ATLANTIC COAST OF LONG ISLAND, N. Y.

JONES INLET TO MONTAUK POINT
(REMAINING AREAS)

INTERIM HURRICANE STUDY

DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK 10003

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1965

DECEMBER 1965

ATLANTIC COAST OF LONG ISLAND, N. Y.

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DEPARTMENT OF THE ARMY
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NEW YORK, NEW YORK 10003

DECEMBER 1965

NADPL-F (31 Dec 65) 1st Ind
SUBJECT: Interim Hurricane Study of the Atlantic Coast of Long Island, New York, Jones Inlet to Montauk Point (Remaining Areas)

U. S. Army Engineer Division, North Atlantic, New York, N. Y. 10007
8 July 1966

TO: Resident Member, Board of Engineers for Rivers and Harbors, Washington, D. C.

I concur in the conclusions and recommendations of the District Engineer.

EDWARD B. JENNINGS
Colonel, CE
Acting Division Engineer

14136825

FIRE ISLAND INLET TO JONES INLET, N. Y.
(also known as Fire Island Inlet, Long Island, N. Y.)

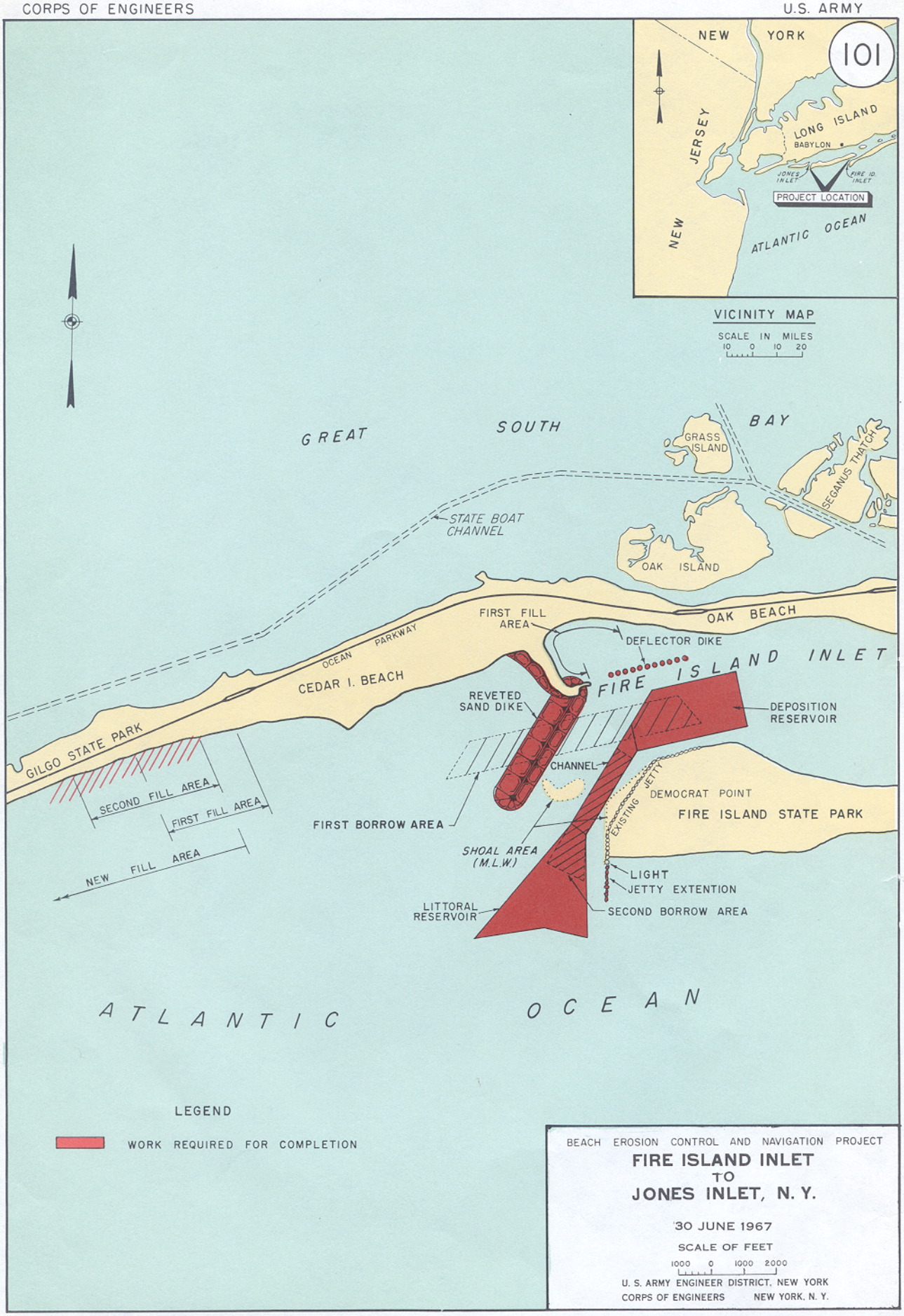
BEACH EROSION CONTROL AND NAVIGATION

Condition of Improvement, 30 June 1968

AUTHORIZATION: The project was authorized by the River and Harbor Act of 3 July 1958 in accordance with House Document No. 411, 84th Congress, second session. The project as modified by the River and Harbor Act of 23 October 1962 authorized a sand bypassing system at Fire Island Inlet. The plans for the system as contained in House Document No. 115, 89th Congress, first session, were approved by the Secretary of the Army and by the President on 20 February 1965

PROJECT: The original project provides for Federal participation in the restoration and protection of the shore from Fire Island Inlet to Jones Inlet by dredging the inlet shoal in Fire Island Inlet to relieve the pressure on tidal currents against Oak Beach, to provide a deposition area for littoral drift, to obtain fill material for a feeder beach and for Oak Beach to contruct a sand dike closure across the gorge channel. The project provides for several dredging operations over a period of ten years. The Federal share of the first increment is 42 percent of the cost of the work. The Federal shares of subsequent increments would be 67.9 percent of the costs of those increments. Local intrests are required to assume the remaining costs. The project as modified by the River and Harbor Act of 1962 provides for combined beach erosion control and navigation improvements comprising a littoral reservoir, a navigation channel, a deposition reservoir, dikes, jetty extension and periodic transfer of littoral drift to a feeder beach. The Federal share of the cost of initial work is presently estimated at 66.1 percent.

PROGRESS: Under the 1958 act the first dredging operation was initiated on 17 April 1959, and was completed on 15 June 1960. The second dredging operation was initiated in June 1964 and completed in November 1964. Advance engineering and design for work under the 1962 act, including a model study, was initated in April 1965, and is about 45 percent complete. The hydraulic model study was completed in June 1968 and the results are currently being evaluated. The design will be developed in detail when the model evaluation is completed.


101
NEW YORK
NEW JERSEY
LONG ISLAND
BABYLON
JONES INLET
FIRE ID. INLET
PROJECT LOCATION
ATLANTIC OCEAN
VICINITY MAP
SCALE IN MILES
10 0 10 20
GREAT SOUTH BAY
GRASS ISLAND
SEGANUS THATCH
STATE BOAT CHANNEL
OAK ISLAND
OAK BEACH
FIRST FILL AREA
DEFLECTOR DIKE
OCEAN PARKWAY
CEDAR I. BEACH
FIRE ISLAND INLET
REVETED SAND DIKE
DEPOSITION RESERVOIR
GILGO STATE PARK
CHANNEL
EXISTING JETTY
DEMOCRAT POINT
FIRE ISLAND STATE PARK
SECOND FILL AREA
FIRST FILL AREA
NEW FILL AREA
FIRST BORROW AREA
SHOAL AREA (M.L.W.)
LIGHT
JETTY EXTENTION
LITTORAL RESERVOIR
SECOND BORROW AREA
ATLANTIC OCEAN
LEGEND
WORK REQUIRED FOR COMPLETION
BEACH EROSION CONTROL AND NAVIGATION PROJECT
FIRE ISLAND INLET
TO
JONES INLET, N. Y.
30 JUNE 1967
SCALE OF FEET
1000 0 1000 2000
U. S. ARMY ENGINEER DISTRICT, NEW YORK
CORPS OF ENGINEERS NEW YORK, N. Y.

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20315

IN REPLY REFER TO
ENGCW-PD

SUBJECT: Jones Inlet to Montauk Point, New York (Remaining Areas)

TO: THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on a survey of the Atlantic Coast of Long Island, New York, Jones Inlet to Montauk Point (Remaining Areas), in partial response to Public Law 71, Eighty-fourth Congress, first session, to determine the feasibility of providing improvements for preventing loss of human lives and damages to property resulting from flooding caused by hurricanes. My report includes the reports of the District and Division Engineers and the Board of Engineers for Rivers and Harbors. Several reports for hurricane protection along the Atlantic and Gulf Coasts have been submitted and others will be submitted later.

2. The District and Division Engineers recommend that no improvements to protect the barrier beach between Jones Inlet and Fire Island Inlet and the Inner Bays between Fire Island Inlet and Montauk Point, New York, against tidal inundation, supplementing those provided for under the authorized beach erosion control and hurricane protection projects along the ocean front of the same area, be authorized by the United States at this time and that the District Engineer's report be published and distributed to appropriate officials in the area who may find the information contained therein of use in the establishment of flood plain regulatory measures and hurricane preparedness and evacuation plans.

3. The Board of Engineers for Rivers and Harbors notes that the authorized beach erosion control project and Ocean Parkway will provide adequate protection for the barrier beach between Jones Inlet and Fire Island Inlet, and that protective structures in the inner bays, in addition to those to be provided by the authorized beach erosion control and hurricane protection project from Fire Island Inlet to Montauk Point, are not economically justified. In the absence of additional structural

measures, the Board concludes that property damages may be reduced by adopting strict zoning ordinances and building codes to regulate construction and that the most practicable means of avoiding loss of life is by implementation or improvement of warning and evacuation plans, taking into account the possibility of more severe hurricanes than have occurred in the past. The Board recommends that Federal improvements for hurricane protection beyond those already authorized for the Atlantic Coast of Long Island, New York, between Jones Inlet and Montauk Point, not be undertaken at this time and that these reports, with selected illustrations, be printed.

4. I concur in the views and recommendations of the Board.

WILLIAM F. CASSIDY
Lieutenant General, USA
Chief of Engineers

ENGBR(31 Dec 65) 2nd Ind
SUBJECT: Interim Hurricane Study of the Atlantic Coast of Long Island, New York, Jones Inlet to Montauk Point (Remaining Areas)

Board of Engineers for Rivers and Harbors, Washington, D. C. 20315
7 September 1966

TO: Chief of Engineers, Department of the Army

1. The Division Engineer issued a public notice stating the unfavorable findings and recommendations of the reporting officers and affording interested parties an opportunity to present additional information to the Board. Careful consideration has been given to the communications received.

2. The Board notes that an authorized project provides for beach erosion control, and the elevation of the existing Ocean Parkway provides adequate protection against hurricane tidal flooding for the barrier beach between Jones Inlet and Fire Island Inlet. It further notes that an authorized project for beach erosion control and hurricane protection for the ocean beaches between Fire Island Inlet and Montauk Point, when completed, will reduce the possible flooding of mainland communities in the inner bays and that additional protective structures in the bays are not economically justified.

3. The Board concludes that, in the absence of additional structural measures, property damages may be reduced by adopting strict zoning ordinances and building codes to regulate construction and that the most practicable means of avoiding loss of life is by implementation or improvement of warning and evacuation plans, taking into account the possibility of more severe hurricanes than have occurred in the past.

4. Accordingly, the Board recommends that Federal improvements for hurricane protection beyond those already authorized for the Atlantic

ENGBR(31 Dec 65) 2nd Ind
SUBJECT: Interim Hurricane Study of the Atlantic Coast of Long Island, New York, Jones Inlet to Montauk Point (Remaining Areas)

Coast of Long Island, New York, between Jones Inlet and Montauk Point, not be undertaken at this time. Because of their general interest to the public and their value to local authorities, the Board further recommends that these reports, with selected illustrations, be printed.

FOR THE BOARD:

R. G. MacDONNELL
Major General, USA
Chairman

S Y L L A B U S

The purpose of the interim hurricane study is to determine feasible measures for protection against tidal flooding of the barrier beach between Jones Inlet and Fire Island Inlet and the mainland areas along Great South Bay, Moriches Bay, and Shinnecock Bay, New York.

The District Engineer finds that the problem of flooding is not of great magnitude for the barrier beach between Jones Inlet and Fire Island Inlet, since adequate protection is afforded by Ocean Parkway, which runs practically the entire length of the barrier. However, the mainland communities along the Inner Bays have experienced considerable tidal flood damage and loss of life during recent hurricanes and other great storms. The low-lying areas are subject to inundation by high stages in the bays resulting from flow through the inlets, wind set-up, and wave run-up. Overtopping of and breaking through sections of the barrier beach east of Fire Island Inlet results in further increase in bay stages and subjects the mainland peninsulas closest to the ocean to direct ocean wave attack. These latter effects of overtopping and breaking through of the barrier beach will be eliminated after completion of the authorized Federal project for beach erosion control and hurricane protection of the Atlantic Coast of Long Island from Fire Island Inlet to Montauk Point, New York, which provides for the raising of the dunes along the barrier beach east of Fire Island Inlet. The resulting reduction of flood stages in the bay will eliminate most of the flood damages in the area.

The study discloses that construction of additional works to protect the area against the residual tidal flood damages after completion of the authorized beach erosion-hurricane protection project along the ocean front is economically not justified. It is therefore essential to control development within the flood plain area and have an adequate storm-warning system as well as evacuation plans, to minimize future flood damage and to avoid loss of life during severe storms and hurricanes.

The District Engineer recommends: (a) that no additional improvements designed to protect the barrier beach between Jones Inlet and Fire Island Inlet and the Inner Bays between Fire Island Inlet and Montauk Point, New York, against tidal inundation be authorized by the United States at this time, and (b) that this report be published and distributed to appropriate officials in the area who may find the information contained therein of use in the establishment of flood plain regulatory measures and hurricane preparedness and evacuation plans.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

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SUPPLEMENT

Information Called for by Senate Resolution 148, 85th Congress, adopted 28 January 1958

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DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
111 EAST 16TH STREET
NEW YORK, N.Y. 10003

NANEN-Rb

31 December 1965

SUBJECT: Interim Hurricane Study of the Atlantic Coast of Long Island New York, Jones Inlet to Montauk Point (Remaining Areas)

TO: Division Engineer
North Atlantic Division, Corps of Engineers
New York, New York

I. AUTHORITY

1. This report is submitted in compliance with authorization contained in Public Law 71, 84th Congress, 1st Session, approved 15 June 1955, which reads:

> "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That: In view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New Jersey coastal and tidal areas, and the hurricane of October 15, 1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other Federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.
>
> "Sec. 2. Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required."

2. On 20 November 1956 the Chief of Engineers directed that a hurricane survey be made of the area from Jones Inlet to Montauk Point, and on 4 February 1957 approved submission of a combined report covering a cooperative beach erosion control study and a hurricane survey of the Atlantic Coast of Long Island from Fire Island Inlet to Montauk Point. The combined report, which was favorable, is published in House Document No. 425, 86th Congress, 2d Session, and forms the basis of the combined project described in paragraph 8 under "Prior Reports". The foregoing report and the subject report fulfill the Chief of Engineers' directive.

II. PURPOSE AND SCOPE

3. The purpose of the subject report is to determine feasible measures for protection against tidal flooding of the barrier beach between Jones Inlet and Fire Island Inlet and areas along Great South Bay, Moriches Bay, and Shinnecock Bay extending from Massapequa to Southampton. While the report is complete in itself for these areas, it is an interim study and one of a series in preparation which, when completed, will cover the entire area from Jones Inlet to Montauk Point, and other coastal areas as authorized by Public Law 71, 84th Congress.

4. In the preparation of this report, extensive basic data developed in connection with the combined beach erosion and hurricane report referred to in paragraph 2, which has a close relationship to the subject study, were utilized. Some of the data, such as storm occurrence and damages from tidal flooding of the study area, were extended and updated. Additional studies consisted of analysis of data pertinent to the hurricane problem. Preliminary studies were made of remedial measures, including hurricane barriers, floodwalls, and levees. Consideration was also given to improvement of flood plain regulatory measures, hurricane warning system, and of hurricane preparedness and evacuation plans.

5. The report was coordinated with various Federal, State, and local agencies as discussed in further detail in Section XVII. Public hearings were held at Babylon and Westhampton Beach, N. Y. to acquaint the people in the area with the purpose of the study and to enable them to present their views thereon. Another public hearing was held at Riverhead, N. Y. to obtain views of local interests on considered improvements along the ocean front which form the basis of the authorized beach erosion-hurricane protection project described in paragraph 8.

III. PRIOR REPORTS

6. HURRICANE AND BEACH EROSION REPORTS. There are no previous reports by the Corps of Engineers specifically dealing with the subject of hurricanes and hurricane protection for the study area. However, consideration of protection along the ocean front of the barrier beach between Jones and Fire Island Inlets was included in a beach erosion study of the shore from Jones Inlet to Montauk Point. This study was completed in 1946 by the Beach Erosion Board and submitted to Congress on 19 December 1947, recommending the raising of dunes without Federal participation in the cost of the work.

7. A cooperative beach erosion control study of the shore from Fire Island Inlet to Jones Inlet is reported in House Document No. 411, 84th Congress, 2d Session. The project recommended in the document and subsequently authorized by Congress in the River and Harbor Act approved 3 July 1958, provides for Federal participation in the restoration and protection of the shore from Fire Island Inlet to Jones Inlet by dredging the inlet shoal in Fire Island Inlet to relieve the pressure of tidal currents against Oak Beach, to provide a deposition area for littoral drift, and to obtain fill material for a feeder beach west of the inlet and for Oak Beach. The first of three dredging operations was completed in 1959 and the second in 1964. The River and Harbor Act of 23 October 1962 authorized a modification of the project to include a sand bypassing system under a plan to be developed by the Chief of Engineers and approved by the Secretary of the Army and the President. A report on such a plan was submitted to the Secretary of the Army by the Chief of Engineers in September 1964 with final approval received from the President on 20 February 1965 as reported in House Document No. 115, 89th Congress, 1st Session.

8. In addition to the previously described reports a combined beach erosion and hurricane study of the Atlantic Coast of Long Island from Fire Island Inlet to Montauk Point referred to in paragraph 2, recommended widening of the beach along developed areas between Kismet and Mecox Bay to a minimum width of 100 feet at 14 feet above mean sea level and raising of dunes to an elevation of 20 feet above mean sea level from Fire Island Inlet to Hither Hills State Park and at Montauk and opposite Lake Montauk Harbor, supplemented by grass planting on the dunes, interior drainage structures at Mecox Bay, Sagaponack Lake, and Georgica Pond, and construction of groins, if needed (see figure C8, appendix C). This project was authorized by Congress in the River and Harbor Act approved 14 July 1960 in accordance with the recommendations of the Chief of Engineers in House Document No. 425, 86th Congress, 2d Session. Further details on this project are contained in paragraphs 78 to 82.

