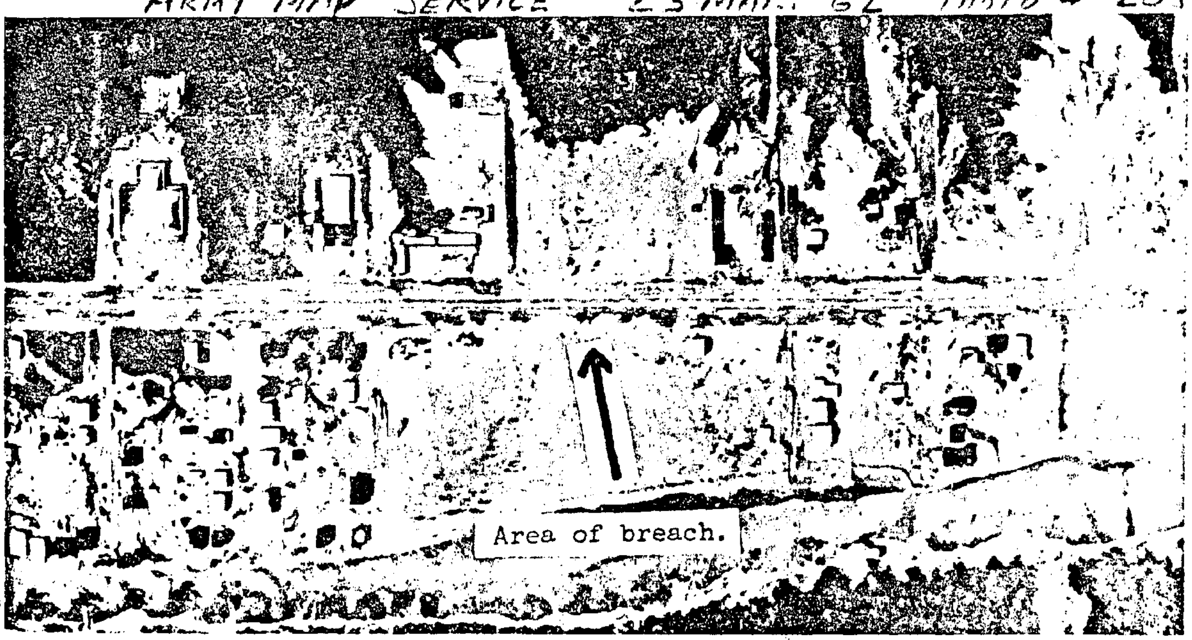


IEP, Inc. JOB NO 83-10

Figure 2C-8. Aerial View of 71st Street following March 1962 Storm. (*Source: COE, 1962*)



Aerial view of the breach in Fenwick Island in vicinity of 71st Street, taken 7 March 1962 (above); with a view of the same area taken 23 March 1962 (below) showing closure made by Maryland State Roads Commission in connection with clearing roads in the area.



channels can be found in Appendix C.

The significance of barrier width relates to the vulnerability and isolation of areas by high water and overwash sand deposition. The narrowest sections are likely to be the most difficult to pass while evacuating during a storm because streets oriented perpendicular to the shoreline will carry overwash debris and water onto the Coastal Highway. In addition, narrow sections and canal or channel sites will be vulnerable to breaching and possible inlet formation (as discussed later).

The lack of efficient storm water drainage, resulting in impounded water on streets, parking lots and other paved areas affects Fenwick Island's ability to respond naturally to storm conditions through infiltration. During a major storm event, high water levels will impede rescue, evacuation and immediate storm response. The lack of efficient drainage becomes a post-storm problem and will impede recovery and restoration. During minor storm events, rainfall contributions will create "major stormlike" conditions during and after the event. Adequate drainage could reduce these problems.

A geomorphic evaluation of storm susceptibility of a barrier island should also involve a consideration of the three-dimensional stratigraphy of the island. For a landward migrating barrier, the upper sand surfaces of the island roll over top of underlying sedimentary environments that were previously in more landward positions. Accordingly, coring down through barrier beach sands should reveal previous stands of the salt marsh and other vestiges of previous bayside sedimentary environments. Dating these buried salt marsh peat deposits can provide an indication of the rate at which the barrier island has migrated landward. The younger the age of the peat, other factors held constant, the faster the island is migrating. Since barriers migrate by undergoing erosion on their oceanward sides concurrent with bayward accretion, an island that is found to be rapidly migrating is more likely to sustain severe erosion and related damage to man-made structures in storms. Unfortunately, there is presently no data of this nature available for Fenwick Island, Maryland.

Three-dimensional stratigraphic studies are also useful in determining the depth to the sand-clay interface under a barrier island. Since sand is much more easily erodable than clay, inlets may preferentially breach through portions of the barrier where the sand layer is thickest. The sand saturation that occurs immediately prior to inlet breaching is aided by the presence of a considerable depth of beach sand since clay is less permeable to water.

The Maryland Geological Survey has collected well log and bore hole information to determine the depths to the sand-clay interface along the length of Fenwick Island. The areas with a generally deeper sand-clay interface can be inferred as being more likely to undergo the severe erosion and scouring that accompanies inlet formation.

Isle of Wight and Assawoman Bays

These two bays located south and north of the Route 90 bridge, respectively, differ in several ways. Isle of Wight Bay has a width (west to east) that is approximately equal to its length (north to south) and has a fairly uniform depth of four feet below MLW. In contrast, Assawoman Bay is longer than it is wide and has a more distinct channel (approximately six feet below MLW) bordered by an extensive tidal flat (-2 feet) behind Fenwick Island. About 85% of the discharge through Ocean City Inlet comes from these two bays, with the remaining 15% coming from Sinepuxent Bay to the south. The 100-year flood stage decreases toward the north gradually from 8.1 feet at Ocean City Inlet to 5.6 feet near the Maryland-Delaware line (Corps of Engineers, 1981). Overall, data from the Corps and the Flood Insurance Studies compare quite well, although the Corps flood elevations are generally higher (see Table 2C-5).

A major shortcoming in the wave height methodology used in the recent Flood Insurance Study (May 16, 1983) was not accounting for the hazard of the ebb surge flowing over the island after a storm has passed the area. In addition, waves may actually form along the bay side of a barrier and this was not addressed by the wave height methodology.

During a hurricane, increased rainfall, heightened discharge of tidal rivers (St. Martin River) and an easterly wind direction all contribute to the impounding of vast quantities of water in the bay behind the barrier island, particularly along the mainland shore. A rapidly moving hurricane can pass over Fenwick Island and the winds abruptly shift around and blow strongly from the west or northwest. The impounded water is then pushed toward the barrier and Ocean City Inlet. Weakened portions of the barrier could be breached and serve as outlets to the ocean for ebbing tidal waters. Island breaching and inlet formation is a very common occurrence because of this condition.

Existing canals and channels, previously discussed, will offer a pathway for ebbing bay water and act to channelize high velocity waters. Overwash channels formed during a storm most often serve as natural pathways for inlet breaching. When overwash channels are aligned with manmade canals the possibility of inlet formation is increased. From Figure 2C-6, note the proximity of overwash occurrence in the March 1962 storm to existing canals or vhannels at 12 street locations. Five inlets have been formed duringpast storms within eight miles of Ocean City Inlet (see Figure 2C-9).

Aside from the threat of inlet formation, bay waters pose an increased flood hazard to developed low-lying filled land. Several areas in Ocean City that were once marshlands have been filled and channelized. The banks of these areas have been bulkheaded;

Table 2C-5. Comparison of the Estimated 10-year, 50-year and 100-year Bay Storm Elevations (NGVD in feet) Predicted by Corps of Engineers and Flood Insurance Study Data

Segments[1]	100-year	50-year	10-year
1	8.1/7.8	7.3/6.7	5.4/5.5
2	7.5/7.3	6.7/6.0	4.9/4.5
3	5.6/5.6	4.4/4.6	2.8/2.9

---

[1] Corps of Engineers
1 - 27th Street to Inlet
2 - 90th to 27th Streets
3 MD/DE line to 90th Street

Flood Insurance Study
1 - 15th Street to Inlet
2 - 27th to 15th Streets
3 - MD/DE line to 27th Street

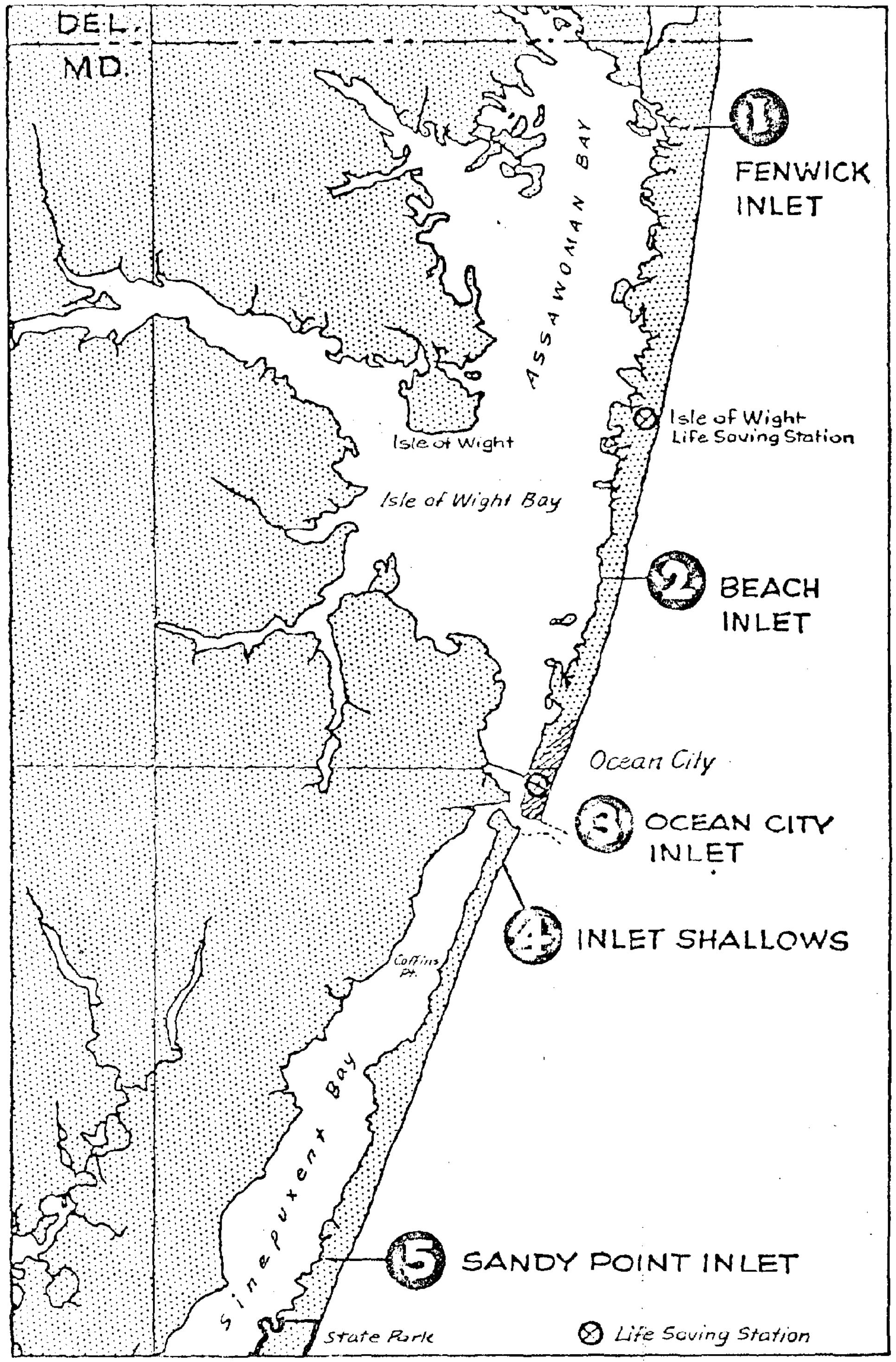


Figure 2C-9. Locations of Inlets Cut Across Fenwick and Assateaque Islands During Major Past Storms.
(Source: Truitt)

however, the elevation of these areas remains low. Construction standards in these flood hazard areas should address bay floods in addition to ocean floods.