9. The unpublished Part Two, Chapter XXXVIII, and Part Two, Chapter XXXIX, of the report (Senate Document No. 14, 85th Congress, 1st Session), on "Land and Water Resources of the New England-New York Region", prepared by the New England-New York Inter-Agency Committee, pursuant to Presidential directive of 9 October 1950, include data on the beach erosion and hurricane problem in the Long Island area and a general discussion of methods of reducing damages. Other pertinent reports which deal with hurricane protection and/or beach erosion control in areas adjacent or in close proximity to the study area, are listed in table 1.

10. NAVIGATION REPORTS. A number of navigation reports have been submitted which considered Federal improvements of channels in the study area. The reports which have been the basis for authorized navigation projects are listed in table 2.

TABLE 1 - OTHER PERTINENT REPORTS ON HURRICANE AND/OR BEACH EROSION IMPROVEMENTS

Waterway	Report	Description
Atlantic Coast of New York City from East Rockaway Inlet to Rockaway Inlet and Jamaica Bay	H. Doc. 215, 77th Cong., 1st Sess.	Reporting officers recommended a hurricane barrier across Jamaica Bay with a navigation opening of 600 feet which can be partially closed to 300 feet, a floodwall along the ocean front between Jacob Riis Park and Beach 19th Street near the eastern end of the Rockaway peninsula with top elevation of 18 feet above mean sea level, fronted by a beach ranging between 100 and 200 feet in width at elevation 10 feet above mean sea level, and other appurtenant works including necessary closures at both extremeties of the improvement.
Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet	Not yet published.	Reporting officers are considering hurricane barriers across Swift Creek, Long Creek, and Reynolds Channel at the Jones Inlet end, a hurricane barrier across East Rockaway Inlet, dunes or floodwalls fronted by a beach extending along the ocean front from Jones Inlet to East Rockaway Inlet, and levees or walls required to make the necessary closures at both ends of the improvement. Report is under preparation.

TABLE 2 - PRIOR REPORTS ON EXISTING FEDERAL NAVIGATION PROJECTS IN STUDY AREA

Report	Project
Jones Inlet, N.Y.	
H. Doc. 409, 77th Cong., 1st Sess.	Jetty 5,200 feet long on the east side of the inlet and a channel 12 feet deep and 250 feet wide through the inlet to the Loop Causeway Bridge over Long Creek. Adopted 2 March 1945. The project was completed in 1959.

TABLE 2 - PRIOR REPORTS ON EXISTING FEDERAL NAVIGATION PROJECTS IN STUDY AREA (Cont'd)

Report	Project
Fire Island Inlet, N.Y. Rivers and Harbors Committee Doc. 33, 75th Cong., 1st Sess. H. Doc. 762, 80th Cong., 2d Sess.	Jetty 5,000 feet long at Democrat Point and channel 10 feet deep and 250 feet wide through the inlet. Adopted 26 August 1937 and 17 May 1950. Jetty completed in 1941 and channel in 1953.
Great South Bay, N.Y. H. Doc. 103, 56th Cong., 2d Sess.	Channel 10 feet deep and 200 feet wide from Fire Island Inlet to the central basin in Great South Bay, thence 8 feet deep and 100 feet wide to the head of navigation in Patchogue River. Adopted 13 June 1902. The project is completed.
Sumpawanus (Babylon Creek) Inlet, N.Y. Survey report dated 30 October 1880 published in Annual Report of the Chief of Engineers for 1881, p. 653.	Channel 5 feet deep and 100 to 150 feet wide from Great South Bay to village of Babylon. Adopted 3 March 1881. No work has been done on the project since 1883. It is considered complete and adequate for commerce.
Orowoc Creek, N.Y. H. Doc. 126, 76th Cong., 1st Sess.	Channel 8 feet deep and generally 75 feet wide from Great South Bay to the head of navigation at Montauk Highway. Adopted 2 March 1945. No work has been done on this project.
Browns Creek, N.Y. H. Ex. Doc. 22, 51st Cong., 1st Sess.	Channel 6 feet deep and 100 feet wide from Great South Bay for 1,850 feet, thence 4 feet deep to the head of navigation; also two stone jetties 1,400 and 1,600 feet long. Adopted 19 September 1890. The project is about 40 percent completed.
Long Island Intracoastal Waterway, N.Y. H. Doc. 181, 75th Cong., 1st Sess.	Channel 6 feet deep and 100 feet wide from Federally improved channel in Great South Bay opposite Patchogue to the south end of Shinnecock Canal. Adopted 26 August 1937. The project is completed.
Moriches and Shinnecock Inlets, N.Y. H. Doc. 126, 86th Cong., 1st Sess.	Entrance channel 10 feet deep and 200 feet wide, thence an inner channel 6 feet deep and 100 feet wide to the Long Island Intracoastal Waterway, rehabilitation and extension of existing jetties, and construction of a sand bypassing facility at both inlets. Adopted 14 July 1960. No work has been done on these projects.

IV. DESCRIPTION

11. GENERAL. The study area covered in this report is comprised of two sections, the barrier beach between Jones and Fire Island Inlets, and the Inner Bays from Fire Island Inlet to Montauk Point. Published maps of the study area are U.S. Coast and Geodetic Survey Charts Nos. 70, 578, 579B, 1000, 1108, and 1214, scales 1:20,000 to 1:1,200,000, and Small Craft Nautical Chart 120-SC, scales 1:20,000 and 1:40,000; Air Photo Compilation sheets T-5051, 5052, 5053, 5055, 5059, 5065, 5066, 5080, 5082, 5083, 5084, 5085, 5086, 5087, 5349, 5350, 5605, 5612, 9298, 9299, 9300, and 9301 of the U.S. Coast and Geodetic Survey, scale 1:10,000; U.S. Geological Survey quadrangle sheets Hempstead, Babylon, Fire Island, Moriches, Riverhead, Sag Harbor, and Setauket, N. Y., scale 1:62,500, and West Gilgo Beach, Bay Shore West, Bay Shore East, Sayville, Howell Point, Moriches, Eastport, Quogue, Shinnecock Inlet, Southampton, Mattituck, Bellport, Patchogue, and Pattersquash Island, N. Y., scale 1:24,000. The 1:24,000 quadrangles are also published by the Army Map Service to a scale 1:25,000. Another map published by the Army Map Service is the New York sheet at a scale of 1:250,000. Plate 1 and photos accompanying this report also show the study area.

12. BARRIER BEACH. Fire Island Inlet to Jones Inlet. The Atlantic Coast of Long Island from Fire Island Inlet to Jones Inlet has a length of about 15 miles and lies in Nassau and Suffolk Counties, New York. This area consists of a barrier beach 1,500 to 3,500 feet wide, entirely publicly owned and developed for recreational purposes. The world-famous Jones Beach State Park, which has been developed by the Long Island State Park Commission at a cost of over fifty million dollars and which is being further enlarged, occupies the westerly 6 miles of the area. The remaining 9 miles of shore to Fire Island Inlet is occupied by Tobay Beach, owned by the town of Oyster Bay; Gilgo Beach, Cedar Island Beach and Oak Beach, owned by the town of Babylon; and the largely undeveloped Gilgo State Park, owned by the Long Island State Park Commission.

13. West of Gilgo Beach, the width of the island is approximately 3,000 feet. From Gilgo Beach to Captree, the width is generally 2,000 feet, but a minimum width of 600 feet is found at Oak Beach, which is a summer residential development of privately owned homes constructed on town owned land. The maximum elevation of the entire island is not more than 20 feet, such elevations being found principally on isolated sand dunes. Ocean Parkway, which runs for practically the entire length of the barrier beach between Jones Inlet and Fire Island Inlet is at an elevation of about 14 feet above mean sea level. North of Ocean Parkway, the area in the developed Jones Beach State Park has elevations generally above 10 feet above mean sea level, while the area to the east is primarily low-lying, undeveloped, and consists of salt water marshland having minimum elevations of approximately 3 to 4 feet above mean sea level.

14. INNER BAYS. Fire Island Inlet to Montauk Point. The Inner Bays covered in this report, consist of Great South Bay, Moriches Bay, and Shinnecock Bay, New York. These bays are interconnected shallow tidal waterways extending along the south shore of the mainland of Long Island

and immediately north of a series of sandy barrier beaches. These barriers generally parallel the mainland and separate the Atlantic Ocean from the Inner Bays. Fire Island, Moriches, and Shinnecock Inlets, which are respectively 50, 80, and 95 miles by water east of the Battery, New York City, connect the ocean with the Inner Bays. Except for a small portion in the town of Oyster Bay in Nassau County, the area is located in Suffolk County, in the towns of Babylon, Islip, Brookhaven, and Southampton.

15. Much of the land along the bays is fringed by marshes and a shallow water shelf having depths less than 3 feet below mean low water. The topography of the mainland is generally gently sloping and is intersected by drowned valleys of numerous streams that drain into the bays. Peninsulas jut out from the mainland in the Smith Point-Mastic Beach and Westhampton Beach-Quogue areas and form a separation between the bays. Narrow Bay, in the Smith Point-Mastic Beach area, is the connecting link between Great South Bay and Moriches Bay and is 4 miles long, 1,000 to 4,000 feet wide with depths up to 10 feet. The Quantuck and Quogue Canals, in the Westhampton Beach-Quogue area, serve as a connecting link between Moriches and Shinnecock Bays and are 4 miles long, generally 100 to 300 feet wide with depths up to 8 feet. The barrier beaches along the southern side of the bays are narrow and low and have irregular sand dunes which range in height up to about 30 feet near the ocean front. Further details on each bay and its ocean inlet are given in the following paragraphs.

16. Great South Bay. Great South Bay extends about 30 miles from Massapequa on the west along South Oyster Bay and Smith Point on the east along Bellport Bay. It varies in width between 2 and 5 miles. With the exception of a number of large shallow flats, depths in the bay generally range from 4 to 10 feet. Its water surface is 100 square miles and it drains about 340 square miles of land area. In addition to the Federal channel described in table 2, local interests have dredged channels leading to various communities along the mainland.

17. Fire Island Inlet. Fire Island Inlet, located somewhat west of the center of the bay, is generally about 3,500 feet wide and 3 miles long. It has a cross-sectional area of about 35,000 square feet at mid-tide and the average volume of tidal flow passing through the inlet is about 2 billion cubic feet per tide. In addition to the Federal jetty and navigation channel described in table 2, other Federal work in the inlet consisted of dredging the inlet shoal in connection with the beach erosion project for Fire Island Inlet to Jones Inlet described in paragraph 7. The latter work was also aimed to reduce problems in maintaining the navigation channel.

18. Moriches Bay. Moriches Bay, 8.5 miles long with widths up to 2.5 miles, extends between Mastic Beach on the west and the village of Westhampton Beach on the east. Its water surface is 18 square miles and it drains about 60 square miles of land area. Depths in the bay average about 4 feet with a maximum depth of 8 feet. Near the center of the bay, Tuthill Point projecting southward from the mainland nearly joins with extensive shoals in the vicinity of Moriches Inlet, thus dividing Moriches Bay into two basins.

19. Moriches Inlet. Moriches Inlet, located just west of the center of the bay, is 2,000 feet long and 800 feet wide. It has a cross-sectional area of about 5,800 square feet at mid-tide and the estimated average volume of tidal flow passing through the inlet is about 200 million cubic feet per tide. The inlet has been improved by local interests by the construction of stone revetments and jetties on its east and west sides. The Federal project described in table 2 provides for rehabilitation of these structures, dredging of a channel, and construction of a sand bypassing facility.

20. Shinnecock Bay. Shinnecock Bay, 8.5 miles long with widths up to 2.8 miles, extends between the villages of Quogue on the west and Southampton on the east. Its water surface is 16 square miles and it drains about 20 square miles of land area excluding about 10 square miles drained by Quantuck Bay and the Quantuck and Quogue Canals. Ponquogue Point, which juts southward from the mainland at about the center of the bay, constricts the width at this point to 1,200 feet and divides the bay into two parts of about equal area. Depths in the bay average about 5 feet with maximum depths in the eastern half at 10 feet and in the western half at 8 feet. In the eastern portion, Shinnecock Canal cuts through a narrow neck of the mainland to Great Peconic Bay.

21. Shinnecock Inlet. Shinnecock Inlet, located just east of the center of the bay, is 1,500 feet long and 800 feet wide. It has a cross-sectional area of 5,500 square feet at mid-tide and the estimated average volume of tidal flow passing through the inlet is about 300 million cubic feet per tide. The inlet has been improved by local interests by the construction of stone revetments and jetties on its east and west sides. The Federal project described in table 2 provides for rehabilitation of these structures, dredging of a channel, and construction of a sand bypassing facility.

22. TIDES. The mean ranges of tide in the ocean at Jones, Fire Island, Moriches, and Shinnecock Inlets are 4.2, 4.1, 3.3, and 2.9 feet respectively. The mean ranges of tide in Great South Bay, Moriches Bay, and Shinnecock Bay are about 0.7, 0.5, and 0.7 foot respectively. The ranges of spring tides are about 20 percent greater than the mean ranges. Hurricane tides have reached elevations above mean sea level of about 10 feet in the ocean, 7 feet in Great South Bay, 15 feet in Moriches Bay and 7 feet in Shinnecock Bay. Numerous breaks through the barrier beach and wave uprush contributed to the extreme tidal heights in the bays, especially at Westhampton Beach in Moriches Bay (see paragraphs 55 to 58, and table A2 of appendix A).

23. GEOLOGY. Long Island consists largely of glacial deposits resting on a core of sediments which probably are the remnants of an old coastal plain that has been in large part submerged. An underlying glacial outwash plain which slopes southward from an elevation of about 200 feet at the north shore and occupies the entire width of the Island is the most dominant physiographic feature. Rising above this plain are two belts of terminal moraine deposited during a later glacial stage.

Deposits of sand and gravel generally predominate to depths of over 100 feet forming a pervious upper stratum. This stratum absorbs a considerable quantity of water which results in relatively low runoff during periods of heavy rainfall.

24. The barrier beach between Jones and Fire Island Inlets and the other barrier beaches south of the Inner Bays were probably formed as westward growing spits since the retreat of the last glacier. Data indicate that the relative position of land to sea level since that time is about 25 feet lower and that the present rate of change is 2 feet per century, believed to be partly due to rising sea level because of melting ice caps and glaciers.

V. ECONOMIC DEVELOPMENT

25. **POPULATION.** The permanent population of the towns immediately adjacent to the study area excluding the town of Hempstead was 742,084 in 1960. During the summer months the population is increased by thousands of vacationists who are attracted by the excellent recreational facilities. The exceptionally rapid growth in population since 1930 in these towns and in the entire Nassau and Suffolk Counties as compared to the moderate growth in New York City, which comprise the major tributary areas, is indicated in table 3.

TABLE 3 - POPULATION DATA[a]

Town	1960	1950	1940	1930	Percent increase 1930-1960
Oyster Bay	290,055	66,930	42,594	36,869	687
Babylon	142,309	45,556	24,297	19,291	638
Islip	172,959	71,465	51,182	33,194	421
Brookhaven	109,900	44,522	32,117	28,291	288
Southampton	26,861	16,830	15,295	15,341	75
Total	742,084	245,303	165,485	132,986	458
Nassau County	1,300,171	672,765	406,748	303,053	329
Suffolk County	666,784	276,129	197,355	161,055	314
New York City	7,781,984	7,891,957	7,454,995	6,930,446	12

(a) Based on U. S. Bureau of the Census statistics.

26. The communities bordering the study area are experiencing a very rapid growth in residential construction. Projections made by the New York Regional Plan Association forecast a continued increase in population for Nassau and Suffolk Counties to the year 1985. During the same period the New York City population is expected to reach a plateau or decline. A summary of the New York Regional Plan Association's projections for the area is contained in table 4.

TABLE 4 - PROJECTED POPULATION, 1965-1985[a]

Area	1960[b]	1965	1970	1975	1980	1985
Nassau County	1,300	1,400	1,450	1,480	1,500	1,510
Suffolk County	667	910	1,160	1,420	1,685	2,005
New York City	7,782	7,750	7,700	7,685	7,700	7,725

(a) From "Spread City", Bulletin 100, September 1962, Regional Plan Association, Inc., New York

(b) Actual census data.

27. Relatively few people live permanently on the barrier beaches as compared with those on the mainland. The population in 1960 and 1964 of the mainland communities along the north shore of the Inner Bays of the study area is shown in table 5. The increase during this period ranged between 2 to 85 percent and averaged about 13 percent.

28. ECONOMIC ACTIVITY. The communities located within the area are chiefly residential in character. However, a number of small manufacturing and commercial establishments are found in the larger communities. The major commercial establishments consist of boat repair and storage yards, coal and lumber yards, lumber and planing mills, printing plants, laundries and dry cleaning establishments. Other establishments are generally of a supporting nature to the recreational activities of the area. Shellfish and commercial fishing industries are located adjacent to the bays, while large quantities of agricultural products are produced in the tributary areas.

29. AGRICULTURE. Truck farming, dairying and poultry farming are the chief agricultural activities. The major crops produced are tomatoes, cauliflower, corn, string beans, peas, and cucumbers. Turkeys, chickens, and ducks are raised on the poultry farms; the Long Island duck being shipped to all parts of the United States and overseas. The total value of agriculture for Suffolk County for the years 1949, 1954, and 1959 as reported by the Census of Agriculture was $33,136,000, $37,761,000, and $39,186,000 respectively. Farm acreage is reducing sharply due to intensive urbanization in the area. Table 6 lists the percentage of land used for farming in Nassau and Suffolk Counties comprising Long Island.

TABLE 5 - POPULATION OF MAINLAND COMMUNITIES IN THE STUDY AREA, 1960 AND 1964

Locality(a)	1960(b)	1964(c)	Percent increase
GREAT SOUTH BAY			
Massapequa	32,900	36,518	11.0
Massapequa Park (I)	19,904	21,048	5.7
East Massapequa	19,608	20,868	6.4
Amityville (I)	8,318	9,006	8.3
Copiague	14,081	16,838	19.6
Lindenhurst (I)	20,905	23,448	12.2
West Babylon	8,051	9,384	16.6
Babylon (I)	11,062	12,257	10.8
West Islip	13,924	15,070	8.2
South Islip	6,589	7,511	14.0
Brightwaters (I)	3,193	3,399	6.5
Bay Shore	9,802	10,914	11.3
Islip	6,362	7,196	13.1
East Islip	4,946	5,085	2.8
Great River	6,554	7,230	10.3
Oakdale	2,774	4,055	46.2
West Sayville	5,849	7,232	23.6
Sayville	6,485	8,444	30.2
Bayport	5,009	5,777	15.3
Blue Point	2,358	2,765	17.3
Patchogue (I)	8,838	9,334	5.6
East Patchogue	6,108	6,782	11.0
South Bellport	2,548	3,110	22.1
Bellport (I)	2,461	2,688	9.2
Brookhaven	713	788	10.5
Subtotal	229,342	256,747	11.9
MORICHES BAY			
Mastic-Shirley	3,397	4,603	35.5
Mastic Beach	3,114	3,582	15.0
Center Moriches	2,521	2,817	11.7
East Moriches	1,210	1,384	14.4
Remsenburg-Speonk	1,505	1,616	7.4
Westhampton	1,102	1,194	8.3
Westhampton Beach (I)	1,460	1,601	9.7
Quiogue	1,871	1,908	2.0
Subtotal	16,180	18,705	15.6
SHINNECOCK BAY			
Quogue (I)	692	735	6.2
East Quogue-West Tiana	1,285	2,384	85.5
Tiana	865	1,062	22.8
Hampton Bays	1,431	1,734	21.2
Shinnecock Hills-Tuckahoe	2,486	2,672	7.5
Southampton (I)	4,582	5,118	11.7
Subtotal	11,341	13,705	20.8
Total	256,863	289,157	12.6

(a) (I) indicates incorporated villages.
(b) U.S. Census data.
(c) From "Population Survey-1964", Long Island Lighting Company.

TABLE 6 - PERCENTAGE OF LAND IN FARMS

Area	1949	1954	1959
Suffolk County	19.0	16.9	15.0
Nassau County	14.3	6.8	3.9

30. TRANSPORTATION. The study area is served by highway, rail, water, and air transport. A network of excellent highways and parkways connect the area with all sections of Long Island and with New York City. Bridges at Jones Inlet, Fire Island Inlet, Smith Point, Westhampton Beach, Quogue, and Ponquogue connect the barrier beaches to the mainland. In addition to nearby airports, the Montauk Branch of the Long Island Railroad provides passenger and freight service to the area with special excursion trains operating to and from New York City. A number of passenger ferries operating in Great South Bay provide access from the mainland to locations on the barrier beach between Smith Point and Saltaire. Bus service is available throughout the tributary area.

31. RECREATION. The bay areas and the barrier beaches, especially the world-famous Jones Beach State Park, which has been developed by the Long Island State Park Commission at a cost of over fifty million dollars and which is being further developed, are part of the Long Island resort region, which affords recreation to hundreds of thousands indulging in fishing, pleasure boating, and bathing. Many hotels and tourist homes are located in the area.

32. NAVIGATION. Great South Bay, Moriches Bay, and Shinnecock Bay are connected via the Federally improved Long Island Intracoastal Waterway, with a channel 6 feet deep and 100 feet wide for a distance of 33.6 miles between the Federally improved channel in Great South Bay opposite Patchogue to the south end of Shinnecock Canal. The channel in Great South Bay which starts at Fire Island Inlet is 10 feet deep and 200 feet wide. Additional information on these projects and data on other existing Federal navigation projects in the study area are given in table 2 under "Prior Reports". Natural or locally improved lateral channels connect the Federal channels with various communities in the study area. These channels provide for the movement of pleasure craft and fishing vessels. The Federal channel in Great South Bay together with the branch channel to Patchogue is also used for the transportation of petroleum products to this area.

33. POLLUTION. There is no known pollution on the ocean side of the barrier beach. However, the waters of the Inner Bays are polluted to varying degrees. Pollution in Great South Bay has been increasing due to abnormal enrichment of its waters by nutrients having their principal origin in organic wastes produced by human activities. These wastes, which come largely from sewage effluents reaching the ground water which is discharged into the bay, support the large plankton population. Algae

of all kinds continue to flourish and occasionally produce excessive blooms. As population density increases, the situation may be expected to become worse unless remedial measures are undertaken. Further details pertaining to this pollution problem are contained in paragraphs E1 to E3, appendix E.

34. The problem of pollution in Moriches Bay is increased due to discharge of wastes from duck farms located on tributaries to the bay, mainly in areas near Forge River and Seatuck Cove. These wastes provide ample nutrients to support algae growth which has a deleterious effect on the propogration of shellfish. A discussion of remedial measures undertaken and their results is contained in paragraph E8 of appendix E.

35. Some pollution also exists in Shinnecock Bay. This results from the presence of duck farms in the area, indiscriminate sewage discharges from boats, and surface runoff of the highly populated areas.

36. FISH AND WILDLIFE. The ocean front fishery resources are not used fully due to the specialized type of fishing and the extensive travel involved to get to the waters. However, the Inner Bays provide accessible important fishing areas. The average annual landings of commercial shellfish from these waters amount to about 20,000,000 pounds. Commercial fishermen also harvest an average of about 800,000 pounds of finfish per year. The complex of marshes, mud flats, and tidal shallows in the Inner Bays are important waterfowl habitat used by many species, but more important, these areas serve as a winter terminus for migrating waterfowl due to the natural feeding and resting facilities the habitat provides. Further details on the fish and wildlife resources are contained in section II of appendix E.

VI. CLIMATOLOGY

37. CLIMATE. The climate of Long Island is characterized by mild winters and relatively cool summers with comparative freedom from sudden extreme changes of temperature owing to the moderating influence of the Atlantic Ocean.

38. TEMPERATURE. The mean annual temperature of the area is approximately 50° Fahrenheit. January and February are the coldest months, and July is the warmest. Temperature extremes range from a low of about -10° Fahrenheit to a high of about 100° Fahrenheit. Along the coast the average frost-free period is about 180 days.

39. WINDS. Wind data which were compiled from observations made at various locations on the south shore of Long Island between 1940 and 1959 are shown on plate 1 and in appendix A, figure A2. These data indicate that the prevailing winds with a total duration of 22 percent are from the southwest and 17 percent from the northwest. On a seasonal basis, the prevailing winds are from the southwest from April through October, from the west in November and December, and from the northwest in January, February, and March. The total movement averages 22 percent from the southwest and 18 percent from the northwest.

40. PRECIPITATION. The average annual precipitation is about 45 inches with less rainfall in summer than during other seasons. The heaviest precipitation recorded on Long Island for a 6-hour period was 5.63 inches on 7 August 1946 at Riverhead. A total of 6.87 inches was recorded for the 24-hour period. Additional data on rainfall associated with storms are contained in paragraphs A33 to A35 of appendix A.

VII. HISTORY OF HURRICANES AND OTHER GREAT STORMS

41. HISTORICAL HURRICANES AND GREAT STORMS. In order to determine the possible frequency and severity of future storm occurrence, a review has been made of historical data, including that contained in Technical Paper No. 36 of the U.S. Weather Bureau entitled "North Atlantic Tropical Cyclones, Tracks and Frequencies of Hurricanes and Tropical Storms, 1886-1958", a book by David M. Ludlum entitled "Early American Hurricanes, 1492-1870", old newspapers, and other sources on past storms which have threatened the study area. A summary of the history of hurricanes is contained in appendix A.

42. RECENT HURRICANES AND GREAT STORMS. Most recent storm (March 1962). The most recent storm causing significant damage over a wide area occurred in early March 1962 when an extratropical coastal storm stopped its northward movement and moved erratically off the Middle Atlantic Coast before turning slowly into the Atlantic Ocean. Strong north to northeast winds persisted for nearly a week with velocities of 35 to 45 miles per hour and gusts possibly reaching 70 miles per hour. The fact that the storm movement was blocked by a high pressure system resulted in a continuous storm surge of 3 to 4 feet on the ocean front during the entire period. This, coupled with spring tide conditions, resulted in five consecutive high tides ranging from 6.1 feet above mean sea level near Jones Inlet to 4.6 feet above mean sea level at Captree. Reported high tides in Great South Bay, Moriches Bay, and Shinnecock Bay were 4.4 feet, 4.7 feet, and 4.6 feet above mean sea level respectively. Rainfall in the study area was less than one-half inch. Damages estimated at $1,350,000 for the barrier beach between Jones Inlet and Fire Island Inlet consisted mainly of beach erosion losses. Damage to the inner bay communities was estimated at $827,000, major damage occurring to various residential communities adjacent to Great South Bay. Further details of this storm and resulting damage are contained in paragraphs A24 to A29 of appendix A.

43. Most severe hurricane (September 1938). The most severe hurricane that directly hit the study area, was initially detected about 300 miles northeast of Puerto Rico on 18 September 1938 and traveled west to within 200 miles of the Florida Coast at which point its path was deflected north. It then traveled northward, narrowing in diameter and increasing in intensity. On the morning of 21 September the storm was reported off Cape Hatteras proceeding northward at a velocity of about 40 miles per hour. The center of the storm skirted the east coast of New Jersey and struck the study area near Moriches Inlet during the afternoon, concurrently with a rising predicted tide. Wave heights were estimated to have reached a height of 10 to 12 feet. The abnormally high tides accompanying the hurricane caused damage to the Long Island coastline. The barrier beach from Fire Island Inlet to Southampton bore the brunt of the storm with heavy loss of life and much property damage. Oak Beach suffered the most severe

damage on the barrier beach between Jones Inlet and Fire Island Inlet. The mainland damage in the study area was generally less severe. Several new inlets were formed in the barrier beach, which along with smaller breakthroughs permitted additional waters to enter the bays, adding to the height of the relatively high tides. Flood heights of 7.2 feet, 15.7 feet, and 7.2 feet were reported for Great South Bay, Moriches Bay, and Shinnecock Bay, respectively. Further details of this hurricane and its effect on the study area are contained in paragraph 68, and paragraphs A5 to A8 of appendix A and paragraphs B9 to B11 of appendix B.

44. Major storms. Seven major storms struck the region during the past quarter century, all of which caused some tidal flooding of damaging proportions to the study area. These storms consisted of the following four hurricanes and three extratropical storms which are described in detail in appendix A. In addition to these storms other recent major storms which had minor effect on the study area are listed at the end of table A6 of appendix A.

Hurricanes	Extratropical storms
21 September 1938	25 November 1950
14 September 1944	7 November 1953
31 August 1954 (Carol)	6-8 March 1962
12 September 1960 (Donna)	

45. STORM FREQUENCY. The historical study of storms discloses that hurricanes and other tropical and extratropical storms that have passed through a 200-mile wide band in the general vicinity of the study area total 231 between the years 1635 and 1962, or once every one and a half years. Some of these storms passed outside the area and either caused minor damage or only threatened the vicinity. However since 1900, storms have damaged or threatened the study area on the average of approximately twice a year.

46. The total number of storms of record that either damaged or threatened the study area, arranged by categories and centuries, is shown in table 7. Further data on storm frequencies are contained in paragraphs A30 to A32 of appendix A.

TABLE 7 - FREQUENCY OF STORMS IN THE STUDY AREA[a]

Category	Time Interval				
	1635 to 1700	1701 to 1800	1801 to 1900	1901 to 1962	1635 to 1962
Unusually severe	2	2	3	3	10
Severe	1	2	8	9	20
Moderate	2	8	29	38	77
Threatened the area	1	9	36	78	124
Total	6	21	76	128	231

(a) For details of storm types see table A3, appendix A.

VIII. HURRICANE CHARACTERISTICS

47. GENERAL. The type of storm which affects the area most severely is the hurricane with its high wind, waves, rainfall, and tidal flooding. This term is applied to a cyclonic storm which originates in the tropical or subtropical latitudes of the Atlantic Ocean and moves erratically but generally following a curved path changing from an initial northwest to a final northeast direction, and may affect localities along the entire Atlantic or Gulf coasts of the United States. The center of the storm is an area of low barometric pressure and dead calm, normally from 7 to 20 miles in diameter. Winds blow counterclockwise around the center, with maximum winds generally occurring about 15 to 60 miles from the center, but winds of 50 miles per hour may occur as far as 150 miles from the center.

48. ORIGINS AND TRACKS. Most of the hurricanes that have affected the eastern coast of North America have formed either near the Cape Verde Islands or in the Western Caribbean Sea. Cape Verde hurricanes move westerly for a number of days with a forward speed of about 10 miles per hour. Occasionally, they proceed straight to the coast of Texas, but generally, after reaching the Middle Atlantic Ocean, they recurve northerly and then easterly. Frequently they cross the West Indies, sometimes striking the eastern coast of the United States between Key West, Florida, and Cape Cod, Massachusetts. After recurving, the storms usually increase their forward speed to a rate of 25 to 30 miles per hour and occasionally to a speed of 60 miles per hour. The hurricanes which form in the Caribbean Sea generally move in a northerly direction, across Cuba, then strike either the Gulf or the Southeastern shores of the United States. The hurricanes that most severely affect the study area usually approach from the south-southwest after recurving east of Florida and skirting the Middle Atlantic States. The tracks of recent major hurricanes are shown on figure A1, appendix A.

49. WINDS. The highest winds of a hurricane are those within a circular region extending from the edge of the "eye", or calm center, outward for 10 to 15 miles. The diameter of the eye is usually about 15 miles, although the eye of a mature hurricane may frequently be 20 to 30 miles in diameter. Wind movement is not directly toward the low pressure cyclone center or eye of the hurricane but approaches the center in a counterclockwise spiral. Consequently, the highest wind velocities occur at points to the right of the hurricane's center where the spiral wind movement and the forward motion of the storm are in the same direction. Since destruction by the wind is greatest in the area on the right side of the hurricane, this area is known as the "dangerous semi-circle". A hurricane following a track over New York City, west of the study area, would place the area in this "dangerous semi-circle".

50. BAROMETRIC PRESSURE. Atmospheric pressure falls rapidly as the center of a hurricane approaches and as the velocity of the wind increases. Minimum barometric readings do not always occur in the center of the eye. In some instances, the minimum is reached at the beginning of the calm period, while in others, the minimum is reached at the end of the calm

period. Usually the barometric low is about two inches below the normal sea level pressure of 30 inches. However, in several hurricanes, pressures as low as three inches below normal have been recorded. The lowest barometric pressure of record in the United States, 26.35 inches, was recorded at the northern end of Long Key, Florida, on 2 September 1935.

51. RAINFALL. Another characteristic of a hurricane is the heavy rainfall that usually accompanies the storm. The rainfall at the edge of the disturbance is light, normally in the form of showers. As the center approaches, the showers increase in frequency and intensity becoming heavy to excessive near the eye. The heaviest rain usually falls ahead of the eye, driving torrentially from spiral bands of clouds that sometimes produce nearly two inches of rain per hour. For a 24-hour period, amounts exceeding 20 inches are not uncommon for some areas along a hurricane's path, while considerably lower amounts are recorded in others. During the hurricane of September 1940, 24.0 inches of rainfall was reported at Ewan, New Jersey for the period 31 August to 3 September. However, in the study area, at Patchogue, only 0.13 inches was reported. Additional data on rainfall associated with storms are contained in paragraphs A33 to A35, appendix A.

52. WAVES. Much of the hurricane damage is caused by waves generated by hurricane winds. Vessels at sea suffer greatly in the northeast quadrant of the hurricane and in the turbulent seas of the storm center where waves 45 feet or more in height have been reported. These mountainous waves appear in wild, pyramidal masses and the magnitude of their destructive power is revealed only in the appalling record of lives lost and ships sunk at sea or wrecked on shoals and shores. Such ocean waves will traverse tremendous distances while diminishing in size and strength, reaching distant shores one or two days in advance of the hurricane and causing damage even before the onset and release of the fury contained in the storm proper.

53. In the deep water of the open ocean the height, period, and velocity of many of the waves produced are a function of the wind velocity. The ultimate size of the waves depends upon the force and duration of the wind and the fetch or distance the wave travels. As ocean waves come into shoal waters, their forward movement is slowed by friction on the bottom, and they rise to a new height before thay are dissipated in shoal waters or break on the shore. Driven by hurricane winds, the breaking waves will run up on a shelving beach or overtop vertical structures well above the wave heights, so that reports of wave and flood damage from 5 to 25 feet above stillwater level are not uncommon. Hurricane waves do great damage to shorefront land and buildings and to vessels and small craft.

54. Storm wave heights of 20 feet have been reported off the south shore of Long Island and wave gages operating off Gilgo and Jones Beaches have recorded a maximum height of 13.4 feet. A statistical study of deep water wave height and direction for a station off the entrance to New York Harbor (see figure C1 of appendix C) based on hindcasting technique

and use of synoptic weather charts for the three-year period 1948-1950 was made by the Beach Erosion Board and is published in Technical Memorandum No. 55. The study indicates that almost three-quarters of the computed offshore waves approach from the direction east-northeast through southeast, and the longest computed waves were between 25 and 30 feet in height. A wave rose presenting data developed by the study is shown on plate 1. The wave characteristics, while quite applicable to the ocean along the western portion of the study area, will be somewhat different along the eastern portion because of the greater fetch from the southwest. A swell diagram developed by the Naval Hydrographic Office as shown on plate 1 indicates that the predominant ocean swells come from the southern and eastern quadrants with the greatest percentage lying in the eastern quadrant.

55. STORM TIDE LEVELS. Flooding results from the movement of the storm surge, or rise in water level, onto a shoaling coast or into a bay or inlet. The surge is caused by a combination of hurricane winds and low barometric pressure in a storm having a track and speed of forward movement synchronized with the normal pattern of tidal movement and oscillations of the sea in the open ocean.

56. Generally the rise of the sea is gradual as the center of the storm approaches but sometimes it comes with great swiftness. The history of terrible storms, revealing many instances of cities and towns flooded, with thousands of lives lost, is evidence that such rises are not always gradual.

57. Usually the level of the storm surge is increased by a rising ocean bed and favorable shore contours, factors which similarly affect the astronomical tide in shore locations. The ordinary rise of the tide amounts to only one or two feet in the open ocean while its range is greater at coastal points. The times of ebb and flow of such tides are of course well known, but the storm surge comes so rarely to any one community that it is seldom anticipated in its fully developed form. A well defined storm surge is not developed unless the slope of the ocean bed and the contour of the coastline are favorable to its rise, in combination with the proper direction of the storm track and speed of movement.

58. An important factor in determining the height of flooding from a hurricane surge is the stage of the normal tide at the time the surge arrives at the coast. Surge computations made for the hurricane of 21 September 1938, the maximum storm of record, indicate that the stillwater elevation in the ocean was about 10 feet above mean sea level, or about 9 feet above predicted astronomical tide. If the storm surge were coincident with high tide, a considerably greater area of tidal inundation would have resulted. High water mark measurements made in the Inner Bays after the hurricane indicate that the elevation of floodwaters at some locations exceeded 15 feet above mean sea level. These levels resulted from wind set-up in the bays and breaks through the barrier beach causing higher water level and higher wave uprush.