Ocean City Inlet, as the only existing link between the Atlantic Ocean and coastal bays, remains a topic of general discussion. Many problems are cureently being addressed which include deterioration of the South Jetty, a 45-60 foot scour hole at its base, additional dredging and continued migration of Assateague Island. The impacts of the alternatives to solving these problems as they relate to the flood hazard vulnerability of Fenwick Island is an important issue. Modification of the inlet geometry could change the tidal prism, but would probably not increase the flood hazard vulnerability to the bay shoreline of the island. However, this speculation would require extensive research and is beyond the scope of this study.

Worcester County 100-Year Floodplain

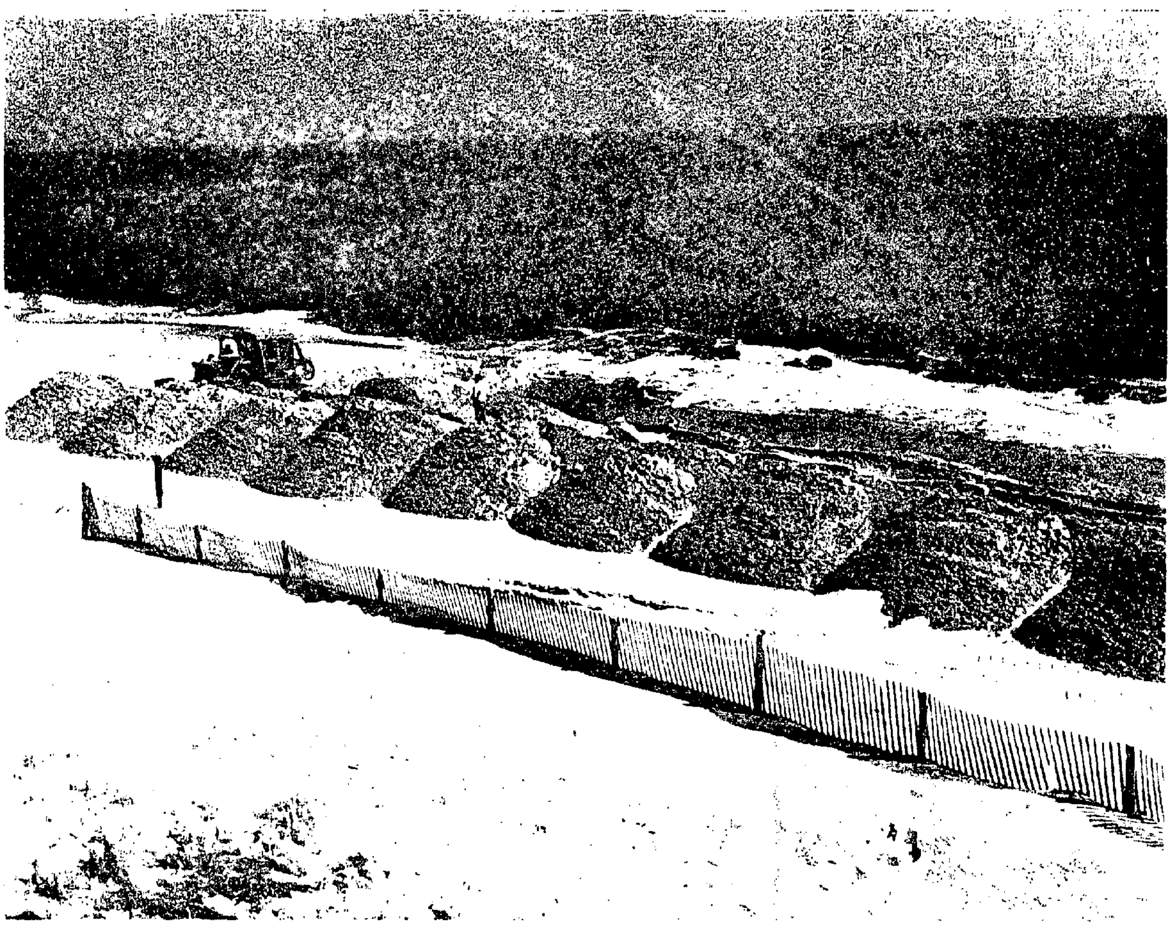
The westernmost shoreline of Isle of Wight and Assawoman Bays comprises an extensive area of salt marsh, agricultural land, rural development and several small towns. This part of Worcester County is protected by Fenwick Island during coastal storms to the extent that no waves greater than three feet in height are predicted to occur there (FIS, 1982). Four reaches were studies for insurance purposes and they include:

1. Ocean City Back Channel/Upper Sinepuxent Neck, West Ocean City to Dog and Bitch Islands;
2. Isle of Wight Bay/Upper Sinepuxent Neck, Turville Neck, Jenkins Neck, St. Martins River outfall, and west side of Isle of Wight;
3. St. Martin River/North and South banks from outfall at Isle of Wight upstream to Piney Island; and
4. Assawoman Bay/East Side of Isle of Wight, St. Martins Neck, Greys Neck and Dirickson Neck.

The maximum wave crest elevation through reach number 1 which connects Ocean City Inlet with Isle of Wight Bay is ten feet (NGVD), and for the other reaches (numbers 2, 3, and 4) the 100-year surge elevation is six feet (NGVD). Aside from a 1.0 foot increase in elevation for part of reach number 1, no major change in the 100-year floodplain occurred since the prior study in August 1978.

The Worcester County bay shoreline can be divided into areas north and south of the St. Martin River for purposes of discussing the extent of development, as well as storm vulnerability. The area south of the river is closer to Ocean City Inlet, has more existing development, has more land prepared for future development and includes Routes 50 and 90 which will be the major evacuation routes from Ocean City. The closer proximity to Ocean City Inlet may present more vulnerability to the flooding hazard than is identified on the FIRMs because the tidal range in Isle of Wight Bay is larger than in Assawoman Bay. Much of the developed land and land soon to be developed consists of extensive low-lying dredgfed and filled areas extending into the bay. Areas along Golf Course and Keyser Point Roads, Turville and Mankiln Creeks and in Ocean Pines should consider minimum elevations higher than the six foot flood elvevation identified on the flood insurance maps. Heightened discharge of the St. Marting River also contributes to the flood hazard.

IS
OCEAN CITY
PREPARED?



Ocean City is aware of its location on a barrier island exposed to the impact of hurricanes and northeasters. In the 20 years since the 1962 northeaster caused extensive damage at Ocean City, the City, state and county have developed several regulations and programs that directly or indirectly reduce the potential for flood losses form these storms. At the same time, development at Ocean City has increased the amount of property and number of people that are at risk from a major storm.

This section describes the major regulations and programs relating to flood and erosion control that now affect Ocean City, and examines the extent to which Ocean City is currently prepared to withistand a major coastal storm.

PROTECTING THE LAND

Immediately after the March 1962 storm, the Corpos of Engineers developed an emergency plan to clear sand from the roads and rebuild dunes that had been washed away. This plan titled Operation Five-High included beach and dune reconstruction from the Maryland-Delaware line south to Ocean City Inlet. The basic plan consisted of a continuous berm and dune with a dune crown not less than 12 feet above mean low water on a line approximately 150 feet west of the mean high water line, and the erection of a sand fence extending along the entire dune crown. Much of the sand used was that cleared from the streets, but an additional 1,050,000 cubic yards was pumped in from Assawoman, Isle of Wight and Sinepuxent Bays. As stated in the preface of the document Operation Five-High:

> The dunes constructed by the Corps of Engineers were designed to protect against Atlantic storms as as severe as any that are expected to occur in an average 10 year period. State, County and City officials have been informed of the limits of the protection and are here again advised that complete protection has not been provided. Steps should be taken by all interests to preserve the constructed work by planting grass and shrubs and erecting additional sand fences, and to further build up the dunes as protection against storms of magnitude greater than those of a 10 year frequency.

Twenty years of growth and development since the March 1962 storm has eliminated almost all dunes on the island and covered up most other available sand on the island with parking lots, roads, shopping centers and condominiums. The 10-year frequency storm protection no longer exists; there is now less than a five-year frequency storm protection.

Several beach protection plans have been developed in the past several years that would reduce Ocean City's vulnerability to coastal storms. One of these, a Corps of Engineers plan, would have provided protection from a 100-year flood, but it has not been funded. In April 1982 a formal beach protection plan was agreed upon by state and city officials which provides for the installation of two groins a year for the next 25 years. Beach fill between the groins is required but no borrow site has yet been selected as a source of sand for the fill. This plan does not include dune restoration.

The specific engineering design of the current groin plan is based on recommendations for short groins made in the Trident Report on Interim Beach Maintenance at Ocean City, October, 1979. To be more effective than the existing 52 asphalt, timber and stone groins, the proposed groins will extend further seaward, end at a lower point in the surf-zone and be spaced more proportionally according to Corps of Engineers specifications. A set of four maps as a scale of 1"=200′ and titled "Groin Location Plan for Interim Beach Maintenance" shows the approximate location of the 50 groins. No existing groins will be removed and some existing groins which meet the spacing criteria will be expanded. Further analysis of the groin plan maps indicates that ten will be built on existing groins, 12 will be relocated to existing groins that meet the spacing criteria,and 28 will be newly constructed. Seventeen existing groins, now exposed, will remain with the field. If and when the plan is completed, 67 groins will be present.

The initial placement of the two groins at 7th and 9th Streets was completed in May 1983. The state legislature allocated the estimated $350,000 it would cost for the two groins; however, with an additional $90,000 the project was still 10-15% over budget. Some of the high cost is attributed to the requirement that filter cloth be used; however, some type of bedding material must be used so that cost cannot be completely eliminated. More importantly, the space between the groins was not filled with sand and their effectiveness is suspect.

Ocean City's current objective is to begin implementing a plan which meets their immediate needs for erosion control and provides for additional recreation area whiel the more extensive Corps plan (U.S. Army Corps, 1980) awaits funding. The Corps has emphasized that (1) recreational projects have a very low priority and it is doubtful the plan will get approval, and (2) the Crops plan doesn't utilize groins so no reimbursement or credits should be expected for groin work done now by the City. Given the Corps position, the city needs to begin planning for an alternative means of providing long-term protection while an interim plan is implemented. The ramifications of the failure to do so will have far-reaching implications regarding the imlementation of additional hazard mitigation measures, explored later in the report.

PROTECTING PROPERTY

Numerous land use and building controls have been established by state, county and city authorities that specifically address the protection of property from damage by floods and storms. The major programs and legal controls of each level of government are discussed below.

State of Maryland Authorities

Flood Hazard Management Act of 1976. This act provides the basic floodplain management and flood hazard mitigation authorities for both the state and local governments. The Act is administered by the Water Resources Administration, Flood Management Division, of the Maryland Department of Natural Resources (DNR). It is significant for the explicit recognition of a need to mitigate flood losses and the establishment of programs for flood loss reduction.

The Act requires the DNR to designate priority watersheds for conducting flood control planning and management studies. The watershed management study including Ocean City and Worcester County is scheduled to begin in the fall of 1983. Following completion of the watershed management study by the state, the city and county will be required to prepare a flood management plan designed to reduce flood losses, and to implement the plan once it has been approved by the DNR.

Flood Insurance Program. The Flood Management Division also provides coordination with the National Flood Insurance Program operated by the Federal Emergency Management Agency (FEMA). It provides assistance to local government in developing floodplain management regulations and reviewing flood insurance studies and maps prepared by FEMA or the department itself.