IX. EXTRATROPICAL STORM CHARACTERISTICS

59. Extratropical storms, also known as "Northeasters", are another type of storm which causes severe damage. Northeasters are also a cyclonic type of storm but normally develops near the Atlantic Coast and may intensify very rapidly. A serious storm may develop in as little as six hours but conditions favorable to the possible development of such a storm can be observed 12 to 24 hours in advance. Wind speeds are not as great and central pressure not as low as in a hurricane, but the winds cover a considerably greater area. A northeaster type of storm of only average intensity, as judged by minimum central pressure, may cause high water. The East Coast of the United States has a relatively high incidence of formation of these storms. The major storms of 25 November 1950, 7 November 1953, and 6-8 March 1962 were of this type.

X. STANDARD PROJECT HURRICANE AND OTHER DESIGN DATA

60. GENERAL. In the design of protective works for the study area, structures must be sufficiently high and strong to withstand the most severe combination of storm tide, including wind set-up, and wave action that can reasonably be expected. A standard project hurricane and other design data developed for use in determining the required height of protective structures are described in the following paragraphs and in appendix C.

61. STANDARD PROJECT HURRICANE. The basis for the standard project storm is a modified transposition of the September 1944 hurricane. This hurricane, off Cape Hatteras, had the greatest amount of energy of any known hurricane, including that of September 1938. I. R. Tannehill, in his book, "Hurricanes: Their Nature and History", 1956, states in reference to the September 1944 hurricane, ".... there is no definite proof of a more violent hurricane in the records". However, the 1944 hurricane was not nearly so serious when it struck the study area along the south shore of Long Island as the September 1938 hurricane, because its energy had been partly dissipated over the land north of Cape Hatteras.

62. In deriving the standard project hurricane, the 1944 storm was transposed so that it would be entirely over water from the Cape Hatteras area to the New England Coast. This change in the track of the storm results in less rise in barometric pressure at the center of the storm as it moves northward than was actually experienced in 1944. The standard project hurricane has a maximum wind speed of 112 miles per hour, a wind pattern similar to the 1938 hurricane near Long Island, a radius of maximum wind of 50 nautical miles, a fetch of 150 nautical miles, a forward velocity of 35 miles per hour, and a central barometric pressure of 27.50 inches.

63. FLOOD LEVELS. Computation of ocean stages. The standard project hurricane was used in determining a standard project hurricane storm tide surge. By application of the method presented in Beach Erosion Board Technical Memorandum No. 83 entitled "Approximate Response of Water Level on a Sloping Shelf to a Wind Fetch which Moves Toward Shore" by R.O. Reid, the height of the standard project hurricane surge

on the ocean front was computed as 13.1 feet above predicted astronomical tide including rise in water level due to barometric pressure deficit. An astronomical tide of 1.6 feet above mean sea level (which is equivalent to the average mean high tide along the oceanfront of the barrier beach) was assumed, making the total surge equal to 14.7 feet above mean sea level. Computations were similarly made for ocean surges that would result from the September 1938 hurricane (recurring), and a moderate hurricane. The corresponding ocean surges and additional data are contained in appendix C.

64. Computation of bay stages. The ocean stage histories for the standard project hurricane, the September 1938 hurricane (recurring), and the moderate hurricane referred to in the preceding paragraph were routed through Fire Island, Moriches, and Shinnecock Inlets and over the barrier beach to obtain corresponding stage histories in Great South Bay, Moriches Bay, and Shinnecock Bay under existing conditions and under improved conditions after completion of the authorized beach erosion and hurricane project for Fire Island Inlet to Montauk Point, which includes raising of the dunes on the barrier beach to 20 feet above mean see level to prevent overtopping (see paragraph 8).

65. Neglecting wind set-up and wave run-up in the bays, a standard project hurricane coincident with mean tide would produce an average stage of about 8 feet, 10 feet, and 10.4 feet above mean sea level in Great South Bay, Moriches Bay, and Shinnecock Bay respectively, if no improvements were made to the barrier beach. With completion of the authorized barrier beach program, for which construction has already been initiated, the respective average stages, exclusive of wind set-up and wave run-up in the bays, will reach only about 3.5 feet, 3.8 feet, and 4.3 feet. Stages for the various bays would be relatively smaller for the hurricane of September 1938 recurring and for a developed moderate hurricane. The bay stages for these lesser storms are listed in table C7 of appendix C.

66. Wind set-up in bays. In addition to the elevation obtained by routing of storm waters into Great South, Moriches, and Shinnecock Bays, there is an added effect which causes an appreciable increase in the bay water level. This is the effect of wind blowing over the bay in the direction of its long axis, east-west in the case of these bays. Indications of the set-up which might occur at the east and west ends of the bays by assumed winds of various speeds acting over an average bay depth from 4 to 15 feet are given in figure C9, appendix C. The additional rise in storm tidal level at each community will depend on the fetch length to the community, wind speed, and direction. While some areas will receive additional damages from wind set-up, other areas will receive comparably less.

67. STAGE-FREQUENCY DATA. Stage-frequency curves (figure C7, appendix C) for Great South Bay, Moriches Bay, and Shinnecock Bay without and with the authorized barrier beach improvements were developed by routing the ocean water resulting from a standard project hurricane, the hurricane of 1938 recurring, and a moderate hurricane through the various inlets

and over the barrier beach at times of mean high tide and mean low tide and averaging the results. Wind set-up, wave run-up, and the minor effect of rainfall were neglected. The average resulting stages were then correlated with the composite ocean frequency curve shown on figure C6 and described in paragraph C25 of appendix C.

XI. EXTENT AND CHARACTER OF FLOODED AREA

68. EXTENT OF FLOODING. The hurricane of 21 September 1938, the maximum of record, caused destructive tidal inundation along the south shore of Long Island. On the barrier beach between Jones Inlet and Fire Island Inlet, severe flooding was halted by Ocean Parkway, except at low-lying areas at Oak Beach and various Jones Beach parking lots. However, about 35,000 acres were inundated between Fire Island Inlet and Montauk Point, including the mainland areas adjoining the Inner Bays, as shown on figure B1, appendix B. Figure B2, appendix B, shows the limits of the mainland flooding in the study area; approximately 21,000 acres were inundated.

69. CHARACTER OF DEVELOPMENT. The development of the area subject to flooding is primarily residential and recreational. These types of development suffer a high proportion of all damage. In addition, there are a number of poultry and truck farms as well as boatyards, public utilities, and small businesses which are affected.

70. EFFECT ON TRANSPORTATION. During times of flooding, hardships are experienced in the area as a result of inundation or washout of roads and bridges connecting the mainland with the barrier beach and along the shore. Washouts from previous storms have required extensive road repairs before normal traffic could be restored. In addition, the facilities of the Long Island Railroad are affected by storm water which causes track inundation and washout.

71. EFFECT ON THE PUBLIC. The records indicate that 38 persons were dead or missing in the study area after the 1938 hurricane as indicated in paragraph B9, appendix B. Evacuation of many people from flooded areas has been necessary during past major storms. Utilities in the area are also seriously affected causing additional problems to the public and communities.

XII. HURRICANE TIDAL FLOOD DAMAGES

72. FLOOD DAMAGE SURVEY. A storm damage survey was completed in 1957 of the area from Jones Inlet to Montauk Point which included the barrier beach between Jones Inlet and Fire Island Inlet and the areas fronting Great South Bay, Moriches Bay, and Shinnecock Bay. The survey was primarily a physical inventory of the area subject to tidal flooding. Losses were estimated for various stages of flooding and stage-loss relationships were developed for various reaches in the study area. Much of the information was obtained through personal interviews, although sampling methods were used whenever similar types of property, subject

to approximately the same depth of flooding, were encountered. Damage values for the higher elevations were obtained by extrapolation of the resulting stage-damage curves with due regard given to the development of the area at the time of the damage survey. The above flood loss data have been updated to 1965 price levels for use in this report. No attempt has been made to make adjustments for additional development in the study area since 1957, as it has been determined that Ocean Parkway affords adequate protection for the barrier beach between Jones Inlet and Fire Island Inlet and that protective works in the inner bay areas supplementing those provided for under the authorized beach erosion and hurricane protection project between Fire Island Inlet and Montauk Point, would not be economically feasible.

73. EXPERIENCED TIDAL FLOOD DAMAGES. Hurricane of 21 September 1938. This hurricane, the maximum of record, caused tidal inundation to some sections of the ocean front south of Ocean Parkway on the barrier beach between Jones Inlet and Fire Island Inlet. However, practically the entire barrier beach east of Fire Island Inlet to Southampton was inundated. A rise in the bay water elevations, due to overtopping of the dunes and breakthroughs along the barrier beach in this latter section exposed the mainland area to direct ocean wave attack and tidal inundation (see figure B1, appendix B for areas affected and photos 1 to 6 for effects of the storm). Damages estimated at $220,000 (1938 prices) were incurred on the barrier beach between Jones Inlet and Fire Island Inlet. Primary physical damage of over $6,000,000 (1938 prices) was reported for the south shore of Long Island from Fire Island Inlet to Montauk Point. Of this amount, almost 80 percent occurred along the barrier beach from Fire Island Inlet to Southampton, and about $800,000 of damage was reported for the mainland of the study area.

74. Hurricane of 12 September 1960 (Donna). This hurricane caused estimated damages of over one million dollars to the barrier beach between Jones Inlet and Fire Island Inlet. Donna sent waves over the boardwalk, caused a large gully in the beach, washed away protective dunes and sand fences, and damaged concrete parking fields (see photo 11). Shore structures at Tobay Beach were damaged, while at Oak Beach, three small boats were lost at a fishing station, but no shore damage was reported. Estimated damages of $850,000 to the inner bay areas were incurred when various communities suffered damages from flooding. Several hundred families were evacuated from low lying areas between Amityville and Babylon. On Shinnecock Bay, the entire causeway of the Ponquogue Bridge was under water and a 50-foot concrete embankment section was broken up and washed ashore. More detailed data on experienced tidal flood losses are contained in appendix B.

75. RECURRING TIDAL FLOOD DAMAGES. Estimates have been made of recurring damages, at 1965 price levels, that would be experienced in future hurricanes causing flooding at various stages in the bays. These damage estimates were computed by using the stage-damage relationships previously described in paragraph 72, based on 1957 conditions of development in the area. Primary damages to the barrier beach between Jones Inlet and Fire Island Inlet is estimated at $5,400,000 for recurrence

of the hurricane of 21 September 1938, while damage to the mainland areas adjacent to the bays is estimated at $12,200,000, assuming no improvements to the barrier beach from Fire Island to Southampton. With completion of the authorized improvement, the corresponding damage estimate to the mainland will be only $1,150,000. Primary damages that would result from occurrence of the standard project hurricane are estimated at $49,000,000 for the barrier beach between Jones Inlet and Fire Island Inlet and $61,000,000 for the mainland of the study area, assuming no improvements to the barrier beach. With completion of the authorized improvements the damage estimate to the mainland will be only $3,250,000. Further data on recurring losses are contained in appendix B.

XIII. TIDAL FLOOD PROBLEM

76. GENERAL. Hurricane damages result chiefly from (1) salt water flooding by the hurricane surge, (2) action of storm-driven waves, (3) fresh water flooding resulting from torrential rains, and (4) effect of high velocity winds. This report is limited to the problem of protection of the study area against salt water tidal flooding and wave action. The effect of high velocity winds is considered only with respect to wave action as described in paragraphs 52 to 54 and wind set-up as described in paragraph 66. Fresh water flooding is not considered since the porous soil covering the drainage area tributary to the bays of the south shore of Long Island, as described in paragraph 23, results in a relatively small quantity of runoff and minor flooding of any significance to warrant Federal interest within the study area.

77. CAUSE OF FLOODING. Although the barrier beach between Jones Inlet and Fire Island Inlet is subject to direct ocean wave attack, the problem of flooding is not of great magnitude since Ocean Parkway, which runs practically the entire length of the island, is at an elevation of about 14 feet above mean sea level, approximately 4 feet above the highest tide experienced in the area. Some sections of the ocean front south of the parkway are subject to tidal inundation during extreme storm tides, but the extent of potential damage is not great. Damage from flooding due to high stages in the bay are also minimal since the low-lying areas north of the parkway are primarily undeveloped salt-water marshlands. The mainland areas fronting the Inner Bays of the south shore of Long Island, are susceptible to flooding by even a small rise of the bay levels due to the flat terrain. The barrier beach affords much protection to the area during severe storms. However, breakthroughs of the barrier beach east of Fire Island Inlet, as described in paragraph 43, cause considerable additional damage to the mainland areas from direct ocean wave attack and inundation from the high ocean tides that results in increased height of the bay waters. The condition of the barrier beach fronting the Atlantic Ocean is therefore an important factor relating to the extent of damage to the bay areas during periods of severe storms. Improvements to the barrier beach east of Fire Island Inlet will correspondingly decrease storm damages to the areas fronting the Inner Bays. The subject of improvements desired in this report is therefore treated in conjunction with improvements to the barrier beach east of Fire Island Inlet.

XIV. EXISTING CORPS OF ENGINEERS' PROJECTS

78. GENERAL. An authorized Federal beach erosion control project for Fire Island Inlet and Shore Westerly to Jones Inlet, as described in paragraph 7, is designed to maintain the shore of this area in a suitable stable condition and provide an adequate navigation channel in Fire Island Inlet. In addition to this project and the pertinent projects on hurricane and/or beach erosion improvements listed in table 1, and the Federal navigation projects listed in table 2, a dual-purpose beach erosion control and hurricane protection project which is closely related to the subject study was authorized by the River and Harbor Act of 1960, substantially in accordance with recommendations of the Chief of Engineers in House Document No. 425, 86th Congress, 2nd Session, and was modified for the cost sharing of the beach erosion portion of the project in accordance with Section 103 of the River and Harbor Act of 1962. This project, which is briefly described in paragraph 8, is described in further detail in the following paragraphs.

79. COMBINED BEACH EROSION CONTROL AND HURRICANE PROTECTION PROJECT, FIRE ISLAND INLET TO MONTAUK POINT, N. Y. This project as contained in the authorizing document, and as shown on figure C8, appendix C, generally provides for:

a. Widening the beaches along developed areas between Kismet and Mecox Bay to a minimum width of 100 feet at elevation 14 feet above mean sea level;

b. Raising the dunes to an elevation of 20 feet above mean sea level from Fire Island Inlet to Hither Hills State Park, at Montauk, and opposite Lake Montauk Harbor;

c. Planting grass on the dunes;

d. Constructing gated interior drainage structures at Mecox Bay, Sagaponack Lake, and Georgica Pond;

e. Constructing not to exceed 50 groins, if needed; and

f. Federal participation in the cost of beach nourishment for a period not to exceed 10 years from the year of completion of a useful nourishment unit;

generally in accordance with the plan of the District Engineer, with such modifications thereof as in the discretion of the Chief of Engineers may be advisable, and subject to certain conditions of local cooperation including the adoption of appropriate ordinances to provide for the preservation of the dunes and their protective vegetation.

80. The latest approved estimated first cost of the project as of 1 July 1965, excluding periodic beach nourishment, is $59,780,000 of which $31,780,000 (53.2 percent) is Federal and $28,000,000 (46.8 percent) is non-Federal. Assurances of local cooperation were furnished by the State

of New York on 14 August 1963 and accepted on 20 August 1963. On 20 April 1964, the State furnished a supplement to the assurances of local cooperation which was accepted on 27 April 1964.

81. Initial construction of not more than 13 groins in the Moriches Inlet to Shinnecock Inlet section was approved by the Chief of Engineers on 25 February 1964 subject to the following provisions:

a. Local interests must agree that artificial fill will be added when found necessary by the Chief of Engineers but not earlier than three years after completion of the groins unless fill is mutually acceptable to local sponsors and the Chief of Engineers.

b. If fill is to be accomplished only to provide for shore protection (beach erosion control), cost sharing (including cost of groins) will be based on existing ownership and public use and will be apportioned in accordance with Federal law and policy for shore protection projects.

c. If fill is to be accomplished to provide both beach erosion control and hurricane protection, cost sharing (including cost of groins) will be based on the project document with specific reference to paragraphs 20(c) and (j) of the report of the Chief of Engineers (pages 10-11, House Document No. 425, 86th Congress, 2nd Session.)

82. Work is underway on the construction of 11 stone groins in the Moriches to Shinnecock section, under a contract awarded on 15 December 1964. Work has been completed on the construction of two groins in the Georgica Pond area under contract awarded on 26 January 1965. Study of the need for at least two groins in this area was previously authorized by the Chief of Engineers on 25 February 1964.

XV. IMPROVEMENTS DESIRED

83. PUBLIC HEARINGS. Public hearings were held in Babylon, N. Y. on 19 December 1955, and at Westhampton Beach, N. Y. on 20 December 1955 for the dual purpose of obtaining information for use in the cooperative beach erosion control study and to ascertain the desires of local interests in connection with the Hurricane Survey of the south shore of Long Island from Jones Inlet to Montauk Point including the Inner Bays. A third public hearing was held at Riverhead, N. Y. on 22 April 1958, to acquaint local interests with, and to obtain their views on the plan of improvement that was under consideration for the Atlantic Coast from Fire Island Inlet to Montauk Point. At the hearings, as summarized in appendix D, emphasis was primarily for improvements to the barrier beach which in turn would protect the mainland areas fronting the Inner Bays.

84. DESIRES OF LOCAL INTERESTS. Local interests desired that adequate protective measures be provided to mitigate losses from coastal storms. They indicated a strong demand for a comprehensive shore protection program for the entire study area with Federal participation in the cost of the work. A number of speakers stressed the inadequacy of the hurricane warning system and requested improvement of this vital service.

There was a general endorsement of the recommendations made by the Beach Erosion Board in 1946 providing for shore and dune restoration, artificial nourishment, construction of groins, construction of sand fences, and the planting of dune grass. Contacts made with local interests subsequent to the Babylon and Westhampton Beach hearings revealed a predominant desire for shore and dune protection to be accomplished by hydraulic fill supplemented by groin construction.

85. Meetings were held with local interests to discuss the possibilities of providing protection against future hurricane and other severe storm damages on the barrier beach between Jones Inlet and Fire Island Inlet. As detailed in a review letter from the New York State Department of Public Works, dated 7 September 1965, contained in appendix D, local interests object to any construction of dunes above 12 feet mean sea level south of the boardwalk at Jones Beach, and feel that Ocean Parkway, which is about 14 feet above mean sea level, affords other areas outside of Jones Beach the necessary protection against hurricanes and other severe storms.

86. In justification of proposed improvements, local interests indicated that loss of life and property damage would be reduced, land would be saved from erosion, property values would be increased and such indirect losses due to loss of facilities, cessation of business, and interruption to traffic would be decreased. They stressed the importance of preventing deterioration of the barrier beach because it provides protection to the mainland against ocean wave attack and inundation by high ocean tides.

XVI. IMPROVEMENTS CONSIDERED

87. PROTECTIVE MEASURES CONSIDERED. Protective measures fall into the following categories: (a) hurricane warning and emergency flood mobilization measures, including plans for evacuation, (b) revised zoning regulations and building codes, and (c) protective structures. They are described as follows:

88. Hurricane warning and emergency flood mobilization and evacuation measures. A hurricane warning system, combined with emergency mobilization and plans for evacuation would materially aid in preventing loss of life and property. However, such a system would not alleviate the problem of physical inundation of land area. Considerable time is required for emergency precautionary measures, such as boarding up and sandbagging windows, evacuating low-lying areas, removing goods and equipment to higher levels, pulling small craft ashore, and driving vehicles to high ground. A warning system, no matter how extensive and elaborate, may not always provide sufficient time for taking adequate precautions. The hurricane of 1938, for example, which was reported stalled at one time off Cape Hatteras, swept north to the New England coast, almost unannounced, only eight hours later.

89. It is necessary to supplement any plan of protection with a hurricane warning service. However, hurricane alerts and "near misses", which result only in "scares", interfere with the normal activities of affected residents and in many cases cause economic loss. The hurricane warning system operated by the U. S. Weather Bureau is constantly being evaluated and improved. Significant improvements have been made for detecting and forecasting storms, and the warning system has been refined to eliminate many of the hurricane "scares". In addition, much has been accomplished at the local level to improve the dissemination of hurricane warnings and alerts to local officials and the general public. The Suffolk County Civil Defense Office has been instituted to spread warnings issued by the U. S. Weather Bureau in New York City. The potential hazard of loss of life and damage to property is expected to be reduced in the area.

90. The hurricane of August 1955, which caused tremendous damage to property and loss of life along the eastern coast of the United States from South Carolina north to Massachusetts, crystallized the need for community hurricane preparedness planning. This function is performed by the Civil Defense organization operating under the State Civil Defense Coordinator. Emergency preparations are made as soon as the U. S. Weather Bureau issues a "Hurricane Watch" which indicates that a hurricane is becoming a threat to a coastal area. Emergency procedures are initiated after the Weather Bureau issues a "Hurricane Warning", which indicates that hurricane conditions are considered imminent, and may begin immediately or within 24 hours. The emergency procedures include various plans of action, including evacuation, depending upon the maximum tide height expected.

91. Details of a hurricane preparedness plan for a typical community have been prepared by the U. S. Weather Bureau in collaboration with the Corps of Engineers and are presented in a pamphlet titled "National Hurricane Research Project Report No. 28, A Model Hurricane Plan for a Coastal Community". This pamphlet offers local interests many suggestions related to planning and organization to minimize hurricane losses. A copy of the pamphlet is included in this report as appendix G.

92. Revision of zoning regulations and building codes. A careful study must be made before zoning a flood plain to serve the needs of the various communities in the best manner possible, with a minimum of danger from hurricane damage, and with proper allowance for the future growth of the community. In the preparation of an appropriate zoning ordinance, two important factors must be considered; namely (a) the height of the flood stage in the area to be zoned below which construction will not be permitted, and (b) land use of development which will be permitted in the zoned area. Information on the bay stages and estimated frequency of bay stages presented in paragraphs 64 to 67 will be helpful in these considerations. However, wind set-up as described in paragraph 66 and wave run-up should not be neglected when establishing the flood stage for each community.

93. Building codes should designate the type and standards of construction of individual homes or buildings in the flood areas. Building codes should specify the minimum level of the first floor of structures, particularly those that are susceptible to damage from tides and waves. The building code should also indicate the minimum setback from the mean high water line. With regard to building codes requiring heavy construction of buildings to withstand hurricane wind forces, it is considered that such codes would not be generally appropriate in the study area because of the high cost which would be involved.

94. The responsibility for enacting legislation on zoning and building regulations lies with the State and municipalities concerned. Some communities in the area already have restrictions in their zoning and building codes, as detailed in appendix F. It is imperative to enforce the present restrictions imposed against impairing the effectiveness of existing dunes and the dunes which will be raised under the authorized beach erosion control and hurricane protection project. The adoption of effective regulatory measures to prohibit development in hazardous flood areas of residential communities and commercial centers will result in the saving of lives and property in the area while diminishing future demands on the Federal, State, and local governments for flood relief and flood control expenditures.

95. As an aid to local flood plain planning, Section 206 of the Flood Control Act of 1960 (Public Law 86-645) authorizes the Secretary of the Army, through the Chief of Engineers, to compile and disseminate information on floods and potential flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies. These studies make available to States and local governmental agencies, information and advice about flood hazards which will help them with such planning, engineering studies, and construction as may be necessary for proper use, or regulation of use, of flood plain areas. The flood plain information studies are applicable to coastal areas as well as stream and river basins. Additional details regarding the general authority and objectives of these studies are presented in appendix F, exhibit 1.

96. Protective structures. Although hurricane warnings, mobilization measures, and revised zoning regulations and building codes will abate the extent of flood damages, they will not eliminate the inherent danger from tidal flooding. The most positive means of protection consists of structures which will physically reduce or prevent the inundation of properties by tidal floodwaters that enter the bays at the time of a hurricane or other major storm.

97. Preliminary studies were made to determine possible measures for protection of vulnerable areas in Great South Bay, Moriches Bay, and Shinnecock Bay against hurricane tidal flooding. Studies indicated that the low-lying Smith Point-Mastic Beach and Westhampton Beach-Quogue peninsulas are areas potentially subject to severe damage. These peninsulas are presently susceptible to flooding from high water in the bays due to inflow through Fire Island, Moriches, and Shinnecock Inlets, flow

over the barrier beach, wind set-up, and wave run-up. Raising of the dunes to 20 feet above mean sea level on the barrier beach, as authorized under the combined beach erosion-hurricane protection project, will prevent flow over the barrier beach and breakthroughs, thus reducing the elevation of storm tides in the bays. However, considerable inundation of low areas would still be possible due to the remaining flow through the inlets, and wind set-up, and wave run-up in the Inner Bays.

98. In order to reduce residual damage in the above-mentioned areas and supplement the protection which would be afforded after raising the ocean front dunes, the possibilities of constructing hurricane barriers with navigation openings were considered for the eastern end of Great South Bay at Smith Point, at the western end of Moriches Bay at Mastic Beach, at the eastern end of Moriches Bay west of Westhampton Beach, and at the western end of Shinnecock Bay at Quogue as shown on figure C10, appendix C. The preliminary studies indicated that these barriers could not be economically justified, even when considering benefits to be received from recent and future development in the areas. Furthermore, local objection was voiced with regard to their installation; the New York State Department of Public Works and the Suffolk County authorities considered them not desirable. The preliminary studies also indicated that local protection improvements, including floodwall and levee construction, along the various bay areas shown on figure B2, appendix B, have a very low economic justification. Further details on the proposed barriers and local protection improvements are contained in appendix C.

XVII. COORDINATION WITH OTHER AGENCIES

99. In the course of this survey, assistance and cooperation have been received from Federal, State, and local agencies that are concerned with hurricane activities, or are particularly interested in the hurricane protection problem of the study area. Statements received from these other agencies are contained in appendix D.

100. The U. S. Weather Bureau has furnished information on the behavior and characteristics of hurricanes and data on maximum wind velocities and durations for locations in proximity to the study area. A meeting was held with the Bureau to obtain data on latest tracking and forecasting techniques for hurricanes and other severe storms, and means of disseminating pertinent information during "watches".

101. The Public Health Service of the U. S. Department of Health, Education and Welfare reviewed data on pollution.

102. The United States Fish and Wildlife Service reviewed data in this report pertinent to water resources, concluding that since no construction features are recommended, fish and wildlife resources are not significantly involved.

103. A meeting was held on 30 June 1965 with State and local officials for the purpose of discussing this report. They reaffirmed their initial objections to the use of hurricane barriers for protection of the more vulnerable areas on the basis that the difficulties caused to navigation interests and the possibility of increasing pollution in the bays. They also concurred with the Long Island State Park Commission that the existing highway on the barrier beach between Fire Island Inlet and Jones Inlet affords the area the necessary protection from hurricanes.

XVIII. DISCUSSION

104. THE PROBLEM. The barrier beach between Jones Inlet and Fire Island Inlet is subject to direct ocean wave attack. However, the problem of flooding is not of great magnitude since Ocean Parkway, which runs practically the entire length of the island, is at an elevation of about 14 feet above mean sea level, approximately 4 feet above the highest tide experienced in the area. Some sections of the ocean front south of the parkway are subject to tidal inundation during extreme storm tides, but the extent of potential damage is not great. However, the areas fronting the Inner Bays of the south shore of Long Island have experienced very heavy tidal flood losses in recent hurricanes and other great storms. The communities adjacent to the bays, although not situated on the open ocean, are subjected to direct ocean wave attack and inundation caused by high ocean tides overtopping of and breaking through the barrier beach east of Fire Island Inlet. A recurrence of the 1938 hurricane under present condition of the barrier beach would cause damages estimated at over $12,000,000 to the area. Under similar conditions, the surge created by a standard project hurricane is estimated to cause tidal inundation damage of over $60,000,000. However, the authorized project, which provides for raising the dunes of the barrier beach east of Fire Island Inlet to 20 feet above mean sea level, will prevent overtopping and breakthroughs and result in considerable reduction in tidal damages. Some inundation of low areas would still be possible due to the remaining flow through the inlets, wind set-up, and wave run-up. Recurrence of the 1938 hurricane under improved barrier beach conditions will produce an estimated flood damage of less than $2,000,000 to the Inner Bay communities; and the standard project hurricane, an estimated damage of less than $5,000,000.

105. PROTECTION CONSIDERED. General. As indicated in the preceding paragraph, the extent of damage caused by tidal inundation of future hurricanes and severe storms will be minor, and therefore construction of additional works to protect the barrier beach between Jones Inlet and Fire Island Inlet is not warranted. For the Inner Bay communities, damages will be minimized after completion of the authorized barrier beach project. In order to eliminate the residual damage within the Inner Bays, consideration was given to local protection improvements involving floodwall and levee construction along the vulnerable mainland areas, as well as barriers with navigation openings. Preliminary studies indicated that these protective structures would not be economically justified, even when considering recent and future development in the area. It was also determined that barriers are not desired by the local governmental authorities. Some reduction in hurricane tidal flood damages can be effected by the provision of improved forecasting and warning services, hurricane preparedness planning, the enactment of revised zoning ordinances, and the adoption of modified building codes.

106. Hurricane forecasting and warning services. The hurricane forecasting system is constantly being evaluated and improved. Significant improvements have been made in detecting and forecasting storms,

and the warning system has been refined to eliminate many of the hurricane "scares". Hurricane forecasting and warnings provided by the U. S. Weather Bureau are disseminated by local radio and television stations, newspapers, and telephones, as well as the Suffolk County Civil Defense Office.

107. Zoning and building codes. Realistic zoning laws and strict building codes, both of which are responsibilities of local governmental agencies, can have the effect of reducing flood damages in some localities. However, these measures have a minimum effect in the already highly developed areas that have sustained the greatest losses, and which are most susceptible to further losses. In such areas, communities should encourage and assist owners or occupants in the flood proofing of existing structures to the elevation of potential flood heights. Zoning regulations and building codes can be applied to areas where development is planned or proposed. In cases where it is not possible to exclude development of vulnerable areas by zoning, developers should be informed of the flood potential, and urged to consider this factor in their planning. Land use regulations should be adopted to guide the community growth in the flood plain area.

XIX. CONCLUSIONS

108. The studies have shown that the barrier beach between Jones Inlet and Fire Island Inlet is adequately protected by the existing Ocean Parkway which is approximately 4 feet higher in elevation than the maximum tide of record. For the Inner Bay communities of the study area, a complete protection plan for preventing damages from tides and waves that would accompany a standard project hurricane would involve floodwalls and levees completely surrounding each area to be protected. Even though considerable development has taken place since the time of the damage survey and some future development is expected, these structures would not be economically feasible, and not practical. It has also been determined that a plan providing for a lesser degree of protection would likewise be uneconomic. A plan involving hurricane barriers to supplement the protection which will be afforded after raising the ocean front dunes (under the authorized barrier beach project) was considered for the more vulnerable areas. This plan could not be economically justified and is not desired by local governmental authorities, thus detailed studies to prepare a final design was not undertaken for any area. It is therefore concluded that a Federal project for the construction of protective works for any part of the study area, other than those provided for under the existing beach erosion and hurricane protection project for the ocean front area, is not warranted at this time. Consequently, it is essential to have an adequate storm-warning system, as well as plans and routes for evacuation of the bay areas, to avoid loss of life during severe storms and hurricanes.

109. The formulation of an adequate hurricane preparedness plan is considered to be a responsibility of local authorities, utilizing any information, statistics, and data available from appropriate State and Federal agencies. The model hurricane plan presented in appendix G can

be helpful in expanding present plans of emergency preparedness of the various communities, thus mitigating damages and other losses experienced with hurricanes and hurricane threats of the past.

XX. RECOMMENDATIONS

110. The District Engineer recommends the following:

a. That no improvements designed to protect the barrier beach between Jones Inlet and Fire Island Inlet and the Inner Bays between Fire Island Inlet and Montauk Point, New York, against tidal inundation, supplementing those provided for under the authorized beach erosion and hurricane protection project along the ocean front of the same area, be authorized by the United States at this time.

b. That this report be published and distributed to appropriate officials in the area who may find the information contained therein of use in the establishment of flood plain regulatory measures and hurricane preparedness and evacuation plans.

R. T. BATSON
Colonel, Corps of Engineers
District Engineer

ACKNOWLEDGEMENTS AND IDENTIFICATION OF PERSONNEL

1. The preparation of this report was administered by:

Colonel M. M. Miletich, C of E, former District Engineer

Colonel R. T. Batson, C of E, District Engineer

Charles K. Panish, Chief, Engineering Division

Frank L. Panuzio, Deputy Chief, Engineering Division

2. This report was prepared under the direction of Samuel Gofseyeff, Chief, Beach Erosion and Hurricane Section. The writing of the report was performed by Samuel Gofseyeff and John Zammit with the assistance of Alexander Loewy and James Daniels.

3. Norman Porter & Associates, Consulting Engineers, made the basic damage surveys. Tippetts-Abbett-McCarthy-Stratton, Consulting Engineers, assisted in preliminary studies of hurricane barriers for protection of the Westhampton Beach area. The above were reviewed by Samuel Gofseyeff.

4. The New York District, Corps of Engineers, is appreciative of the cooperation rendered in connection with the study by personnel of a number of other offices and agencies, particularly the following:

United States Public Health Service

United States Fish and Wildlife Service

United States Weather Bureau

New York State Department of Public Works

Long Island State Park Commission

Various departments of Nassau and Suffolk Counties and the Towns in the study area.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

SUPPLEMENT

INFORMATION CALLED FOR BY
SENATE RESOLUTION 148, 85TH CONGRESS
ADOPTED 28 JANUARY 1958

ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)
Information Called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

1. FLOOD PROBLEM. The barrier beach between Jones Inlet and Fire Island Inlet and the Inner Bays of the Atlantic Coast of Long Island from Fire Island Inlet to Montauk Point have experienced tidal flood losses resulting from hurricanes and other great storms. The barrier beach between Jones Inlet and Fire Island Inlet is subject to direct ocean wave attack. However, the problem of flooding is not of great magnitude, since Ocean Parkway, which runs practically the entire length of this barrier is approximately 4 feet above the highest tide experienced in the area. Some sections of the ocean front south of the parkway are subject to tidal flooding during extreme storm tides, but the extent of potential damage is not great. The low-lying mainland communities adjacent to the Inner Bays are susceptible to flooding from high waters in the bays resulting from flow through the inlets, wind set-up, and wave run-up. During severe storms, increased flood stages in the bays result from high ocean tides overtopping of and breaking through sections of the barrier beach east of Fire Island Inlet, and the peninsulas closest to the ocean are subjected to direct ocean wave attack in the vicinity of the breakthroughs.

2. DISCUSSION. The construction of protective works along the barrier beach east of Fire Island Inlet was discussed in a separate report entitled "Cooperative Beach Erosion Control and Interim Hurricane Study (Survey) of the Atlantic Coast of Long Island, N. Y., Fire Island Inlet to Montauk Point", dated 31 July 1958. The project recommended therein, which includes raising of the dunes along the barrier beach east of Fire Island Inlet to 20 feet above mean sea level, was authorized by Congress in the River and Harbor Act of 1960 in accordance with the recommendations of the Chief of Engineers in House Document No. 425, 88th Congress, 2d Session. This project, when completed, will greatly reduce flood damages in the Inner Bay areas by eliminating overtopping of and breaks through the barrier beach.

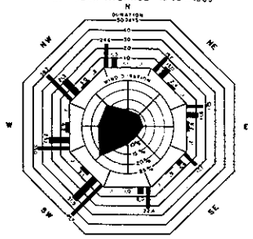
3. The expensive additional works necessary for the direct protection of vulnerable areas against the residual tidal flood damages cannot be justified economically. However, the hazards and damages accompanying tidal flooding may be reduced by local action such as appropriate regulation of the use of the flood plain through adequate zoning laws and building codes, development of hurricane preparedness and evacuation plans, and other safety measures. The adoption of such measures by local governments may result in the saving of lives and property in the area, while diminishing the future demands on the Federal, State, and local governments for flood relief and flood control expenditures. Under the circumstances cited above, there is no basis for project analysis of the type called for by Senate Resolution 148.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

PLATES

WIND DIAGRAM

SOUTH SHORE OF LONG ISLAND
20 YEAR AVERAGE 1940 – 1959

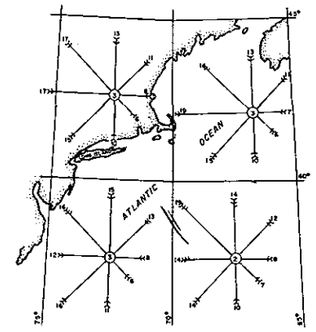


LEGEND
VELOCITY RANGE M.P.H.
0 TO 12
OVER 12-24
OVER 24-38
OVER 38

BASED ON WIND RECORDS AT FOUR HOUR INTERVALS AT THE U.S. COAST GUARD STATIONS AT TIANA FROM 1940 TO 1945 AND AT SHINNECOCK FROM 1944 TO MARCH 1948 AND ON HOURLY READINGS FROM THE SUFFOLK COUNTY HIGHWAY DEPARTMENT RECORDING GAGE AT WESTHAMPTON BEACH FROM APRIL 1948 TO DECEMBER 1959.