Shore Erosion Control Law. The Shore Erosion Control Division of DNR provides technical and financial assistance to property owners with shore erosion problems. Individual landowners, municipalities and counties may apply for 25 year, interest-free loans for projects designed to control shore erosion. Construction loans cover 100% of the first $50,000, 50% of the next $20,000, 25% of the succeeding $20,000, and 10% on any remaining amounts. DNR supervises the design and construction of the structures, but property owners are responsible for maintenance.

Sediment Control Law. This act and the Sediment Control Rules and Regulations adopted by the DNR are administered within DNR by the Erosion and Sediment Control Divison. They require each county and municipality to adopt grading and sediment control ordinances. Approval of sediment control plans for construction projects is required by the appropriate Soil Conservation District and, in some cases, by DNR. DNR provides technical assistance to local governments and the soil conservation districts, and periodically evaluates the local governments' grading and sediment control programs.

The Sediment Control Law also contains a provision creating a Beach Erosion Control District that extends from the Delaware line to the Virginia line. On Assateague Island the western boundary of this district is approximately the west crest of the existing natural dune line. In Ocean City it is a line known as the" State-Ocean City Building Limit Line which coincides, more or less, with the existing Ocean City Building Limit Line and on occasion may coincide with the crest of the littoral system." Construction of permanent structures within the Beach Erosion Control District is prohibited.

This section of the law also provides that "If the prohibitions imposed on the beach erosion control district would constitute a taking of a property right without just compensation in violation of the constitution of the United States or the constitution of Maryland, funds under program open space may be used to purchase or otherwise pay for any property taken. In 1975 it was estimated that approximately 10 acres of property might need to be acquired because of denial for building permits. To date, the state has acquired through the Program Open Space a total of 34 1/2 lots (5.2 acres) from 19 different property owners. Land acquired by the state under this program is maintained as open space to provide greater beach access and beach area.

Stormwater Management Act. This 1982 act requires each county and municipality to adopt, by July 1, 1984, ordinances necessary to implement a stormwater management program. The Stormwater Management Division of DNR has developed regulations setting forth minimum stormwater management requirements for each county and municipality.

State Wetlands Act. This act defines two categories of tidal wetlands: state wetlands and private wetlands. State wetlands are defined as "all land under the navigable waters of the State below the mean high tide, which is affected by regular rise and fall of the tide." Private wetlands are "all lands not considered State wetlands bordering on or lying beneath tidal waters, which are subject to regular or periodic tidal action and which support aquatic growth." The Wetlands Division of DNR reviews and permits if appropriate, all proposed activities in wetlands, except for certain hunting, fishing and agricultural activities. The same permitting policies generally apply to both State and private wetlands. This program is carried out in coordination with the Corps of Engineers Section 404 Permit Program, and DNR has a Memorandum of Agreement with the Corps for a joint permit review program.

Prior to the passage of the Wetland Act, considerable dredging and filling occurred on the bay side of Ocean City. Most of this dredge and fill activity is now prohibited.

Coastal Zone Management Program. The Tidewater Administration of DNR administers the Maryland Coastal Zone Management Program.

This program operates primarily by providing technical assistance to, funding for, and cooperation with other state programs that affect the coastal zone. It assists with stormwater management, erosion and sediment control, mapping, watershed management plans, and project review. The Tidewater Administration is sponsoring this current study of the Ocean City area in a cooperative agreement with the Water Resources Division.

The state programs briefly described above provide the greatest and most direct potential for flood loss reduction in the Ocean City area. Other state programs can also affect the degree of flooding that may be experienced, such as the State Highway Administration's programs and policies for design and location of state highways, and the Department of State Planning's review and development of funding priorities for State funded capital projects.

Ocean City, Maryland

The Code of the Town of Ocean City contains the following major provisions specifically related to flooding and erosion.

Section 34. Building Construction. The Standard Building Code published by the Southern Building Code Congress International, Inc. has been adopted as the Building Code of the Town of Ocean City. Appendix M, Flood Plain Construction Standards, of this code provides performance criteria for building in flood hazard areas, but these criteria are provided as guidance rather than as a part of the formal code. Further, the performance criteria can result in varying interpretations of design and construction specifications.

Section 36. Oceanfront Building Limit Line. This section prohibits new construction east of a designated building limit line along the beachfront. The State-Ocean City Building Limit Line which was established later, essentially follows the Ocean City Building Limit Line. In most areas the Building Limit Line is east of the natural dune line.

This section also adopts an Open Space Implementation Program, establishes a Town policy to acquire by acquisition or easement areas designated in the Open Space Implementation Program, and requires development of a financing program to fund the acquisition of open space. Althouth the City has acquired several lots and easements along the beach, this program does not appear to have been used in several years.

Section 46. Erosion and Sediment Control. Two erosion and sediment control districts have been established within Ocean City: the Beach Erosion Control District which extends 250 feet west of mean low water or to the highest point of the natural dune, whichever is greatest; and the Bay Erosion Control District which includes the remainder of Ocean City. Sediment and erosion control plans must be approved by the Worcester Soil Conservation District, but inspection and enforcement are the responsibility of the city.

Buildings may be constructed within the Beach Erosion Control District and the natural dune may be removed. All buildings constructed east of the natural dune linemust be constructed on steel-reinforced concrete pilings properly engineered and designed tobear theload of the structure and so certified by a registered professional engineer or architect. The building must also be at an elevation of at least 16 feet above mean low water.If the natural dune is removed, a new dune must be developed and maintained as part of any approved construction. In past years the requirement for dune maintenance was not adequately enforced. Berms were often maintained by bulldozing sand from the lower beach, but sand fences and vegetation were not provided to held the artificial dunes becomes established. As a result, there are few dunes remaining in Ocean City.

During the past year or two the Worcester Soil Conservation District has taken a more active role in the dune restoration and maintenance program. The District has begun working with the Condominium Association to encourage property owners to place sand fences and plant dune vegetation. In 1982 54 properties were planted with beach grass in the cooperative project with the Condominium Association.

Section 52A. Flood Damage Controls. This section adopts the Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency which identify A-zones (areas subject to flooding from a 100-year flood), V-zones (areas subject to velocity waters, including hurricane wave wash and tidal waves in the 100-year flood), and indicates expected water levels during a 100-year flood. This section also establishes minimum elevation requirements in the A-zone for residential construction (lowest flood elevated to 10.5 feet above mean low water - 9.0 feet above mean sea level) and nonresidential construction (elevated to or above the level of the 100-year flood or floodproofed to the level of the 100-year flood.

In V-zone, any permitted construction must be located landward of the reach of mean high tide, be elevated to or above the 100-year flood level, and have the space below the lowest floor free of obstructions or constructed with breakaway walls. It also prohibits the use of fill for structural support in V-zones, placement of mobile homes in V-zones, and man-made alterations of sand dunes if the alterations would result in an increase in potential flood damage.

FEMA has conducted evaluations of the Ocean City Flood Damage Control regulations in 1976 and 1981 and found that the City was largely in compliance with the regualtions. The 1976 evaluation also determined that the water and sewer facilities were reasonably floodproofed.

Section 54. Foundation Regulations in Critical Areas. This section establishes more specific and more stringent standards for scour and impact loads of building foundations located along the beachfront. It also specifies design windloads for buildings located in this area.

Section 105. Zoning. The zoning regulations of Ocean City establish limits on lot coverage, building size, height, and other standards provisions. They do not contain any provisions specifically relating to location of buildings for flood damage reduction.

Comprehensive Plan of Ocean City, Maryland. The Comprehensive Plan was first adopted in 1969 and last revised in 1978. Although the plan recognizes the importance of the beachfront to Ocean City and that the Town occupies a sand spit, it does not specifically address the flood hazard vulnerability of Ocean City, and does not appear to have taken the flood hazard into account.

Worcester County

Worcester County has established the following regulations pertaining directly to floodplain management:

Building Regulations. Worcester County is authorized to adopt a building code, but has not yet done so. It has adopted plumbing and electrical codes.

Building Regulations. Floodplain Management. Floodplain Management regulations are included under Worcester County's Building Regulations. As in Ocean City, the regulations adopt the flood insurance rate maps prepared by FEMA as the basis for delineating flood hazard areas and regulating construction and use within them. The latest revision of the FIRM's became effective June 15, 1983. There are no V-zones designated in the area of Worcester County across from Ocean City. The Worcester County regulations require that the lowest floor of residential construction must be elevated to the 100-year flood elevation or higher rather than specifying a uniform elevation requirement as in the Ocean City code. Nonresidential structures must be elevated to the 100-year flood elevation or floodproofed to the 100-year flood level.

Natural Resources. Erosion. These regulations require a grading permit by a Worcester County sediment control inspector. The Worcester Soil Conservation District must approve the grading plan before a permit can be issued.

Natural Resources. Fill and Bulkhead Line; Borrow Limit Line. This regulation establishes a fill and bulkhead line which establishes the westerly limit for bulkheading and filling along the bay side of Ocean City. It also establishes a borrow area limit line which sets a western limit for borrow areas for filling along Ocean City.

Natural Resources. Construction along Shorelines. This regulation creates a Worcestrer County Shoreline Commission and gives it authority to establish construction standards and issue permits for construction along shorelines of Worcester County. It defines and establishes separate permit conditions for major construction and minor construction.

Zoning and Subdivision Control. The zoning regulations include the establishment of a floodplain district which is similiar to but less detailed than the Floodplain Management provisions under the Building Regulations portion of the code. It also includes a conservation district for the protection of areas unsuitable for development.

Worcester County Comprehensive Plan. The Worcester County Comprehensive Plan was prepared in 1976. In contrast with the Ocean City comprehensive plan, it specifically recognizes a need to preserve much of its remaining wetlands and other natural areas. However, the plan also encourages Worcester County to support Ocean City's plans for continued growth and more intense development.

PROTECTING PEOPLE

As a highly developed and very popular coastal resort, Ocean City's population varies seasonally. The year-round resident population is estimated at about 5,700 (1972). In contrast, the estimated average daily residential and transient population ranges from about 11,500 during January to as high as 232,000 during August (see Figure 3C-1). An even higher population may occur on weekends during June through September. Although the permanent population is low, it also has been increasing in the last few years, partially as a result of retirees moving to the city.

The requirements for providing for the safety of Ocean City's population varies with the season, and is dependent upon both the number of people on the island and the type of storm that may occur. Unfortunately, the season of highest population occurs during the hurricane season which lasts from June through November and peaks during August and September. The high winds, high water levels and waves associated with hurricanes can all cause injury or death to those exposed to the storm. It is essential that everyone in Ocean City either be evacuated prior to the time a hurricane is predicted to strike the city, or, as a last resort, be provided with safe shelter to weather the storm.

During the late fall, winter and spring, northeastern storms pose the greatest risk. Although these storms pose less threat than a large hurricane, they can be intense and long lasting. Populations levels are much lower during these months of the year, but there are still a sufficiently large number of people on the island to cause evacuation concerns.

It has been more than 20 years since Ocean City was affected by a major storm. During the March 1962 storm, tides wre nine feet above mean low water, parts of Ocean City were completely underwater, and several feet of sand were deposited on streets and lots. Although many buildings in Ocean City were destroyed

FIGURE 3C-1. Estimated Average Daily Resident and Transient Population (000,s)

	1978	1979	1980	1981
January	20.8	12.0	13.1	11.5
February	18.1	12.5	23.1	13.1
March	22.6	26.6	29.8	21.9
April	24.6	27.6	33.8	43.8
May	53.7	58.7	69.9	74.4
June	87.3	119.0	134.4	158.7
July	141.0	161.9	196.9	205.1
August	152.8	173.7	199.7	232.3
September	71.3	99.7	103.2	123.2
October	23.2	31.8	45.8	53.8
November	19.8	22.8	25.8	41.8
December	11.8	11.5	14.8	24.8
Monthly Average	53.9	63.2	74.2	83.7

Source: Ocean City Health Services

or severely damaged, the efforts civil preparedness, police, volunteer firemen and other volunteers were credited with providing emergency warnings for evacuation or safe shelter and for rescuing those who required assistance.