73°30'

PREVAILING WINDS

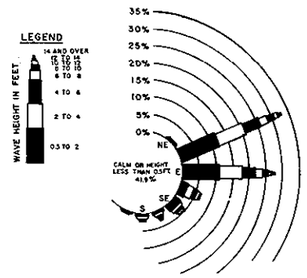


WIND ROSES SHOW AVERAGE WINDS FOR 5° SQUARE OVER ENTIRE PERIOD OF RECORD. ARROWS FLY WITH THE WIND. FIGURES AT END OF ARROWS INDICATE PERCENT OF OBSERVATIONS WIND HAS BLOWN FROM THAT DIRECTION. NUMBER OF FEATHERS REPRESENTS AVERAGE FORCE, BEAUFORT SCALE. FIGURE IN CIRCLE REPRESENTS PERCENTAGE OF CALMS, LIGHT AIRS AND VARIABLE.
BASED ON OBSERVATIONS BY THE U.S. NAVY HYDROGRAPHIC OFFICE FOR 10 YEAR PERIOD, 1932–1942.

73°00'

WAVE DATA

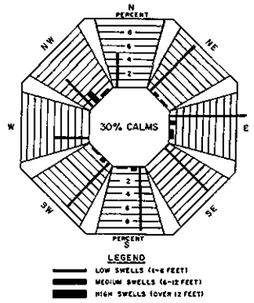
ENTRANCE TO NEW YORK HARBOR
(LAT. 40°-15'N LONG. 73°-45'W)



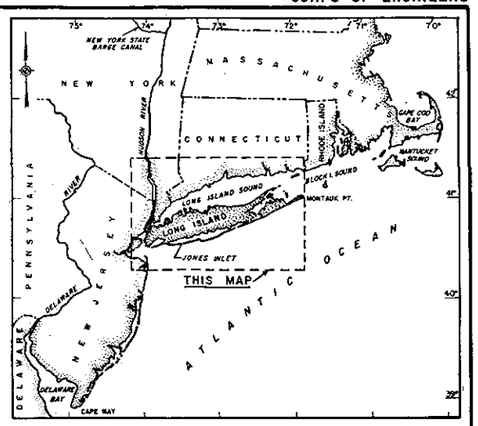
THE DATA, WHICH SHOW PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION, WERE DERIVED BY HINDCASTING METHODS & USE OF SYNOPTIC WEATHER CHARTS FOR THE THREE-YEAR PERIOD 1948-1950.

72°30'

SWELL DIAGRAM

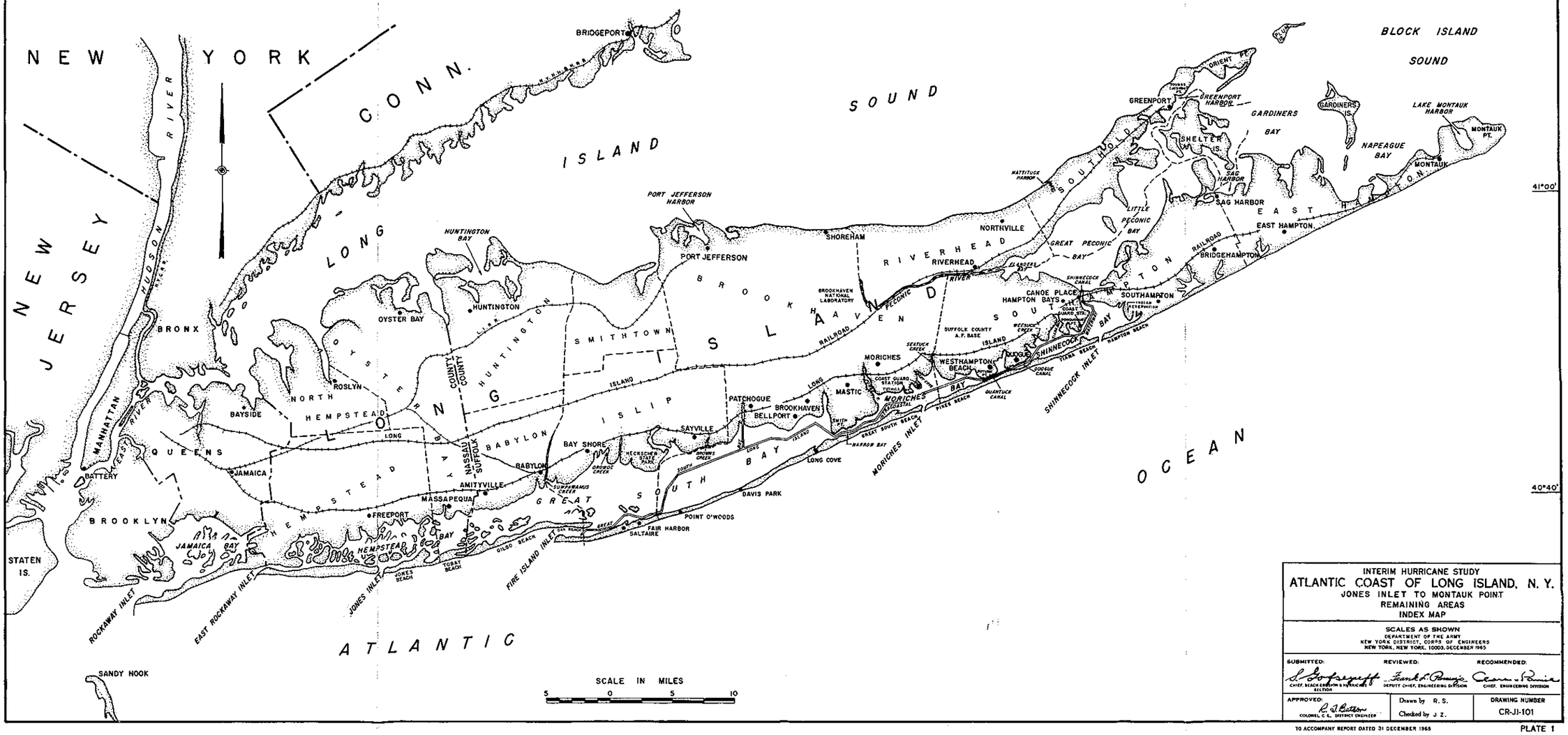


THE LENGTH OF BAR DENOTES THE PERCENT OF TIME THAT SWELLS OF EACH SIZE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION. THE FIGURE IN THE CENTER OF THE DIAGRAM INDICATES THE PERCENT OF CALMS. THE DIAGRAM APPLIES TO THAT AREA OF THE ATLANTIC OCEAN WEST OF LONGITUDE 70°W & NORTH OF LATITUDE 39°N, THE INTERSECTION OF WHICH IS ABOUT 190 MILES SOUTHEAST OF MORICHES INLET.
BASED ON OBSERVATIONS BY THE U.S. NAVY HYDROGRAPHIC OFFICE FOR 10 YEAR PERIOD, 1932–1942.



LOCATION MAP

SCALE IN MILES
25 0 50 100



INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, N. Y.
JONES INLET TO MONTAUK POINT
REMAINING AREAS
INDEX MAP

SCALES AS SHOWN
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK, 10003, DECEMBER 1965

SUBMITTED:	REVIEWED:	RECOMMENDED:
CHIEF, BEACH EROSION & HURRICANE SECTION	DEPUTY CHIEF, ENGINEERING DIVISION	CHIEF, ENGINEERING DIVISION

APPROVED:		
COLONEL, C.E., DISTRICT ENGINEER	Drawn by R. S. Checked by J. Z.	DRAWING NUMBER CR-JI-101

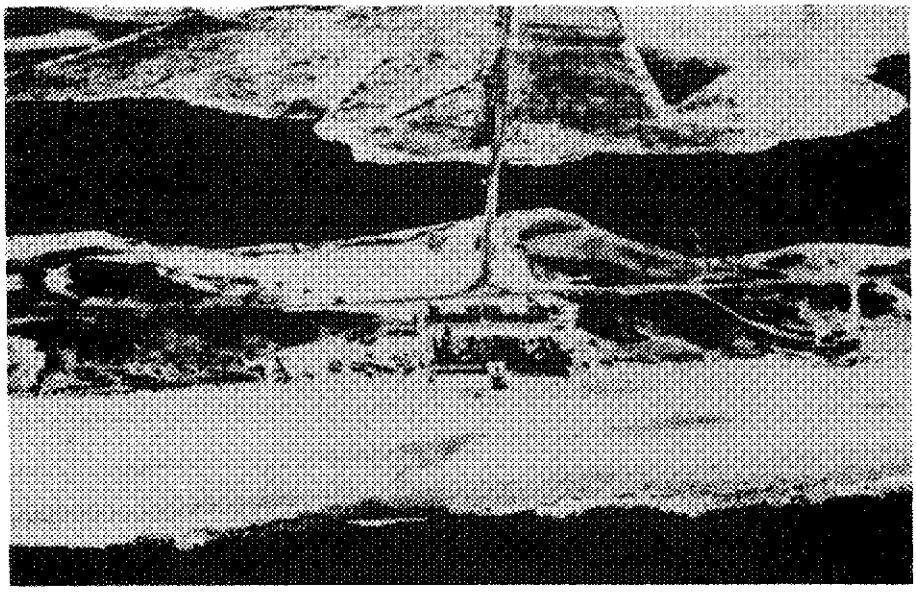
TO ACCOMPANY REPORT DATED 31 DECEMBER 1965

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

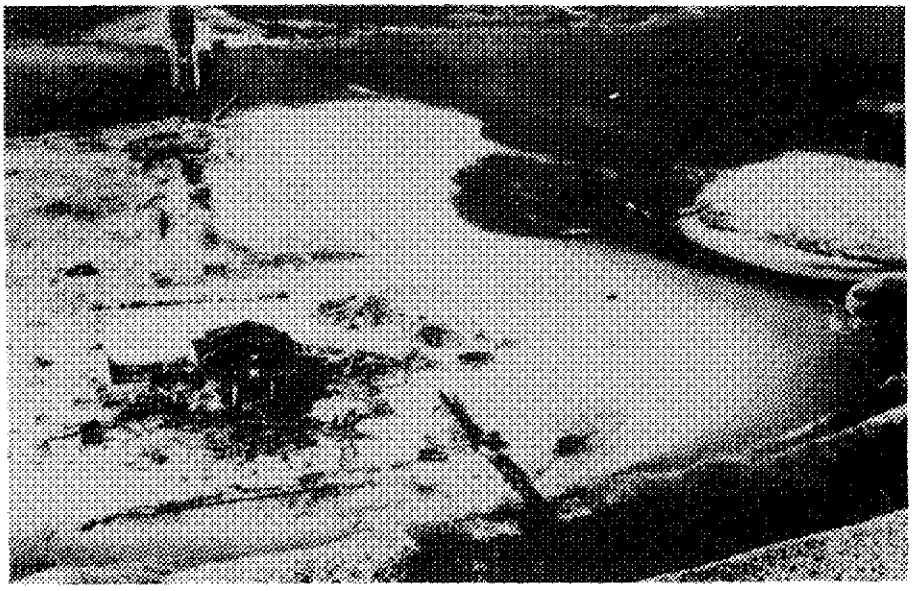
PHOTOGRAPHS

Wreckage of the community of Saltaire from hurricane of 21 September 1938 deposited in Great South Bay.

PHOTO 1



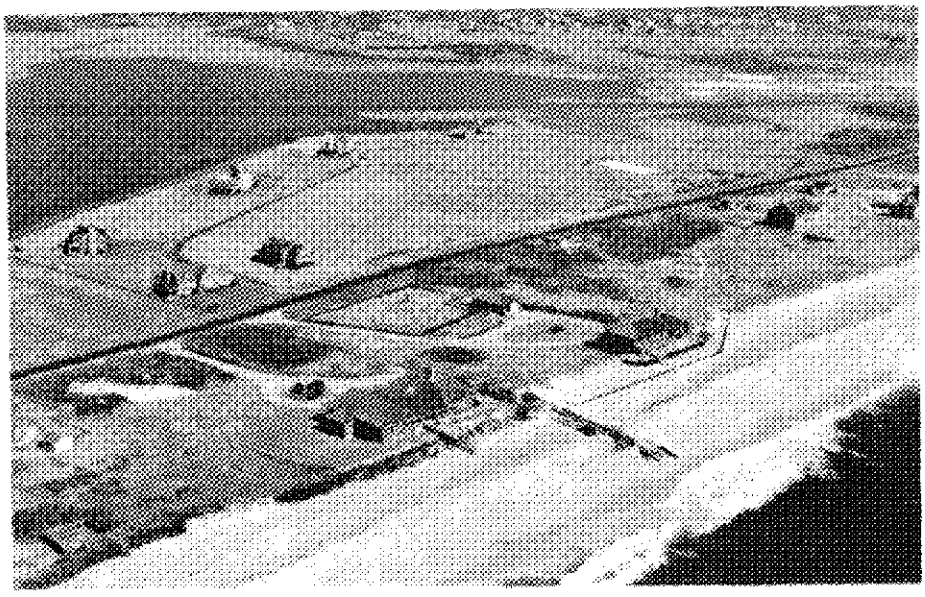
Before storm, in 1936.



After storm, in 1938.

Westhampton Beach on south shore of Long Island depicting condition of shore front before and after the hurricane of 21 September 1938. Damage included partial destruction of West Bay Bridge and complete loss of nearby property.

PHOTO 2



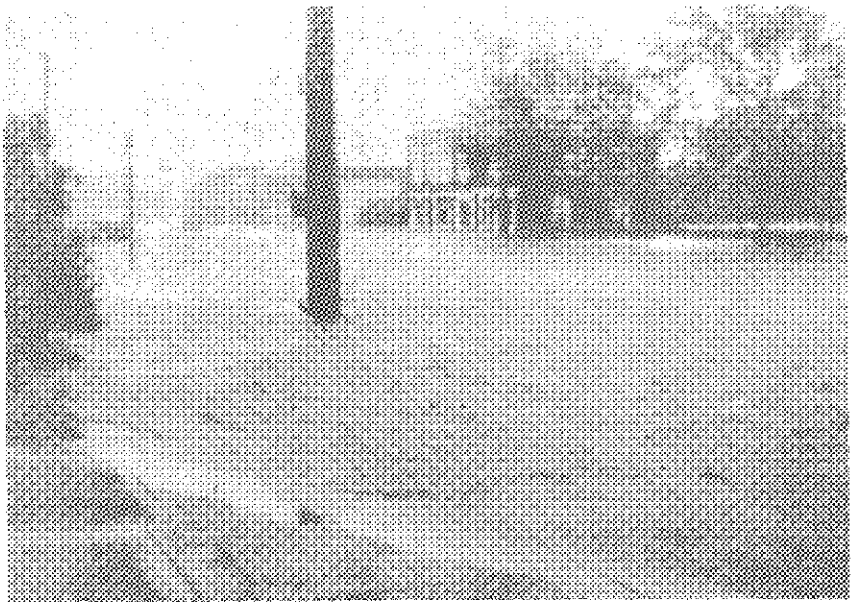
Before hurricane, in 1931.

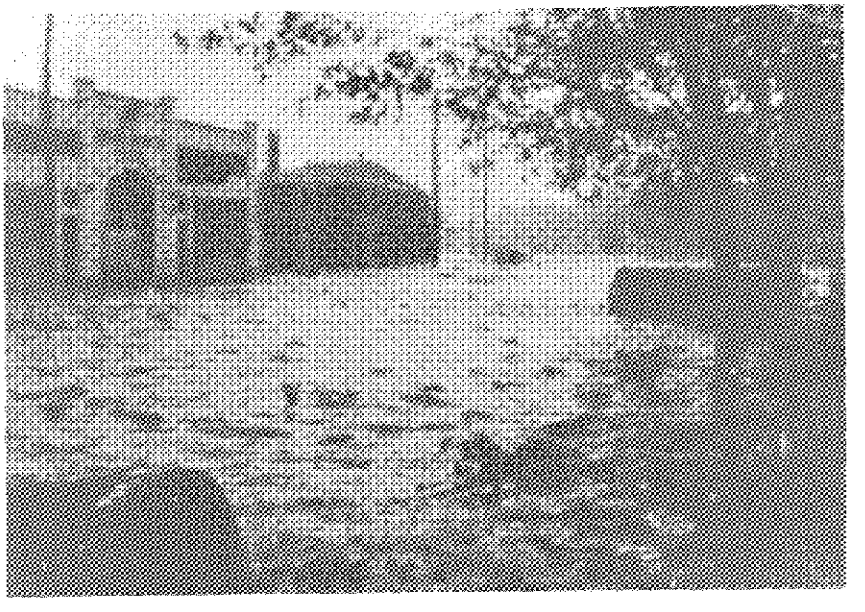
After hurricane, in 1938.

Before and after the hurricane 21 September 1938 at Quogue, N. Y. Development too close to the ocean reduced the effectiveness of the dunes to resist storm waves, leaving the two houses in the center foreground of the upper photo easy prey to complete destruction.

Extensive destruction of dunes and breaks through the barrier beach east of Ponquogue Bridge due to the hurricane of 21 September 1938. The storm resulted in the opening of Shinnecock Inlet shown in the photo.

PHOTO 4





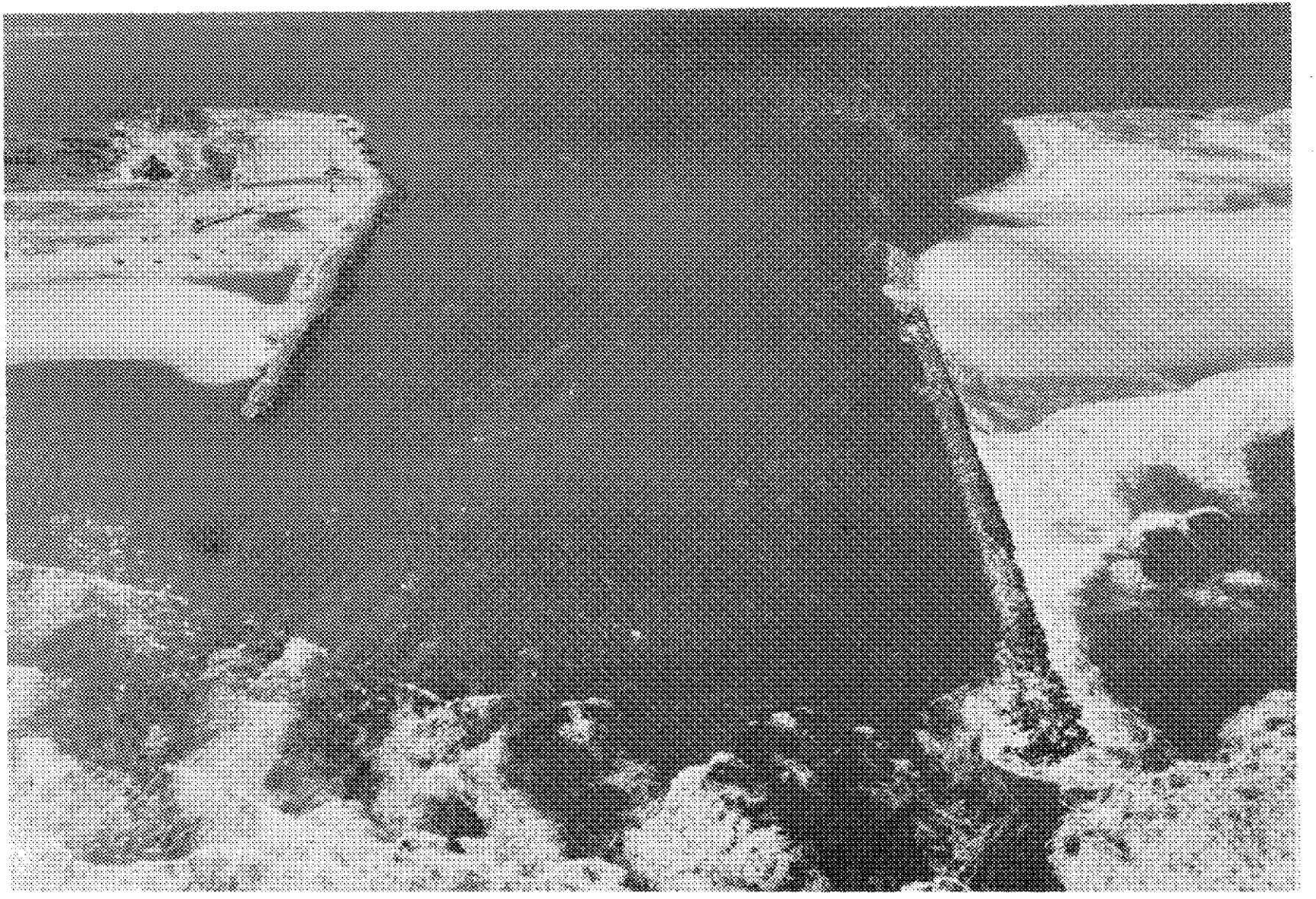
Flooding of Main Street in Westhampton Beach during hurricane of 21 September 1938.