Today Ocean City is well aware of the potential for another damaging storm similar to the 1962 northeaster or for an even more damaging hurricane. City officials have expressed their belief that Ocean City is well prepared to provide sufficient warnings, evacuate people if necessary, and survive the storm just as they did in 1962. These views are based on the existence of an "Ocean City Emergency Operations Plan" and confidence in those city employees and volunteers who would assist in implementing the plan.

The "Ocean City Emergency Operations Plan" was developed several years ago (the plan is undated) and is reviewed annually and updated as needed. Table-top exercises are also held periodically, but apparently no field exercices have been held. The Emergency Operations Plan provides a detailed breakdown of individual and department responsibilities, available equipment, coordination with county and state emergency management agencies, and which of the three potential evacuation routes that should be used by different geographic areas within Ocean City. However, the plan does not address several important issues: special evacuation needs of certain segments of the population, such as the elderly and handicaped; how much warning time is likely and whether the population can be evacuated within that time; the time at which one or more of the evacuation routes may become impassable due to flooding. Additionally, information regarding the evacuation routes and other key elements of the plan do not appear to have been made available to most residents and property owners.

A Storm Evacuation Planning Map was released in June 1983 that includes the Ocean City area. This map was prepared by the National Ocean Survey in cooperation with the Maryland Emergency

Management and Civil Defense Agency. The map identifies the key evacuation routes over a large geographic area, but provides no details on evacuation procedures for any area.

CONCLUSIONS

1. It has taken 20 years since the March 1962 storm to adopt a beach restoration plan, but problems encountered during the first year of implementation of the plan indicate that many procedures need to be further refined.

2. The current approved groin plan will only provide for 10-year storm protection when completed in 25 years and only if: (1) beach fill is provided between groins, and (2) sufficient yearly appropriations are provided to implement the plan.

3. Bulldozing of sand from the beach to higher elevations may have costs which outweigh any economic or environmental benefits.

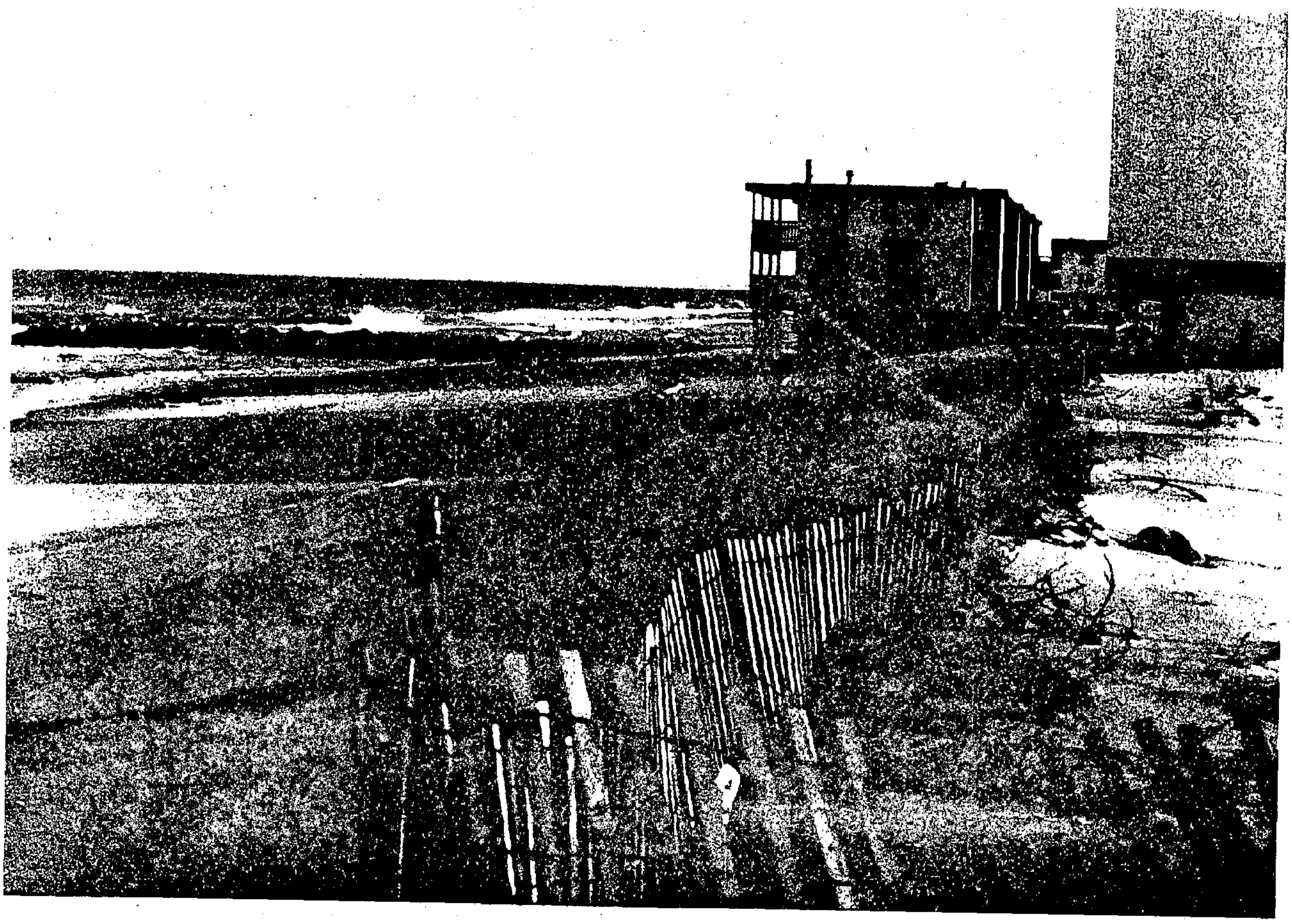
4. Efforts to properly restore or create dunes will have benefits which outweigh the costs.

5. The state, county and city have developed and implemented several regulations and programs that have positive flood loss reduction benefits.

6. Ocean City today is more vulnerable to losses from a major hurricane or northeaster than at nay time in the past. There are several reasons for this:

- Much of the present development occurred during the late 60's to mid 70's when several of the present controls did not exist;
- The original dune line has been largely removed.
- There has been heavy reliance upon the building code to ensure that new buildings will be designed and constructed to withstand the forces of wind and water during storms;
- Enforcement of some regulations appears not to have been uniform over the years;
- Many Ocean City officials and residents/property owners believe that having survived one severe storm in 1962 they can fair equally well during the next major storm; and
- Perhaps most importantly, the nature of Ocean City as a barrier island has not been fully recognized in most of existing regulations and development decisions.

BEFORE THE STORM:



REDUCING DAMAGE POTENTIAL

EROSION AND FLOOD CONTROL

Four beach protection plans which address beach erosion and flood control in varying degrees, are currently being considered by federal, state and city officials for Ocean City, Maryland. They include the following:

1. "Hurricane Protection and Beach Restoration Plan" prepared by the U.S. Army Corps of Engineers, Baltimore District, and described in Atlantic Coast of Maryland and Assateague Island, Virginia - Feasibility Report and Final Environmental Impact Statement, revised August 1980;

2. "Interim Beach Maintenance at Ocean City" plan prepared by Trident Engineering Associates, Inc. and described in The Trident Report On Interim Beach Maintenance at Ocean City, October 1979;

3. "Hybrid Plan" prepared by the Coastal Resources Division, Department of Natural Resources, Tidewater Administration which combines features of the Corps and Trident plans; and,

4. "Groin Location Plan for Interim Beach Maintenance" jointly agreed upon by the state and city in April 1982, referred hereafter as the status quo.

For purposes of this section, analysis of these various storm and beach protection alternatives was made regarding their effectiveness and their costs and benefits. Following the next section on land use management controls, implications of their implementation on other proposed hazard mitigation measures will be discussed.

Effectiveness

The effectiveness of each beach protection plan varies with respect to its erosion and flood control functions. To make a qualitative evaluation of each plan's effectiveness, seven basic design characteristics were assessed. The characteristics included: (1) beach width; (2) berm width; (3) berm height; (4) dune width; (5) dune height; (6) bulkhead height; and, (7) nonstructural measures. For purposes of this discussion, those characteristics relating to width (nos. 1, 2 and 4) are considered to provide for erosion control and those relating to height (nos. 3, 5 and 6) are considered to provide for flood control. Nonstructural measures are associated with flood control. Two other aspects considered in the evaluation of effectiveness include the length of time required to complete the plan and the long-term effectiveness. Table 4A-1 summarizes the basic information used for evaluating the four plans.

In general, the Corps and hybrid plans have the most effective design for both erosion and flood control. They both incorporate dunes and bulkheads and are expected to offer protection against the 100-year frequency storm event (1% chance of occurring in any given year). Both plans are estimated to take ten years to complete. The actual construction procedures have not been established but it is assumed that sections of beach and dune would be completed in order to provide both erosion and flood control for each section of shoreline. A major difference between these two plans would be the order in which sections are completed.

Table 4A-1. Summary of Basic Design Characteristics of the Four Current Beach and Storm Protection Plans for Ocean City, Maryland.

Plans	EROSION AND FLOOD CONTROL CHARACTERISTICS						STORM PROTECTION (frequency event in years)	Work Schedule
	Beach Width	Berm		Dune		Bulkhead Height		
		Width	Height[1]	Crest Width	Height			
1. "Hurricane Protection and Beach Restoration Plan" (Plan 3) Corps of Engineers August 1980	200'	135'	8.7'	25'	16'	16'	100	10 years to complete
				extends from 27th St. to State Boundary		extends from N. Division St. to 27th St.		
2. "Interim Beach Maintenance at Ocean City" Trident Engineering Associates, Inc. October 1979	170'	90'	8.7'	-	-	-	8	47 short groins with sand fill over 5 years
3. Hybrid Plan (1&2) DNR-Coastal Resources Division	170'	90'	8.7'	25'	16'	16'	100	10 years to construct groins dunes and bulkhead
				extensions same as Corps Plan				
4. Status Quo Yearly Allocation from State	170'	90'	8.7'	-	-	-	<10	2 short groins per year for 25 years

[1] Referenced to National Geodetic Vertical Datum (NGVD).

Construction of groins in the hybrid plan may require the sections to be completed in order from south to north. This would leave sections in north O~~an City vulnerable until project completion. The Corps plan, however, seems to have more flexibility whereby lower, more vulnerable sections of beach could be constructed on a priority basis (see Figure 4B-1). Also, a proposed warning and evacuation plan associated with the Corps plan addresses an additional flood hazard mitigation concern. The warning and evacuation plan could be designed to complement the beach and dune construction plan so that protection is provided to those sections not completed during the ten year period.

The Trident and status quo plans are comparable in that they provide only limited and interim erosion control. Neither plan proposes dune or bulkhead construction and only offer protection against the 8-to 10-year frequency storm event. Both plans incorporate the installation of groins; however, the major difference lies with the length of time required to complete each plan. The estimated five year construction period for the Trident plan makes it more effective than the 25 year period estimated for the status quo plan. With an average erosion rate of 2.3 feet per year, a maximum shoreline retreat of 57.5 feet at the north end of Ocean City would occur before the status quo plan is completed. No additional nonstructural measures are proposed for either plan, other than flood insurance which is currently available.

In all plans, except for the Corps plan, groins are a primary feature. The long-term performance record of groins, in general, has not been good. Sand starvation and excellerated erosion on the downdrift side of groins is more of the rule than the exception. The effectiveness of existing groins (Table 2C-2) in Ocean City has

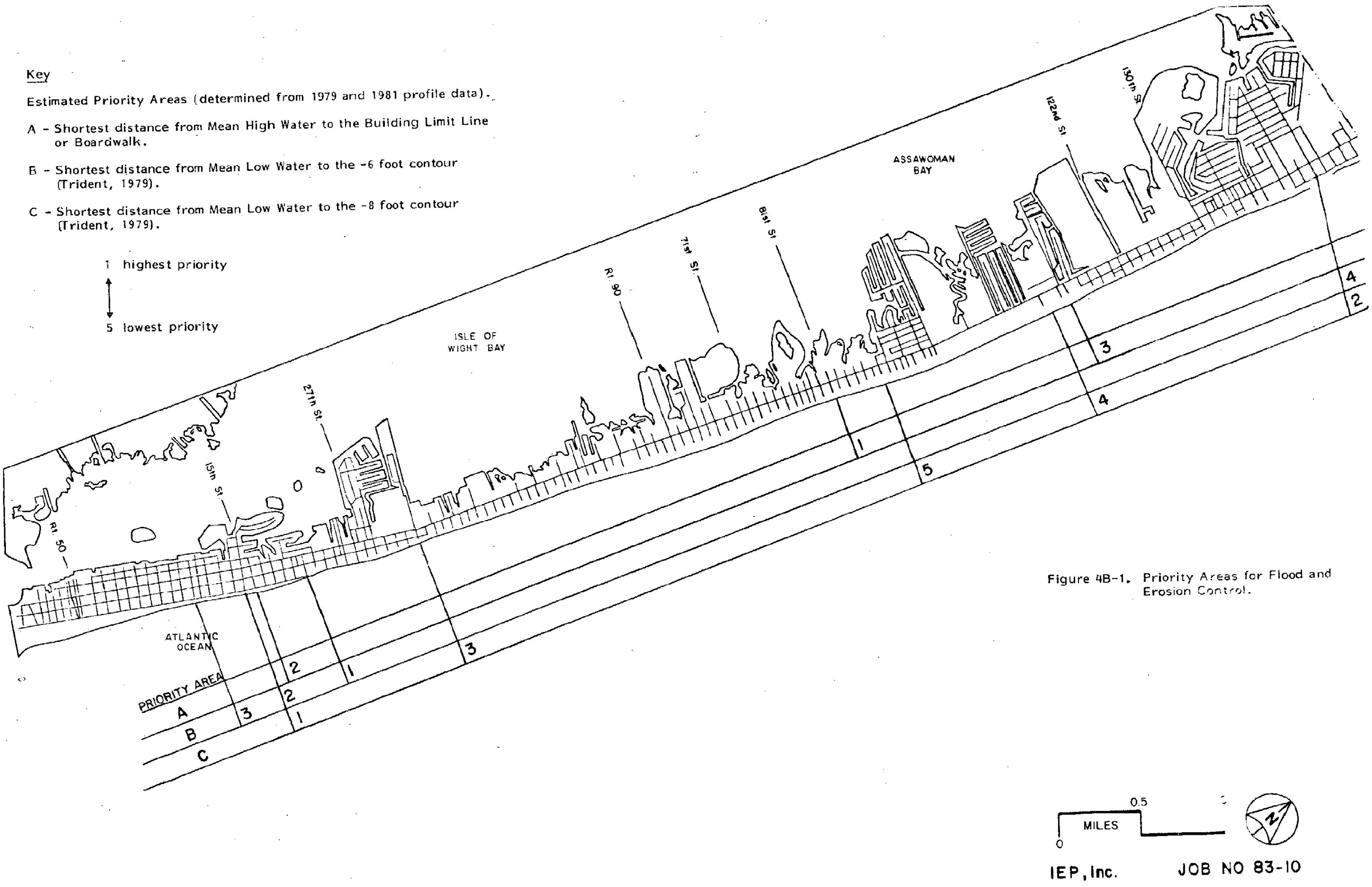


Figure 4B-1. Priority Areas for Flood and Erosion Control.

IEP, Inc.

JOB NO 83-10

not been quantitatively determined, but qualitatively they have been considered ineffective because they are too short and spaced too far apart (Trident, 1979). While filling each groin cell with sand is considered a primary requirement to assist in avoiding the negative impacts of groins, a borrow site for sand in the initial phase of the status quo plan between 7th and 9th Streets has not yet been identified. Another disadvantage to the use of groins relates to their ineligibility for credit towards any federally funded beach restoration project. Since groins are not part of the proposed Corps plan, no funds will be reimbursed to the city or state if and when the federal plan is approved and authorized.

Other erosion and flood control efforts which occur on an emergency basis and which are limited to isolated areas, are considered least effective. Beginning with an emergency authorization in June 1976, bulldozing of beach sands to form dune-like mounds has apparently become an accepted form of beach maintenance. The largest direct expenditures that have been documented includes approximately $136,000 in October and November 1977 and approximately $648,000 between December 1977 and February 1978. State reimbursement totalled $250,000 for these periods. The bulldozing occurred without study of the actual effect it had on beach erosion, but generally, the effort is considered to have long-term value (Public Hearing testimony, June 7, 1977) and a diminishing value as offshore slopes steepen (Trident, 1979). A request by the Department of Interior Fish and Wildlife Service to the Corps of Engineers on September 21, 1977 focused on the need for monitoring either by the applicant (city), Corps of Engineers or the Maryland Shore Erosion Control and the Maryland Geological Survey to determine "...amount, frequency and overall effectiveness of bulldozing as a beach maintenance technique." It doesn't appear any action has been taken on this request.

Private or individual efforts to establish dunes in front of their property are isolated and have limited effectiveness. While these efforts should not be discouraged, recognition of the discontinuous nature of the isolated dunes is emphasized. A substantial benefit and increased effectiveness would occur if these dunes were incorporated into a dune plan, similar to that proposed in the Corps and hybrid plans.

All four large scale plans, emergency bulldozing and individual efforts to establish dunes are actions which emphasize the public desire to stabilize Fenwick Island. The long-term committment of these actions has different implications regarding man's desire to stablize and fight nature versus nature's power to move the barrier regardless of what man does. The long-term value and effectiveness of bulldozing and constructing discontinuous dunes is that they can be implemented at any position the shoreline takes. They will only provide protection for particular areas and only during low frequency storm events (less than 10-year event).

Three of the four large scale plans that require groins have the least amount of long-term value and effectiveness because of the static position they will hold. Groins will not respond to natural changes in the beach position or offshore slopes. Groins will have their best results if they are positioned properly with respect to mean low water, if they are properly spaced apart, if they have a bedding material, if they are wide and long enough and if they are filled to capacity with sand. In reality, removal of beach fill between the groins during erosional storm processes will expose the groins and other detrimental impacts may result. The Trident and status quo plans are short-term or interim plans in the first place. They are not expected to have long-term effectiveness. The incorporation of a dune line in the hybrid plan gives it more long-term value; however, the groins would detract from the overall value.

The Corps plan, or one like it, has the greatest long-term value and effectiveness because of its ability to fluctuate and move in response to gradual and immediate changes in beach form and offshore slopes. Exchange of sand between the beach and offshore environments will not be impeded by shoreline structures such as groins. The relative position between the beach and dune must remain fairly constant but it can shift seaward or landward and not lose any of its ability to provide erosion and flood control.

The preceding discussion of beach nourishment activities assumed that sea level will follow its previous trend. However, an Environmental Protection Agency report to be released this summer projects a substantial rise in sea level resulting from emissions of carbon dioxide, methane, nitrous oxide, and fluorocarbons. Increasing concentrations of these gases are expected to produce a global warning which could cause ocean water to expand and glaciers in Greenland and Antarctica to melt. The EPA report projects a rise in sea level of one-half to over two feet by the year 2025, and two to ten feet by 2100.

Without additional beach nourishment activities, such a rise in sea level could cause several hundred feet of erosion. Of the projects under consideration, only sand replenishment is likely to effectively stabilize the shore. Directly or indirectly, it would be necessary to raise the entire beach profile by the amount of sea level rise. Assuming that the closure point is 1500 feet from dune line a 1-1/2 foot rise in sea level implied by EPA's medium scenario would require approximately 3.5 million cubic yards of sand along the eight miles of shoreline by 2025, in addition to the quantity required by parograms to address erosion that has occurred in the past.

The prospect of accelerating erosion and increased flooding from sea level rise could also have important consequences for post-disaster planning. In the absence of a major disaster, Ocean City may prefer to wait for better projections of sea level rise, which should be forthcoming in the next decade. However, because of the substantial amount of resources involved in the rebuilding phase, the private sector would need a clear signal of the City's anticipated response to sea level rise in the following decades.

Most importantly, Ocean City would have to explicitly decide whether its policy would be to maintain the 1980 (year?) shoreline regardless of cost, or whether there is an upper limit to the annual sand replenishment that the city is willing to consider. In the latter case, ocean front property owners considering reconstruction of severely damaged houses would want to consider whether future erosion would be likely to cause increased risks and insurance premiums in the future; and the town would want to consider whether the benefits of rebuilding damaged structures would be worth the price of the future public beach being cluttered with houses. If not, additional set back requirements might be necessary. By reducing uncertainty, a decision concerning Ocean City's strategy for responding to sea level rise would substantially improve allocation of resources by reducing uncertainty.

Costs and Benefits

The costs and benefits (in dollars) for each of the four plans are not completely documented. Cost estimates exist for all four plans but benefit estimates only exist for the Corps plan. Existing cost estimates have been made over a three year period (1979-1982) and changes in construction costs (material and labor), inflation and interest rates make direct and quantitative comparisons difficult. The Corps and Hybrid plans have estimated costs which exceed the Trident and status quo plans primarily because of the added costs associated with dune and bulkhead construction. Groin construction costs for the hybrid plan make it the most expensive initially; however, annual beach maintenance costs are expected to be lower if the groins successfully trap sand as they are designed. As previously discussed cost overruns may also contribute to any groin plan. Other factors not considered, but which are admittedly difficult to assess and derive a long-term value, are the maintenance of the groins themselves and the lack of eligibility for disaster funding following a presidentially declared disaster.

Costs associated with the status quo plan should be expected to be higher than those for the Trident plan because of the 20 year separation in completion dates (and an expected increase in costs). It appears that the Trident plan would have the lowest costs of the four plans but a selection based solely on this criteria would be shortsighted. Costs of any plan should be balanced with longer term erosion and flood control benefits that are provided.

The average annual benefits of the Corps plan have been estimated to be 2.4 times greater than its average annual costs. This is fairly high for a Corps project. But the benefit to Ocean City is primarily recreational and, thus, the plan has a low priority status for Corps approval. No benefit/cost ratio exists for the Trident, hybrid or status quo plans which precludes any comparison of plans in terms of their dollar value. Qualitatively, the primary benefit for all four plans is recreational with additional hurricane protection (flood control) provided by the Corps and hybrid plans. Any benefit analysis for these two plans would account for damage reduction to structures utilities and lives as a result of the protection provided by dunes and bulkheads. Since the primary benefit of the Trident and status quo plans is erosion control, a benefit analysis is primarily confined to evaluating the day usage during the summer months.

As Ocean City continues to grow as a recreational facility, pressures will increase to maintain a recreational beach. However, growth of the community is also translated in numbers of structures, extent of infrastructure and possible damages that can result from storms. The benefit of a hurricane protection plan will have higher value over time because of the increased investment relating to the recreational benefits. Estimated storm damages four years ago as compared to those in 37 years without hurricane protection increase substantially as noted below (Corps, 1980):

	10-year	20-year	50-year	100-year (storm frequency)
1979	$2.9 million	5.3	32.9	50.8
2020	6.4	8.4	39.1	73.7

COMPARISON WITH OTHER COASTAL STATES AND COMMUNITIES

The state and local regulations that currently govern Ocean City provide at least a minimum protection from flood hazards when compared with national standards and the regulations prevalent throughout coastal communities. Many states and communities have concluded that they prefer more than minimum protection. Often the decision to adopt flood protection requirements that are more stringent than required or in common practice has come after a community sustained severe damage from a hurricane or northeaster. This section looks at some of the actions other coastal states and communities have taken to see how they compare to the existing requirements affecting Ocean City.