PHOTO 5

Damage to causeway of Ponquogue Bridge caused by hurricane of 21 September 1938.

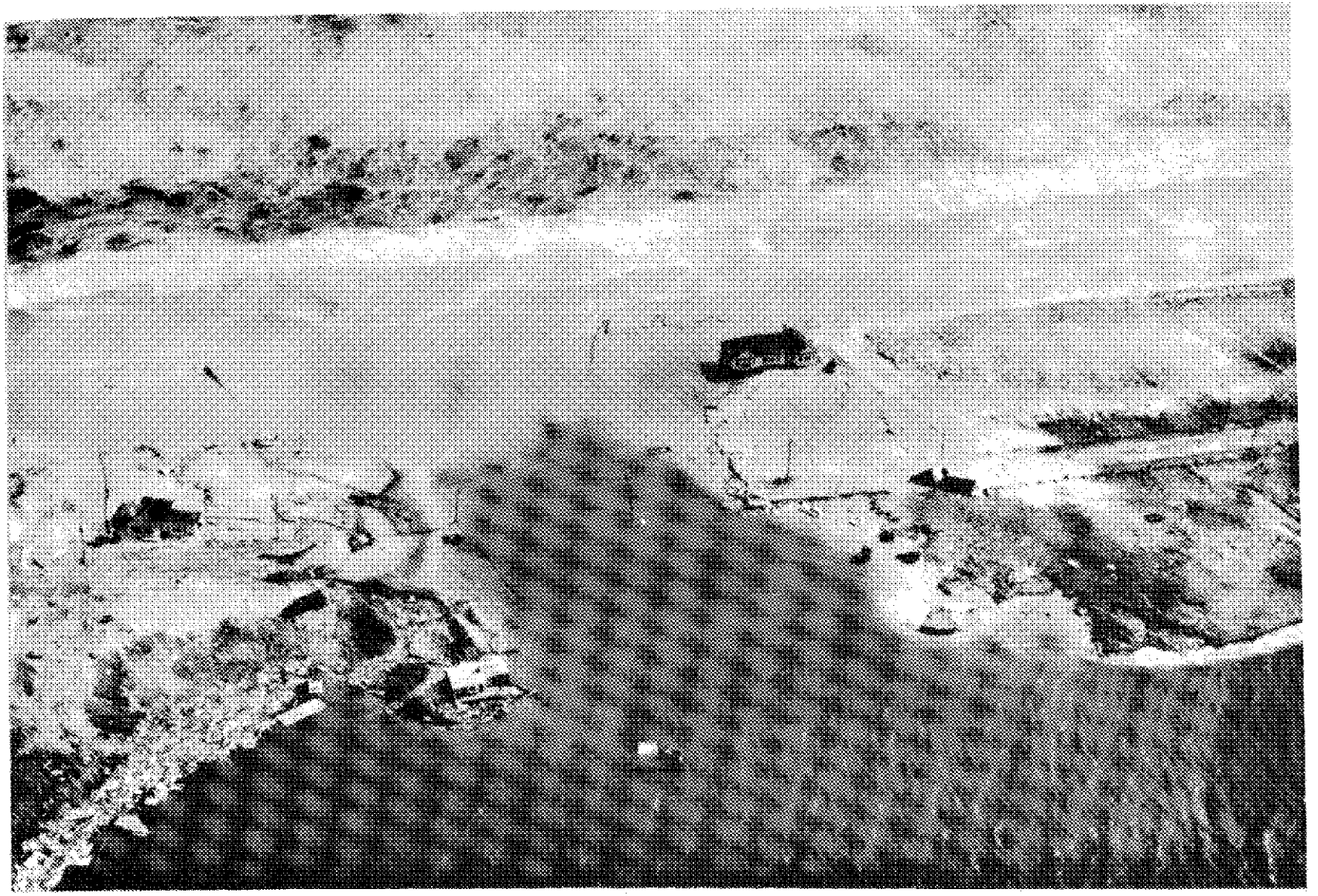
PHOTO 6

Jetties at Moriches Inlet, N. Y., immediately after hurricane of 31 August 1954.



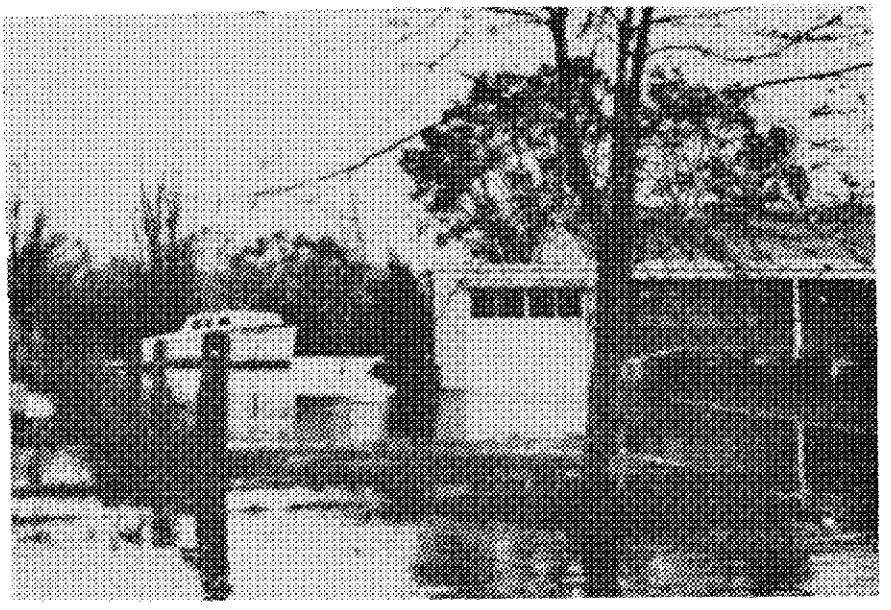
Jetties at Shinnecock Inlet, N. Y., immediately after hurricane of 31 August 1954. Note damage to east (right) jetty at seaward end and at the inshore end where the structure is being flanked.

PHOTO 8



Break through the barrier beach located 2,000 feet west of the west bridge at Westhampton Beach resulting from hurricane of 31 August 1954.

PHOTO 9



Flooded areas in Massapequa during the hurricane of 31 August 1954.

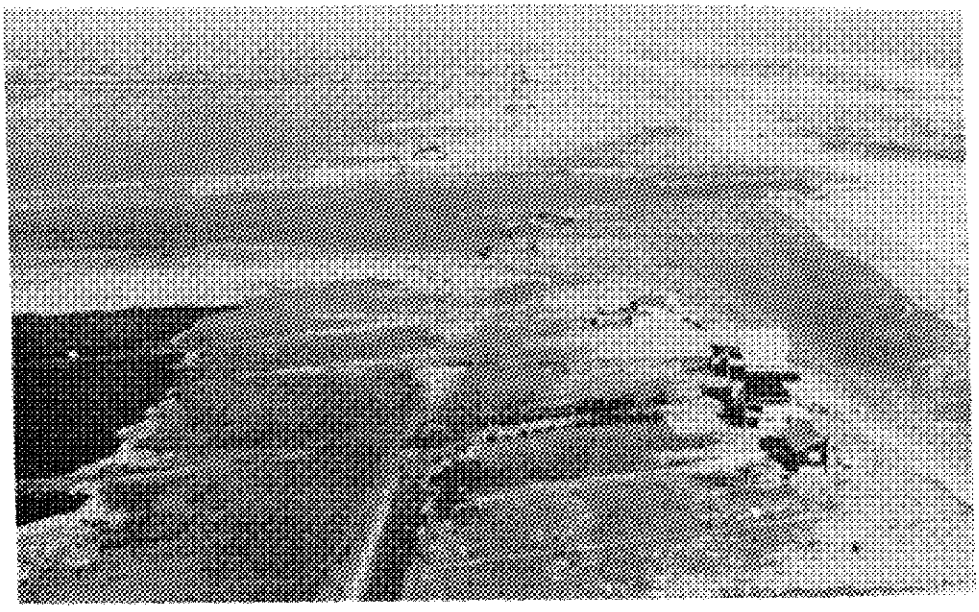
PHOTO 10

View from center mall along debris-laden boardwalk

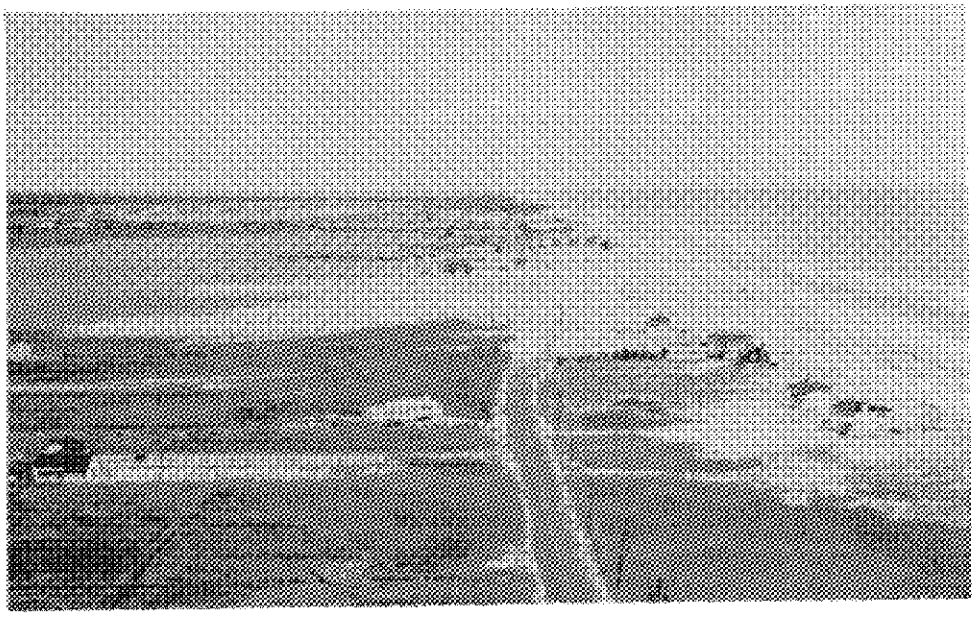
Gully in beach caused by storm

DAMAGE AT JONES BEACH STATE PARK DURING HURRICANE DONNA, 12 SEPTEMBER 1960

PHOTO 11



Before closure



After closure

Site of inlet breakthrough at Westhampton Beach during storm of 6-8 March 1962 which was subsequently closed.

PHOTO 12

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDICES

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

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B	Estimates of Flood Damage
C	Design Criteria and Improvements Considered
D	Digest of Public Hearings, and Statements from Other Agencies
E	Pollution and Fish and Wildlife
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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX A

HISTORY OF STORMS

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX A - HISTORY OF STORMS

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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX A - HISTORY OF STORMS

A1. GENERAL. A review has been made of historical data, including that contained in Technical Paper No. 36 of the U. S. Weather Bureau, entitled "North Atlantic Tropical Cyclones, Tracks and Frequencies of Hurricanes and Tropical Storms, 1886-1958", a book by David M. Ludlum, entitled "Early American Hurricanes, 1492-1870", old newspapers, and other sources on past storms which have struck or threatened the study area, in order to determine the possible frequency and severity of future storm occurrences.

A2. SUMMARY OF STORMS. Table A6 at the end of this appendix is a listing of all storms known to have struck or threatened the study area since 1635. It covers all hurricanes and other tropical storms, including those of less than hurricane intensity which passed through Atlantic Coastal Zone 4 shown in figure A3. A hurricane as defined here is a tropical storm known to have reached hurricane intensity (74 miles per hour) somewhere along its path and having a central barometric pressure of 29.0 inches or less, but not necessarily retaining these characteristics at the time of crossing the study area. Frequency of occurrence of hurricane central pressure for the period 1900 to 1956 for the aforementioned Zone 4 as developed by the U. S. Weather Bureau, is shown in figure A4. Extratropical storms which are known to have affected the study area are also included. The designation extratropical refers to storms which are also known as northeasters. They differ from hurricanes in that wind velocities are not as great and the central pressure is not as low as they are in a hurricane. Most extratropical storm data were found in newspapers after determination of dates of extreme high tides since 1886 at the Battery, New York City. The following assigned categories pertain to the effect of storms on the study area.

Category A. Unusually severe

Category B. Severe

Category C. Moderate

Category D. Threatened the area. Available data indicate that the storm did not cause damage to the study area.

A3. TRACKS OF MAJOR HURRICANES AND WIND, WAVE, AND TIDE DATA. Figure A1 shows the complete tracks of recent category A and B hurricanes, based on the data developed by the U. S. Weather Bureau. Data on winds for the south shore of Long Island and on winds and waves at sea are shown on plate 1 of the main report. Monthly wind data for the south shore of Long Island are shown on figure A2. Summaries of maximum winds and tides during recent category A and B storms since 1938 are given in tables A1 and A2 respectively.

Storm of Record (see C-1)

TABLE A1 - WIND DATA DURING RECENT STORMS

Date of storm	Maximum wind velocity: Miles per hour	Type of record	Location
21 September 1938	82	5-minute average	Block Island
	96	U.S. Weather Bureau wind pattern (a)	East end of Long Island
14 September 1944	88	Fastest mile (b)	Block Island
	82	5-minute average	Block Island
	55	5-minute average	Fire Island
25 November 1950	68	Average hourly	Westhampton Beach
	70+	U.S. Weather Bureau wind pattern (c)	West end of Long Island
6-7 November 1953	98	Gust	Block Island
	95	Fastest mile (b)	Block Island
	75	5-minute average	Block Island
	60+	U.S. Weather Bureau wind pattern (d)	East end of Long Island
	63	Gust	Suffolk County Air Force Base
	78	Gust	Brookhaven
31 August 1954	135	Gust	Block Island
	100	Fastest mile (b)	Block Island
	90	Average hourly	Block Island
	96	Gust	Westhampton Beach
	56	Average hourly	Westhampton Beach
12 September 1960	120	Gust	Montauk Point
	105	5-minute average	Montauk Point
	97	Gust	LaGuardia Airport, New York City
	70	Fastest mile (b)	LaGuardia Airport, New York City
6-8 March 1962	58	Gust	Westhampton Beach
	50	Average hourly	Westhampton Beach
	68	Gust	Montauk Point
	43	Fastest mile (b)	LaGuardia Airport, New York City
	54	Gust	LaGuardia Airport, New York City
	51	Fastest mile (b)	Central Park, New York City

(a) From U.S. Weather Bureau Memorandum HUR 7-8 dated 1 June 1956.
(b) Duration in minutes equals 60 divided by the velocity shown.
(c) From U.S. Weather Bureau Memorandum HUR 7-27 dated 16 April 1957.
(d) From U.S. Weather Bureau Memorandum HUR 7-29 dated 24 April 1957.

TABLE A2 - HEIGHT OF STORM TIDES

Location	Feet above mean sea level						
	21 Sept. 1938(a)	14 Sept. 1944	25 Nov. 1950	6-7 Nov. 1953	31 Aug. 1954	12 Sept. 1960	6-8 Mar. 1962
Atlantic Ocean							
Jones Inlet		8.4	9.4		6.9		6.1
Oak Beach, Fire Island Inlet			9.1		6.6	7.1	4.6*
Shinnecock Inlet			5.1		10.4(c)		4.6*
Montauk Point	15.7(b)						
Great South Bay							
Amityville	4.7					4.3	4.4*
Heckscher State Park, Nicoll Point	3.6	5.0	4.6			2.7*	3.6*
Patchogue, north end of breakwater	4.8		3.8				
Smith Point	7.2						
Moriches Bay							
Mastic Beach at Forge Point	9.7						
East Moriches Coast Guard Station		4.7	3.2	2.9*	2.4*	3.3*	4.7*
East Moriches, head of Hart Cove	15.7					4.6	
East Moriches, outer end of Hart Cove	13.5						
Westhampton Beach	15.3	5.8	3.8				
Quogue Canal, westerly end	5.3						
Shinnecock Bay							
Ponquogue Bridge	4.2						
Just west of Shinnecock Inlet				3.3*	5.5*	5.1*	4.6*
Shinnecock Indian Reservation near Southampton	6.5						
Southampton, head of Heady Creek	5.8						
Shinnecock Canal, south end	7.2		4.7				
Shinnecock Canal, north end				7.0		6.2*	

(a) Numerous breaks through the barrier beach connecting the ocean with the inner bays contributed to the extreme tidal heights in the bays, especially at Westhampton Beach. Computations indicate that the still water elevation in the ocean was about 10 feet above mean sea level. The high elevations in Moriches Bay may also include wave run-up.

(b) Drift line.

(c) Estimated by Suffolk County Department of Highways.

(*) Data obtained from available tide gage records. Other data are based on high water mark measurements which may include wave uprush.

A4. DESCRIPTION OF STORMS. During the period 1635 to 1962 the following number of storms have been recorded: category A, 10 storms; category B, 20 storms; category C, 77 storms; and category D, 124 storms. Detailed effects of some of these storms, especially the earlier ones, are not known. However, considering their effect on nearby areas, it is assumed that they also affected the study area. A description of the unusually severe and severe storms, categories A and B, experienced in the study area since 1938, is given in the following paragraphs. This information was collected from newspaper accounts, other public agencies, and previous Corps of Engineers' reports.