Elevation Requirements. Currently, within the V-zone, Ocean City Flood Damage Control Regulations require elevation to or above the 100-year flood level, including wave heights. Several communities have recognized that the FEMA methodology for determining coastal flood elevations is conservative (especially when wave heights have not yet been included) and subject to numerous errors along the coast because of the limited detail in which the flood insurance studies are performed. Consequently, these communities require the lowest floor of buildings in the V-zone to be elevated from one to five feet or more above the 100-year flood elevation (e.g., Southhampton, NY, East Providence, RI, Wrightsville Beach, NC, and Scituate, MA). The State of Connecticut amended its state building code in 1981 to require any structures within the V-zone to be elevated at least one foot above the 100-year flood level with wave heights. Among the reasons for establishing this requirement is to allow sufficient freeboard for the passage of wave-tossed debris without damaging the structure.

Building Limit Line. The Ocean City Building Limit Line provides a setback of structures from the beachfrong. Setbacks are a common regulatory method used by coastal states and communities. Some setback regulations required a special permit or variance in order for a structure to be located within the setback line (State of Florida), and others prohibit construction within the setback line as does Ocean City. Setbacks may be intended to protect structures from flooding or from erosion, and may also be intended to preserve natural features such as sand dunes and wetlands. North Carolina has established setbacks for three critical areaa: areas of rapid erosion; areas where inlets may from or inlets are known to shift; and areas of estuaring shoreline concern.

The setback distance can be determined based on several factors, but two common criteria used are the landward extent of the FEMA designated V-zone (e.g. Panama City Beach, FL) and the western edge of the primary dune (e.g. Wrightsville Beach, NC). In areas of severe erosion some communities (e.g. San Diego, CA) have adopted a setback distance sufficient to protect the structure for its expected life. If erosion averaged 2.5 feet per year and a structure was expected to last 100 years, the setback requirement would be 250 feet. A similar requirement is to establish a setback keyed to the financial investment in the structure (State of Michigan), e.g. a 30-year life based onthe length of the average home mortgage in an area with 2.5 feet of erosion per year would have to be setback 75 feet.

Dune Protection and Restoration. Regulatory setback requirements are often combined with programs designed to maintain and restore the natural dune line. Dune protection and restoration through the use of sand fencing and dune vegetation is practiced by numerous communities as a means of reducing the impact of storm surge. For example the town of Avalon, NJ embarked on a successful dune restoration program after suffering damages in the same March 1962 storm that affected Ocean City.

Acquisition of Hazardous Areas. Following the March 1962 storm, Avalon and Sea Isle, NJ acquired several storm damaged properties using funds provided by the State of New Jersey Green Acres program. Other communities such as Scituate, MA and Gulf Shores, AL have used federal funds (FEMA Section 1362 program) to acquire flood damaged properties following a major disaster. Other communities use their zoning or subdivision regulations to require developers to set aside or dedicate to the town hazardous areas that are part of their development. This technique has been used in Clearwater, FL to require 10% of the area of a subdivision to be set aside for public use.

Construction Standards. Ocean City, like most coastal communities, relies on a standard building code and the certification of a professional engineer or architect to ensure that all buildings in coastal flood hazard areas are properly constructed, and flood-proofed if necessary, to withstand the expected forces of wind and waves. Most building codes do not contain specific standards for floodproofing buildings and instead rely on performance criteria that are subject to varying interpretation by the engineers and architects responsible for design and construction. Few of these engineers and architects have been trained in the proper techniques for construction and floodproofing in coastal flood hazard areas. Likewise, few building inspectors have any sound basis for judging the design proposed by the engineer or architect.

The loss of hundreds of buildings during coastal storms to the forces of wind, wave impact, or a combination of waves and wind are evidence of the inadequacy of most building codes and constuction techniques. Some of the major problems that have been observed are inadequate connections between the foundation and the upper structure, improperly designed walls that do not permit the passage of waves, and failure to sink pilings and other foundations properly and deep enough to withstand general erosion and scour around the foundation.

In response to these problems, some communities, such as Scituate, MA and Gulf Shores, AL, that have suffered major building losses during a coastal storm have enacted supplemental standards to their building code that provide specific requirements for foundation construction, depth of pilings, foundation bracing, and connections throughout the structure. These standards apply mostly to one and two story structures and are largely based on research sponsored by FEMA into proper construction techniques in coastal high hazard areas. These research results are also resulting in the addition of specific construction and floodproofing standards in some basic building codes. The BOCA code was revised earlier in 1983, but the Standard Building Code used by Ocean City has not been revised.

Warning and Evacuation. Even when other measures to reduce flood losses have been taken, it is not safe to remain in vulnerable coastal areas during a major hurricane. In the last few years many coastal communities have become increasingly concerned about their ability to evacuate the people in their towns in the time that is available following a hurricane warning from the National Weather Service. Florida has led the nation in the development of detailed, regional evacuation plans. These evacuation plans are based on a detailed evaluation of the number and special needs of people that will have to be evacuated from a given area, how their evacuation routes may be shared with other communities, flooding and other problems that may restrict the use of some evacuation routes, and the capacity of the routes to handle the traffic that will be required. Florida is also developing its own hurricane warning system to supplement the information provided by the National Weater Service so that it can provide Florida communities with additional warning of the probability of a hurricane striking any given area.

The community of Sanibel, FL (an island off the southwest coast of FL) was sufficiently concerned about its ability to evacuate residents and visitors to the island that it established a cap on growth keyed to the ability to safely evacuate within the warning time provided by the National Weather Service.

CONCLUSIONS AND RECOMMENDATIONS

1. The most effective erosion and flood control plan for Ocean City on a long-term basis appears to be the Corps of Engineers' "Hurricane Protection and Beach Restoration Plan" based on its level of protection, time of implementation, long-term ability to endure and adapt to shoreline changes and study justification (benefit/cost ratio).

2. Any erosion and flood control plan that incorporates the use of groins will require a higher degree of shoreline stability to be effective on a long-term basis.

3. Groins will have their best results if:
   - They are positioned properly with respect to mean low water;
   - They are properly space apart;
   - They have a bedding material;
   - They are wide and long enough;
   - They are filled to capacity with sand; and
   - Everyone realizes they will only provide interim or short-term, 10-year storm protection.

4. No detailed benefit/cost analyses exist for any erosional and flood control plan other than the Corps plan; therefore, comparison of the four proposed plans is not possible at the present time.

5. A source of sand for beach or dune restoration must be identified and selected regardless of what individual or combination of interim or long-term plans is implemented.

7. Strategies for obtaining financial contributions from permanent residents, developers, merchants and seasonal visitors who invest in the recreational amenities of Ocean City should be devised to compensate for additional costs of an erosion and flood control plan.

8. A more detailed and complete Emergency Operations Plans should be developed that:

- Determines the time required for evacuation given different population levels, the capacity of evacuation routes, including impediments to evacuation such as road level below flood level and use of evacuation routes by other communities.
- Evaluates evacuation time compared to expected warning time to be provided by the National Weather Service, and if evacuation time exceeds warning time, identifies measures to improve the capacity of evacuation routes, limit development or other appropriate actions.
- Provides guidance to owners/managers of motels and condominums for development of their own warning and evacuation procedurs which will be coordinated with the Ocean City Emergency Operations Plan.
- Provides for evacuation procedures for special segments of the population such as the elderly, handicaped, and families of emergency workers.

9. Land use controls should recognize that the delineation of hazard areas on a coastal barrier is imprecise because of uncertainities in the methodologies employed, and that the hazard areas are subject to constant change. Consequently, hazard areas delineation should be viewed as conservative and land use controls modified to reflect this situation.

- The Comprehensive Plan for Ocean City should be revised to reflect an awareness of the flood hazard and the changing nature of the hazard. Setbacks from the oceanfront should be increased, wetland areas on the bay side recognized as protected, open space areas identified that coincide with potential washover areas, infrasturucture located to increase useability during early stages of storms, and emergency facilities located to provide protection to all parts of the town during a flood emergency.

- The Ocean City Open Space Implementation Program should be updated, including the specificfunding mechanisms, and incorporated into the Comprehensive Plan.
- The Building Limit Line should be modified by the town and state toconicide with the currently designated V-zone or the western edge of the former natural dune line, and reevaluated and adjusted as necessary each time the flood hazard areas are revised.
- The Ocean City Zoning Regulations should be revised to conform with the revised Comprehensive Plan ad Building Limit Line.
- The Ocean City Erosion Control Regulations should prohibit destruction of theremaining natural dunes, and Ocean City should provide strict enforcement of requirements to maintain artificial dunes and berms.
- The state Tidewater Administration and the Erosion Control Division of DNR along with the Worcester Soil Conservation District should assist the Town of Ocean City in developing a long-range, comprehensive program of dune maintenance and restoration that is coordinated with property owner responsibilities for dune maintenance.
- Additional canals that increase the potential for island breaching should be prohibited.

10. Construction standards should also recognize the uncertain and conservative nature of hazard area delineation on a barrier island and be modified accordingly. Particular attention needs to be addressed to the potential hazards associated with development on the bay side of the island.

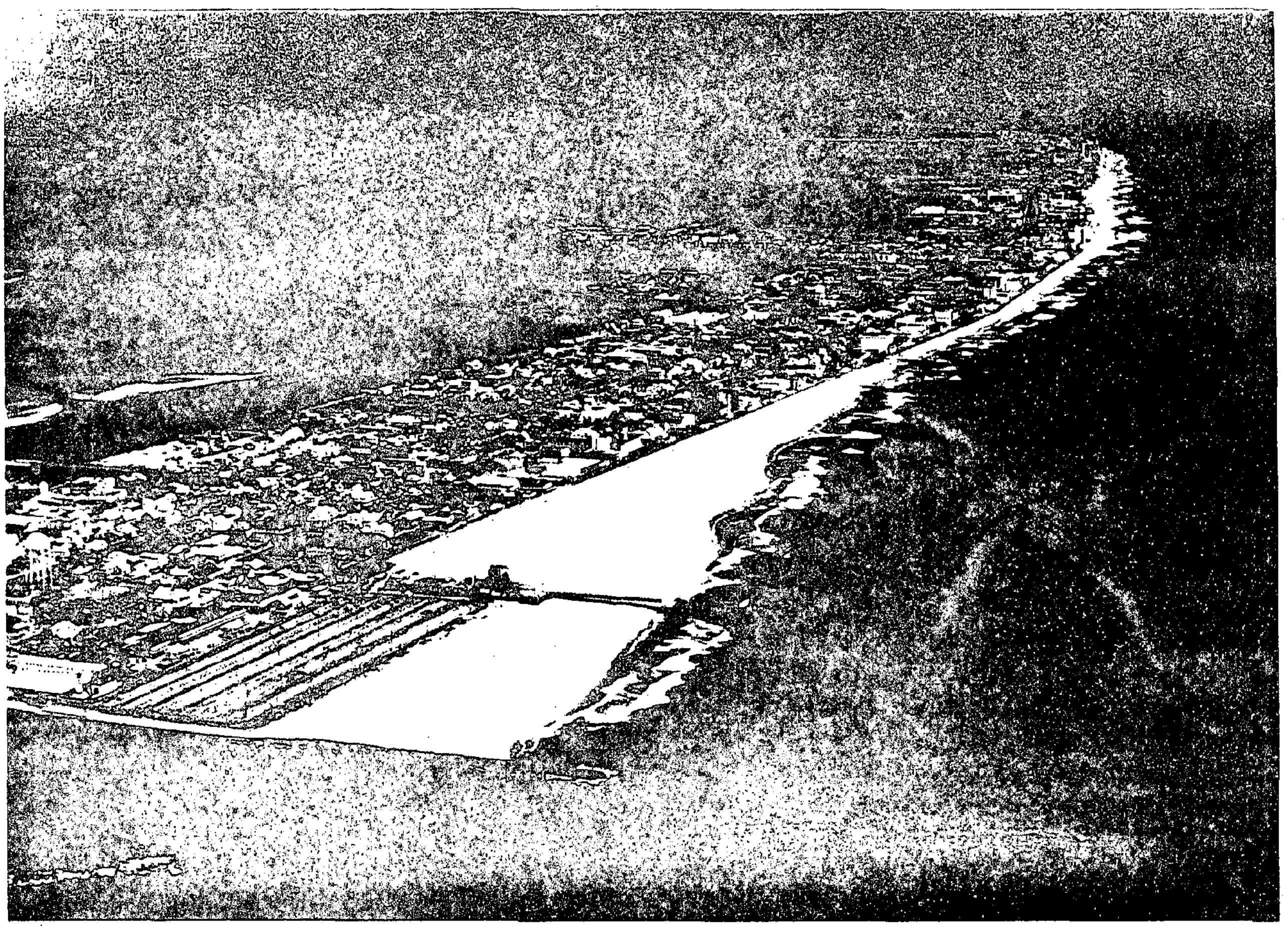
- The current building code for Ocean City should be supplemented with the best available specific standards for construction in coastal flood hazard areas, e.g., the appropriate sections of the recently revised BOCA code.

- Protection of individual buildings by seawalls, bulkheads, and similar means should not be permitted if there will be any potential increase in erosion or flood damage to adjacent properties.
- Current and revised constructions standards should be strictly enforced.

11. Additional state investments that would permit or encourage growth in Ocean City should not be made unless and until a detailed evacuation plan has been prepared that clearly demonstrates the ability to evacuate the population with available warning time.

12. All public investments by Ocean City in new buildings and infrastructure should ensure that they will withstand a 100-year flood, and critical facilities such as police, fire, and emergency care facilities should be built to an even higher standard.

AFTER THE STORM:



GUIDING REDEVELOPMENT

Ocean City is fortunate that it has not been affected by a major storm in over 20 years. Inevitably though, another major storm will strike the island and cause considerable damage. The city will then be faced with many hard decisions regarding recovery and reconstruction. These decisions will begin immediately after the emergency relief and rescue operations have ended and will continue for several months.

Most communities are not prepared to deal with a natural disaster. Commonly, the period following a disaster is extremely disruptive. Although officials and citizens, usually aided by state and federal governments, exert enormous efforts and cooperation in dealing with the effects of the disaster, the toll in personal stress and economic losses is great. In the end, the community usually rebuilds so that it is nearly as vulnerable to a natural disaster as it was before.

Although the disruption caused by a major disaster cannot be eliminated, it can be minimized if Ocean City takes actions beforehand to prepare itself for dealing with the aftermath of the disaster. Ocean City can also seize the disaster as an opportunity to correct some of the previous land use decisions that may have contributed to storm losses. Just as important will be the need to determine if the City is left in a more vulnerable position than it was before the storm and to take appropriate actions regarding redevelopment.

ACTIONS TO TAKE BEFORE THE STORM

The previous section of this report identified several hazard mitigation actions which Ocean City could take now to reduce potential flood losses during the next major storm. There are also actions which the City should now in order to strengthen its ability to take effective flood hazard mitigation actions during the recovery and reconstruction efforts following that storm. Some of the pre-storm actions needed to enable effective post-storm hazard mitigation actions are described below.

Revision of the Comprehensive Plan of Ocean City. The Comprehensive Plan should be revised to include a statement of policy that recognizes the hazard vulnerability of Ocean and the intent of the City to permit development and redevelopment only in locations and in a manner that provide adequate protection from a 100-year flood. The policy should further state that the flood hazard areas in Ocean City are subject to both gradual and sudden change as a result of long-term erosion forces and strom impacts. Consequently, in order to protect people and property it may be necessary to periodically reevaluate the flood hazard areas and adjust them as necessary, particularly following a major storm. Following adjustment of the flood hazard areas, the Comprehensive Plan and zoning regulations may have to be revised to reflect the change in hazard areas. The Comprehensive Plan should also reference a Post-Disaster Recovery/Redevelopment Plan.

Preparation of a Post-Disaster Recovery/Redevelopment Plan. A Post-Disaster Recovery/Redevelopment Plan should be prepared before the disaster to avoid unnecessary confusion, delay and inappropriate actions after the disaster. The purpose of the plan is to expedite recovery from the disaster while also identifying ways to mitigate future loss potential.

The plan should identify the actions and decisions that will be needed after the disaster, who is responsible for each decision or action, and the criteria upon which the decisions will be made. The plan should identify any special roles that city officials, employees and citizens may have in the recovery effort, such as a recovery task force and damage assessment teams. It should also identify any types of services needed that may be beyond the capacity of the local government during the disaster and for which outside assistance will be required. Figure 5A-1 lists the major activities that Ocean City will need to undertake following a disaster. Each of these activities is discussed later is this section.

Some of the activities involved in the recovery plan are the same as activities already addressed in the Ocean City Emergency Operations Plan, such as damage assessment. Other recovery activities such as hazard mitigation evaluation may require a modification of the way some emergency operations are normally handled, e.g. non-emergency debris removal should not occur until the debris can be examined for evidence of the specific causes of damage. Therefore, the recovery plan should be coordinated with the Ocean City Emergency Operations Plan.

<u>Authority to Impose a Temporary Building Moratorium</u>. After a disaster, important opportunities for flood hazard mitigation are often lost because property owners immediately begin rebuilding their damaged buildings in the same location and to the same level of protection as before the storm. This often occurs because the community's permitting officials are overworked. They may not be able to give each application the attention it needs to assure compliance with applicable requirements and property owners may undertake reconstruction without seeking a permit. A temporary building moratorium can avoid this situation as well as provide time to reassess the City's flood hazard vulnerability and to identify hazard mitigation opportunities.

The Mayor and City Council should act to establish the clear legal authority to impose a temporary moratorium on all redevelopment

Figure 5A-1: Sequence of Local Activities in Assessing Damages and Permitting Reconstruction

Events	Weeks 0	1	2	3	4	5	6	7	8	. . . .
Disaster and Declaration	x									
Damage Assessment --										
Deploy Assessment Teams	x									
Assess, Classify, and Map Damages	——	——								
Submit Damage Survey Reports to State and Federal Agencies	——	——								
Notify Property Owners of Damage Classifications and Repair Requirements		——	——							
Attend Applicant's Briefing and Submit Requests for State and Federal Assistance		——	——							
Reconstruction Permitting --										
Deploy Recovery Task Force	x									
Declare Moratorium on Repairs and New Development	x									
Set Calendar of Milestones for Other Tasks		x								
Begin Repairs to Critical Utilities and Facilities	----	----	----	- ? -	->					
Lift Moratorium for "Minor" Repairs		----	----	----	----	----	----	->		
Lift Moratorium for "Major" Repairs to Conforming Structures			- - -	- - -	? - -	- - -	----	----	----	->
Evaluate Hazards and the Effectiveness of Mitigation Policies		----	----	----	- - -	? -	->			
Amend Policies					- -	? - -	----	----	->	
Initiate Negotiations for Relocations and Acquisitions			----	----	----	----	----	----	----	->
Lift Moratorium on "Major" Repairs (with changes to conform)					- - -	? - -	- ----	----	----	->
Participate in Federal Hazard Mitigation Planning		----	----	----	----	----	----	----	----	---->
Lift Moratorium on New Development							- - -	? - -	- - ----	---->

and new development following a major natural disaster. The maximum duration of the moratorium should be identified (e.g., six months). The authority may also include provisions for lifting the moratorium on "minor" rehabilitation prior to "major" reconstruction or new development.

Appointment of Special Teams and Task Forces. Recovery and reconstruction after the disaster will require duties that are beyond the normal scope of city officials and employees. Special needs will have to be met such as damage assessment, evaluation of hazard vulnerability, evaluation of effectiveness of current hazard mitigation requirements, and identification of additional hazard mitigation opportunities as well as coordination of the entire recovery effort. These activities can be partially handled by city officials and staff, but many may require or be aided by the addition of citizens with specialized expertise and the use of outside services.

All of the special task forces and teams that are identified in the Post-Disaster Plan should be formed prior to the disaster. Individuals should be assigned to the various groups and briefed on their responsibilities. Outside services or products that may be procurred should be identified to the extent possible.

DAMAGE ASSESSMENT PROCEDURES

Damage assessment will be the first step in the recovery and redevelopment process. Damage assessment may occur more than once during disaster recovery and serve several purposes. In each instance it will be necessary to assess the damages, classify the damages by several categories, and map the location of the damaged property.

Damage assessment teams may need to be established for different categories of property. For example, there may be teams assigned to public property (buildings, equipment, roads, bridges, sewer, water, etc.); commercial establishments (retail stores, restaurants, hotels and motels, etc.); and residential property (individual private dwellings, mobile homes, condominums). The composition of each team may differ in order to provide the greates exertise in making the damage assessments.

The initial damage assessments will be the least detailed and will probably be of the "windshield survey" type. This initial assessment should occur as soon as the storm has subsided enough to enable the assessment teams to safely survey the area. The results of this assessment will enable the Mayor and City Council to determine if the damage is sufficient to declare a continued state of emergency, to impose a temporary building moratorium, and to request state aid to supplement local resources. The initial survey will result in a determination of the number of structures, roads and other property categories that have been damaged; whether the property has received minor or major damage or is destroyed; and a rough dollar estimate based on "rule of thumb" estimating procedures. This initial damage assessment may be performed by key city employees rather than the full damage assessment teams.

The second damage assessment will occur as soon as the damage assessment teams can be assembled and given their assignments. They should be supplied with forms and maps for recording the damages. These forms should provide for recording information in a format that is consistent with the information required by the Federal Emergency Management Agency for federal disaster assistnace. They should also provide for additional information that will be important for local decision making. For example it will be important to classify private property according to whether it was damaged 50% or more of market value. Properties damaged more than 50% of market value will be required to comply with the flood damage controls and other sections of the Ocean City code relating to nonconforming uses.

The results of this second damage survey should be submitted to state and federal agencies as part of the process of applying for federal disaster assistance. Relevant information should also be supplied to property owners along with information regarding permit and other requirements for making temporary or permanent repairs or for rebuilding structures that were destroyed. The property owners should also be notified of the building moratorium if it has been imposed by the Mayor and City Council. Notification of property owners will be especially important in Ocean City since many owners to not occupy the property or live on the island.

In addition to recording damages to property, the damage assessment teams should also determine the cause of damages. The structure should be examined as well as the surrounding area, including debris that may be left on the property. Damages should be classified according to whether it was caused by wind, direct impact of waves, overwash (either from the ocean to bay or bay to ocean), high water levels, wind blown debris, water tossed debris, or a combination of two or more of the above categories. This information will be essential for determining the effectiveness of the existing hazard mitigation measures in Ocean City and for identifying possible new hazard mitigation measures.

If a presidential disaster declaration is made, the damage assessment teams will also be involved in still another round of damage assessments. FEMA will assign teams federal and state employees to prepare Damage Survey Reports. These reports will verify the damage assessments submitted to the state and federal government by the Ocean City damage assessment team and will determine the extent to which the properties are eligible for federal assistance

These Damage Survey Reports will be prepared over a period of weeks or months. It is important for the Ocean City damage assessment teams to accompany the federal/state team on their inspections so that they can clarify information concerning their damage estimates and provide information about the cause of damages that may no longer be evident because of debris removal or other reasons.

PERMITTING RECOVERY AND RECONSTRUCTION

After the initial damage assessments are completed, the Mayor and City Council will have to determine if they should declare a temporary building moratorium. Criteria will have been established to aid in making this decision. For example, the decision may be based on the number of buildings that were destroyed or received major or minor damage. It may also be based on the estimate of total dollar damages. Another criteria will be the initial observations regarding the extent of erosion and washover (and possibly breaching) that occurred. A decision will also have to be made regarding how long the moratorium will remain in effect.

Once a building moratorium is established (and even if it is not) a timetable will need to be developed for the major actions that will occur. The timetable will be based on the best estimate of the time required to complete the various tasks involved in disaster recovery and the sequence in which actions will have to occur. A general sequence of events and timetable such as shown in Figure 5A-1 will need to be prepared before the disaster as part of the Disaster Recovery Plan, but the specific times and dates can only be determined based on the extent and nature of damages that occurred.

The first repairs that will be undertaken are to critical utilities and other public facilities. Temporary repairs (including debris removal) should be made to the major roadways and bridges providing access to Ocean City, to the water and sewer facilities, to electrical and communications equipment, and to essential public buildings such as police, fire, emergency medical services and Town Hall.

After completion of the detailed damage assessment, the temporary moratorium on minor repairs may be lifted. Minor repairs would include those that suffered less that 50% damage. The moratorium on major repairs (greater than 50% damage) should continue until the hazard vulnerability and mitigation effectiveness evaluations are completed.

Immediately after the storm an evaluation of the hazard vulnerability of the island should begin. This will include determining the amount of erosion that occurred, damage to protective sand dunes, changes to the bay side of the island, and areas that were affected by overwash and may have caused or increased the potential for island breaching. Although this evaluation should begin as soon as possible, final conclusions regarding the amount of erosion that occurred should not be made until several days have passed in order to permit the shorefront to readjust naturally to the temporary effects of the storm.

Results of the vulnerability analysis will be a critical factor in decisions or issuance of rebuilding permits. If erosion has been severe and the protection from storm surge and wave impact greatly reduced, it may not be wise to permit redevelopment of substantially damaged building in the same location.

Closely related to the vulnerability analysis is the evaluation of the effectiveness of the existing hazard mitigation measures. A major factor influencing this evaluation will be the estimated return frequency of the storm. If measures to protect property against a 100-year storm proved to be ineffective in a storm estimated to have a 50- to 75-year return frequency, then they should be considered inadequate and either strengthened or replaced with a different hazard mitigation measure.

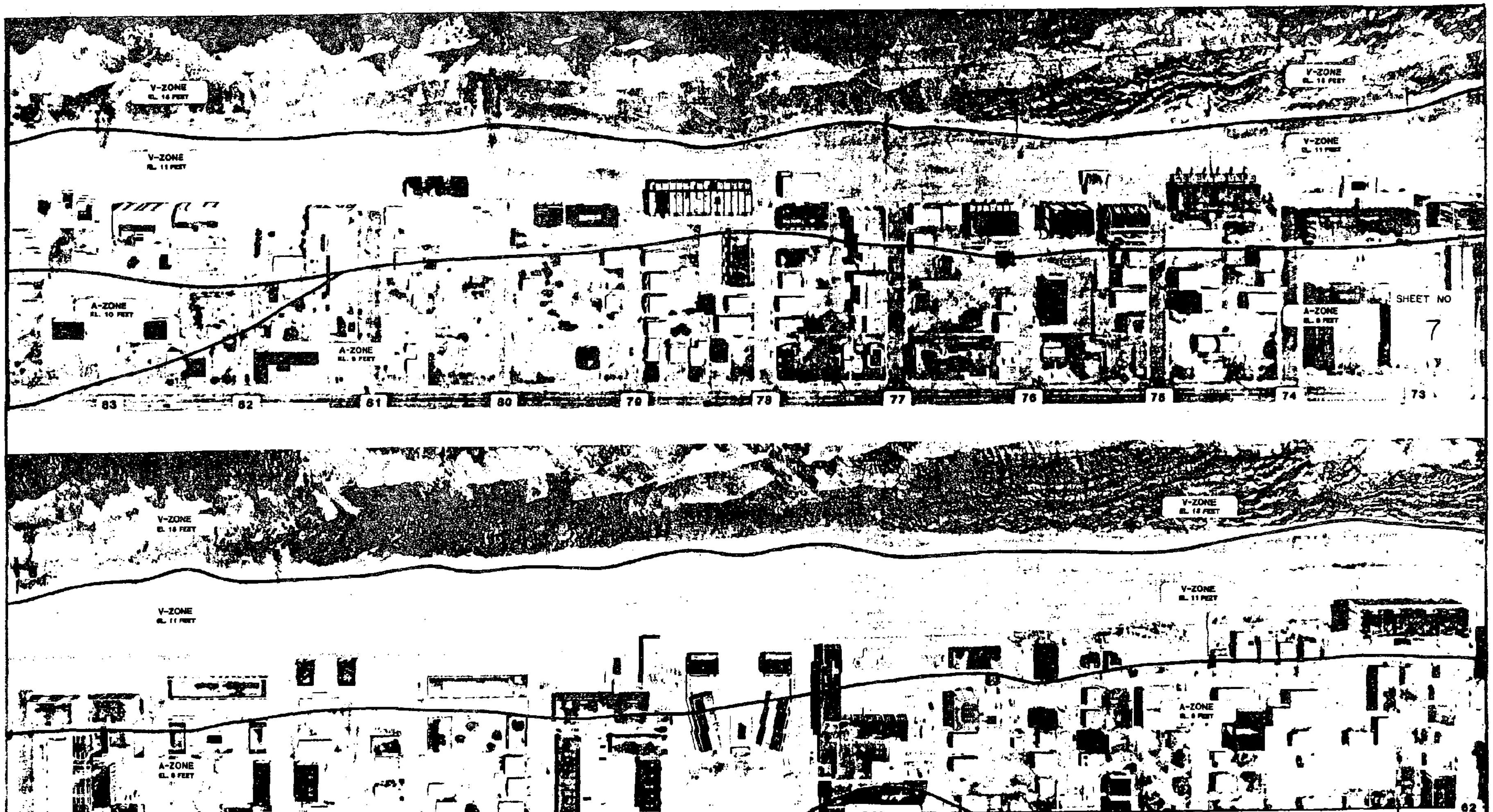
Hazard mitigation measures that should be evaluated include the building code, the location of the Building Limit Line, the beach protection program, the sand dune preservation program, flood elevation requirements, flood proofing requirements, foundation requirements, etc. Ocean City should conduct its own evaluation of the effectiveness of hazard mitigation actions and it should actively participate in the federal and state hazard mitigation teams that will be required to prepare hazard mitigation reports.

If hazard mitigation measures are found to be inadequate or the vulnerability of the island has significantly changed, then additional hazard mitigation measures should be considered. Among those to be considered would be strengthening the building code requirements, relocating the Building Limit Line, and acquiring properties that should not be rebuilt because of their hazardous location.

Once decisions of new or improved hazard mitigation measures are made, then the building moratorium can be lifited on those structures that suffered major damage but can be rebuilt in the same location and be considered safe if they conform to all codes and hazard mitigation measures. Properties that suffered major damage and cannot be rebuilt in the same location without being subject to a flood hazard should be denied a building permit. In these instances determinations will have to be made as to whether the property should be acquired by the city, if the property owner should be permitted to build in another location (transfer of development rights) or if no form of compensation will be offered.

APPENDIX A

APPENDIX C



73 72 71 70	69	68 67 66	65 64 63	
Example of a plate showing approximate location of Flood Insurance Rate Map Information. Set of eight will be completed for Final Report.	SCALE	STATE OF MARYLAND DEPARTMENT OF NATURAL RESOURCES TIDEWATER ADMINISTRATION · CAPITAL PROGRAMS ADMINISTRATION COASTAL ZONE DIVISION · SHORE EROSION CONTROL PROGRAM	AERIAL PHOTOGRAPHY BEACH EROSION CONTROL DISTRICT DELAWARE STATE LINE TO THE OCEAN CITY INLET OCEAN CITY, MARYLAND MAY 1981	SHEET NO 8

Ocean City, Maryland
Man-Made Canals and Natural Creek Channels
Oriented Perpendicular to the Shoreline
(measurements in feet)

Street	Width	Minimum Length	Distance to Boardwalk or Coastal Highway
13-14	80	340	1160
17-18	~80	450	900
18-19	80	160	900
24	60	620	930
25-26	50	470	940
28-29	120	980	600
29-30	70	1200	1520
36	40	600	230
37-38	60	240	320
48	60	230	460
52-53	40	380	630
53-54	80	670	310
54-55	80	600	280
59-60*	90	260	500
61-62*	120	460	510
63-64*	110	1400	700
66-67*	90	1530	800
73-74*	150	600	550
74-75*	80	700	550
77*	100	600	500
79-80*	40	400	520
82-83*	100	800	420
86*	200	600	500
88	180	540	1200
91-92	70	1120	1200
92-93	60	1060	1180
95	80	2820	1240
99*	60	~7500	360
106-107	50	2000	100
108	50	1950	120
109-110	50	1910	140
111	40	1900	130
117	100	2050	210
118	100	3100	220
122-123	140	2920	160
124	150	Modified	1000
126*	150	Modified	1000
130-131	120	1000	780
135-136	80	1300	530

*Signifies natural tidal creek channels

Ocean City, Maryland
Barrier Widths (measurements in feet taken from
May 16, 1983 FIRMs)

Street	Bay to Boardwalk
N. Jetty	760
Worchester	1260
Caroline	1460
1st	1550
2nd	1550
3rd	1550
4th	1560
5th	1540
6th	1520
7th	1460
8th	1460
9th	1520
10th	1520
11th	1520
12th	2040
13th	2340
14th	2320
15th	2240
16th	2440
17th	2340
18th	2370
19th	2420
20th	1520
21st	1530
22nd	1160
23rd	1600
24th	910
25th	1640
26th	3400
27th	3700

Street	Bay To Coastal Highway
28th	3200
29th	3400
30th	3000
31st	3800
32nd	3880
33rd	920
34th	750
35th	830
36th	230
37th	840
38th	840
39th	1090
40th	1090
41st	1080
42nd	1020
43rd	800
44th	620
45th	550
46th	710
47th	550
48th	470
49th	740
50th	750
51st	1000
52nd	1530
53rd	1010
54th	1130
55th	1110
56th	1090
57th	950
58th	710
59th	1000
60th	960
61st	2430
62nd	2460
63rd	2450
64th	1860
65th	2330
66th	2220
67th	2160
68th	2200
69th	2370
70th	2430
71st	2300
72nd	1400
73rd	1240

Street	Bay To Coastal H
74th	1170
75th	1420
76th	2110
77th	2540
78th	1900
79th	940
80th	1530
81st	1800
82nd	1270
83rd	800
84th	1220
85th	1200
86th	530
87th	1890
88th	3180
89th	3270
90th	3750
91st	3930
92nd	4000
93rd	4030
94th	4040
95th	3790
96th	3780
97th	3760
98th	3820
99th	3710
100th	3440
101st	2850
102nd	2850
103rd	2250
104th	2240
105th	2470
106th	3340
107th	3180
108th	3100
109th	3100
110th	3120
111th	3130
112th	2150
113th	2000
114th	2060
115th	2100
116th	3200
117th	3220
118th	3320

Barrier Widths (Continued)

eet	Bay To Coastal Highway
:h	3680
:h	3720
st	3750
nd	3780
rd	3080
:h	2880
:h	1980
:h	2540
:h	2600
:h	1500
th	3920
:h	4200
st	4500
nd	4870
rd	4900
:h	4840
th	4710
:h	4420
:h	3930
:h	3700
nett	3600
varthy	3600
	3660
nkford	3900
ckley	4010
lor	3840
ley	3640
te Bound	3790