A5. Hurricane of 21 September 1938 (category A). This destructive hurricane was detected about 300 miles northeast of Puerto Rico on 18 September 1938 and traveled west to within about 200 miles of the Florida Coast, at which point its path was deflected to the north. On the morning of 21 September the storm was reported off Cape Hatteras proceeding northward at a velocity of about 40 miles per hour. The center of the storm skirted the east coast of New Jersey and struck the south shore of Long Island near Moriches Inlet, less than 10 miles west of Westhampton Beach, on the afternoon of 21 September during a rising predicted tide. The predicted stage for that time was one foot above mean sea level near Moriches Inlet. At Bellport Coast Guard Station, about 15 miles west of Westhampton Beach, the lowest recorded barometric pressure was 27.94 inches. The central pressure of this hurricane at the time the center passed the south shore of Long Island was estimated by the Weather Bureau as 27.86 inches. A maximum wind speed of 96 miles per hour was reported near the east end of Long Island. A 5-minute average wind velocity of 82 miles per hour was observed at the Block Island Weather Bureau Station. It was estimated that waves reached a height of 10 to 12 feet along the south shore. Abnormally high tides accompanying the hurricane caused damages along the Long Island coastline. Computations indicate that the stillwater elevation in the ocean was about 10 feet above mean sea level. The maximum rainfall for this storm in the study area was recorded as 11.3 inches during the period 17 to 21 September, including 4.2 inches on the last day (see figure A5).

A6. In the Inner Bay areas the highest reported tides in Great South Bay were 4.7, 3.6, 4.8, and 7.2 feet above mean sea level at Amityville, Heckscher State Park, Patchogue, and at Smith Point respectively. In Moriches Bay the highest reported tides were 9.7 feet above mean sea level at the south shore of Mastic Beach, 13.5 and 15.7 feet at two widely separated locations at East Moriches, and 15.3 feet at Westhampton Beach. The extremely high tidal stages at Westhampton Beach are attributed to the numerous breaks which occurred through the barrier beach at this locality and wave run-up. At Shinnecock Bay, maximum tides of 4.2, 6.5, 5.8, and 7.2 feet above mean sea level were reported at Ponquogue Bridge, Shinnecock Indian Reservation, the north end of Heady Creek in Southampton, and the south end of Shinnecock Canal respectively.

A7. The barrier beach between Jones Inlet and Fire Island Inlet suffered considerable damage, especially at Oak Beach and Jones Beach State Park. However, the barrier beaches from Fire Island Inlet to Southampton bore the brunt of the storm with heavy loss of life and much property

damage; the mainland damage in the study area was generally less severe. The principal damage occurred east of Babylon. Immediately east of Brookhaven the peninsula which reaches out toward the barrier beach suffered severe inundation, causing considerable damage to the summer colony located at Mastic Beach. Westhampton and Quogue, some 10 miles to the east and situated on similar peninsulas, suffered the worst damage along the south shore of the mainland. High tides and waves washing over the barrier beach inundated these highly developed communities, which were separated from the beach by the narrow Quantuck and Quogue Canals. Seven new inlets were formed in the barrier beach and numerous smaller breakthroughs occurred. Shinnecock Inlet was one of those formed during the storm. With the exception of the latter inlet, all other inlets have subsequently been closed.

A8. The total physical damage along the south shore of Long Island from Jones Inlet to Montauk Point was estimated at over $6,000,000 (1938 prices). Further details of the effects of the 1938 hurricane on the barrier beach and mainland are contained in paragraphs B9 to B11 of appendix B.

A9. Hurricane of 14 September 1944 (category B). On 9 September 1944 the storm was located about 350 miles northeast of Puerto Rico moving in a northwesterly direction. When it was about 300 miles from the Florida Coast it changed direction to the north, reaching Cape Hatteras on the morning of 14 September where a central barometric pressure of 27.88 inches and a wind speed of about 108 miles per hour were reported by the U. S. Weather Bureau. Toward evening the storm center crossed the eastern portion of Long Island during a falling predicted tide. Average wind velocity was 80 miles per hour, with peak gusts of 95 miles per hour. Ocean tides, including possible wave up-rush were reported to be 8.4 feet above mean sea level at Jones Inlet while in Great South Bay, 5.0 feet above mean sea level was reported at Heckscher State Park. The highest reported tides in Moriches Bay were 4.7 and 5.8 feet above mean sea level at East Moriches and Westhampton Beach respectively. Rainfall of 4.8 inches was reported at Babylon.

A10. At Jones Beach State Park, a parking field (No. 9) and a refreshment stand were damaged. A refreshment stand was also damaged at Tobay Beach. At the old Coast Guard building at the western end of Gilgo State Park, a boat shed and bulkhead were damaged. Erosion was reported as being extensive at Cedar Island Beach where the foundation of a pavilion was uncovered to a depth of approximately six feet. In a report dated 26 September 1944 mention is made that Commander Gray, U.S. Coast Guard, stated that in the vicinity of Fire Island there was no property damage on the ocean side, but that on the bay side a number of buildings were demolished. He stated that water passed over the barrier in several places but that no breakthrough occurred. Complete estimates of the monetary loss are not available but damages of $100,000 were reported for Westhampton Beach and vicinity by local interests at the public hearing of 20 December 1956.

A11. Extratropical storm of 25 November 1950 (category B). This extratropical storm resulted from the clash of a humid air mass lying along the Atlantic Coast with an abnormally dry, cold front moving eastward over the continent. The storm center formed over eastern North Carolina and moved northward toward the study area.

A12. The Brookhaven National Laboratory Station at Upton, Long Island, reported winds having a maximum hourly velocity of 61 miles per hour and maximum velocity for 5 minutes of 73 miles per hour. At Westhampton Beach average hourly winds of 68 miles per hour were reported. The United States Coast Guard reported waves reaching an alevation of about 20 feet in the vicinity of Jones Inlet. The peak tide on the ocean side of the inlet was 9.4 feet above mean sea level, or about one foot higher than the 1944 hurricane tidal height. The highest reported tides in Great South Bay were 4.6 and 3.8 feet above mean sea level at Heckscher State Park and Patchogue respectively; 3.2 and 3.8 feet at East Moriches and Westhampton Beach respectively in Moriches Bay; and 4.7 feet at the south end of Shinnecock Canal in Shinnecock Bay.

A13. On the barrier beach between Jones Inlet and Fire Island Inlet there was reported considerable erosion of the beach. Damages estimated at $30,000 were sustained by bathhouses, buildings, and the boardwalk at Jones Beach State Park. At Gilgo and Cedar Island Beaches, small breaks occurred in undeveloped areas resulting in minor changes. At Oak Beach, a major break through the dunes resulted in flooding of the area behind the beach, causing damage to buildings estimated at $100,000 based on 1950 price levels. For the entire frontage between Jones Inlet and Fire Island Inlet, the estimated damages were $941,000 based on 1950 price levels. In other parts of the study area a major break through the barrier beach occurred at Westhampton Beach when an inlet formed, estimated at 100 feet wide with a depth of 10 feet. The Department of Public Works, State of New York, completed artificial closure of the inlet on 27 November 1950. Complete estimates of the monetary loss are not available but damages of $131,000 were reported for the village of Westhampton Beach at the public hearing held at Westhampton Beach on 20 December 1955.

A14. Extratropical storm of 6-7 November 1953 (category B). The storm of 1953 originated in the Gulf coastal region and traveled easterly to a position offshore of the Georgia Coast where it was deflected to a more northerly course. A high pressure area, centered over the Upper Great Lakes region, brought cold air into the southeastern portion of the country and tended to intensify the storm. The storm center, moving in a northerly direction, moved inland in the vicinity of New York City.

A15. At Block Island a 5-minute wind velocity of 75 miles per hour with a fastest mile measured at 95 miles were recorded. Gusts of 98, 78, and 63 miles per hour were recorded at Block Island, Brookhaven, and Suffolk County Air Force Base respectively. An exceptionally strong natural tide was predicted for the morning of November 7. With this exceptionally high tide and extra strong winds, large sea swells were created. Estimated wave heights were around 20 feet along the south shore of Long

Island. No data on tidal heights in the study area is available except at Shinnecock Inlet and at the north end of Shinnecock Canal where highest tides were 3.3 and 7.0 feet above mean sea level respectively. The near coincidence of the storm passage with predicted high tide resulted in extremely high levels in the general area.

A16. On the barrier beach between Jones Inlet and Fire Island Inlet, damage was reported at Jones Beach State Park, where a parking field (No. 9) adjacent to the ocean was severely damaged by undermining. Almost the entire length of the barrier beach in this part of the study area was severely eroded. Erosion of sand on the south side of Gilgo Pavilion exposed the entire building foundation and caused the garage floor to collapse. The total estimated damage on the barrier beach between Jones Inlet and Fire Island Inlet was $600,000, including $430,000 for beach restoration.

A17. Residential damage in the Fire Island area was especially high as numerous homes were inundated, undermined, and damaged. From Fire Island Inlet to about 2½ miles east, the ocean broke through the barrier beach into Great South Bay at five locations. There were at least two major breaks in the barrier beach in the vicinity of Smith Point which contributed to the inundation of Mastic Beach for a distance of about ¼ mile and resulted in heavy residential damage. East of Moriches Inlet the ocean broke through the barrier beach at about eight places, resulting in the inundation of the mainland to a depth of about 2 feet for a distance of about ½ mile inland. Available estimates of the damage in the Inner Bay areas including damage at the barrier islands east of Fire Island Inlet reached a total of $1,100,000.

A18. Hurricane of 31 August 1954 (Carol) (category B). Hurricane Carol was detected northeast of Cuba on 25 August 1954. It moved generally northward to a position about 250 miles east of the Florida Coast at latitude 30 degrees where it came to a near standstill. Still moving sluggishly, Carol changed direction to the northwest and by 30 August its path was deflected to the northeast, reaching a point a few miles east of Cape Hatteras on the evening of the 30th. Thence its forward speed accelerated to 40 miles per hour and the storm center crossed the south shore of Long Island approximately 25 miles east of Westhampton Beach on the morning of 31 August near the time of predicted high tide.

A19. At Block Island a barometric pressure of 28.50 inches, an average hourly wind velocity of 90 miles per hour with a fastest mile measured at 100 miles and a gust of 135 miles per hour were recorded. At Westhampton Beach an average hourly wind velocity of 56 miles per hour with a gust of 96 miles per hour was recorded. The maximum height of ocean tide was 6.9 and 6.6 feet above mean sea level at Jones Inlet and Oak Beach respectively. The Suffolk County Department of Highways estimated the ocean tide at Shinnecock Inlet at 10.4 feet above mean sea level. In Shinnecock Bay just west of Shinnecock Inlet the tide was 5.5 feet above mean sea level. Wave observations are not available, however, because of the greater severity of the storm along eastern Long Island,

the waves in that area were higher than along western Long Island. The total rainfall during the period of the storm was about 3 inches in the study area.

A20. Upon request of the Governor of New York for Federal aid in connection with the damage resulting from Hurricane Carol, the President of the United States designated Suffolk County as a major disaster area under authority of Public Law 875, 81st Congress, as amended by Public Law 107, 82nd Congress. The Corps of Engineers at the request of the Federal Civil Defense Administration made an engineering analysis of the claims of local interests.

A21. Damage along the eastern portion of Long Island was considerably greater than along the western portion. Estimates of physical camages are incomplete, but it is believed to have exceeded $1,500,000. For details of the effects of Hurricane Carol on the south shore of Long Island from Fire Island Inlet to Montauk Point, see paragraph B12 of appendix B.

A22. Hurricane of 12 September 1960 (category A). On 9 September 1960 the storm, known as Hurricane Donna, was located about 100 miles east of the central part of Cuba moving in a northwesterly direction. The storm recurved crossing Florida in a northeasterly direction. This hurricane skirted the North Carolina Coast and was reported about 100 miles east of Atlantic City at 11 A.M., E.S.T. on 12 September. The "eye" of the storm, which passed over the study area while moving northerly at the time of predicted high tide, became elongated and extended from New York City to Montauk Point. U. S. Air Force Radar Operators at Montauk Point indicated that Hurricane Donna had separated into three "eyes" upon reaching this area. At Montauk Point gusts of 120 miles per hour were reported with a 5-minute average of 105 miles per hour. The fastest mile recorded at LaGuardia Airport, New York, was 70 miles per hour from the northeast, with a peak gust of 97 miles per hour. The highest reported tides were 7.1 feet and 6.8 feet above mean sea level at Oak Beach and near Jones Inlet in Hempstead Bay respectively; 4.3 and 2.7 feet above mean sea level at Amityville and West Sayville respectively in Great South Bay; 3.3 and 4.6 feet above mean sea level at East Moriches Coast Guard Station and East Moriches (head of Hart Cove) respectively in Moriches Bay; and 5.1 and 6.2 feet above mean sea level just west of Shinnecock Inlet and at the north end of Shinnecock Canal respectively. Rainfall of 6.0 inches on 12 September was reported at the New York State Research Farm north of Riverhead.

A23. Damages in the study area were estimated over one million dollars for the barrier beach between Jones Inlet and Fire Island Inlet and $850,000 to the Inner Bay areas. Further details of the effects of Hurricane Donna are contained in paragraph B13 and B14 of appendix B.

A24. Storm of 6-8 March 1962 (category A). Because the storm of 6-8 March 1962 was of such magnitude and covered a large area and because of the scarcity of observations over the ocean it was difficult to plot

a well defined path or show the location of the storm at any particular time. The following description of the storm was taken mainly from a preliminary report of the storm by the U.S. Weather Bureau, Washington, D.C.

A25. This unusual storm, which was complex in structure and erratic in behavior, began on 4 March 1962 as a weak circulation along a cold front in the Atlantic Ocean east of Florida. Concurrently with this a widespread but rather weak storm area was moving slowly eastward through the Mississippi Valley. By the afternoon of Monday, 5 March, the circulation off Florida had strengthened and had moved northward to a position off the Carolinas and had partially merged with the midwestern center, which by this time had moved to the upper Ohio Valley. The offshore storm center continued to intensify and move slowly northward during the night of 5 March and the morning of 6 March and absorbed the weakening center in the upper Ohio Valley. By Tuesday, 6 March, the storm area had grown to encompass the eastern third of the United States and a large part of the western North Atlantic.

A26. During Tuesday, 6 March, the main center of the large storm stopped its northward movement and became nearly stationary off Delaware, Maryland, and Virginia Capes. During this period the storm seemed to develop at least two centers. The western center apparently described a small westward loop over Chesapeake Bay and the eastern center developed a loop southeastward into the Atlantic off the outer banks of North Carolina. This complex pattern of multiple centers persisted as the storm moved eastward out into the Atlantic on 7-9 March. Winds of gale force from the northeast with velocities of 35 to 45 miles per hour and gusts possibly reaching 70 miles per hour generated waves of increasing height which broke on the beaches with destructive force.

A27. A continuous storm surge of 3 to 5 feet coupled with spring tide conditions resulted in high tides reaching stages close to the second highest of record. Tides at Jones Inlet and Captree were 6.1 feet and 4.6 feet above mean sea level respectively. The highest reported tides at Amityville and West Sayville were 4.4 and 3.6 feet above mean sea level respectively in Great South Bay; 4.7 feet above mean sea level at East Moriches Coast Guard Station in Moriches Bay; and 4.6 feet above mean sea level just west of Shinnecock Inlet in Shinnecock Bay.

A28. On 16 March President Kennedy declared the coastal sections of New York City and Long Island a disaster area. Total damage in New York City and the south shore of Long Island was estimated at about $40,000,000. Damaging high waters occurred on five successive high tides over a period of 48 hours. The momentum of these high tides aided by the force of high waves carried the water inland to reach buildings which would ordinarily be beyond the reach of these tides. The long duration of the storm caused unprecedented destruction.

A29. Along the barrier beach between Fire Island Inlet and Southampton about 50 shallow breakthroughs or sluices occurred. At Westhampton Beach a new 1200-foot wide inlet was formed which was subsequently closed

by the Corps of Engineers as emergency work under authority of Public Law 875, 81st Congress, as amended, and through the auspices of the Office of Emergency Planning (see photo 12). The total emergency work along the south shore of Long Island after this storm involved the placement of 2,520,000 cubic yards of sand fill along 15 miles of beach front at a cost of $2,170,000. About three-quarters of the work was along the shore between Fire Island Inlet and Southampton. Nearly every community and locality in this reach was affected by the storm. About 100 dwellings and other structures were destroyed. Another 130 houses were damaged and 60 houses had pilings exposed and damaged. The total damage from this storm along the ocean front between Jones Inlet to Montauk Point was estimated at $16,549,000, approximately $1,350,000 of which were incurred along the barrier beach between Jones Inlet and Fire Island Inlet where the greatest damage consisted of beach and dune erosion, and damage to bulkheads and buildings caused by both flooding and wave action. Jones Inlet jetty was badly raveled and broken down to about high water level at the end of the jetty for approximately 200 feet. The west parking field at Jones Beach State Park was eroded and the parking field at East Overbrook was washed out and the pavement crumbled. Between Jones Beach and Gilgo Beach the sand beach was cut back from 50 to 100 feet creating an embankment 5 to 10 feet high. Gilgo Pavilion was flanked by storm waters, causing extensive damage to the foundation. Extensive damage was also experienced along the shores of the Inner Bays of the study area. Damage in Great South Bay was severe in Lindenhurst, Copiague, and Amityville where there was considerable residential damage. There was also residential and commercial damage in the remainder of the north shore of Great South Bay. There was also damage along the mainland shores of Moriches and Shinnecock Bays, but to a comparatively minor extent. Damage in the aforementioned Inner Bays was estimated at $827,000.

A30. STORM FREQUENCY. Research of the records indicates that 231 storms of all types passed through Atlantic Coastal Zone 4, shown on figure A3, between the years 1635 and 1962. Table A3 is a compilation of these storms arranged by types in several time intervals.

A31. A cursory review of table A3 reveals that storm data prior to 1800 is scanty and must therefore be considered incomplete. Limiting the analysis to the 204 storms of record between the years 1801 and 1962, leads to the general conclusion that, on the average, the study area is either threatened by or experiences at least one storm every year. It might be expected that a moderate storm will occur once in two years, a severe storm once in ten years, and an unusually severe storm once in thirty years. Combining the severe and unusually severe storm indicates that damage due to storms could be inflicted about once every seven years.

TABLE A3 - FREQUENCY OF STORMS IN THE STUDY AREA

Category	Type of Storm[a]	Time Interval 1635 to 1700	1701 to 1800	1801 to 1900	1901 to 1962	1635 to 1962
A (Unusually severe)	Hurricane	2	1	3	2	8
	Tropical	-	-	-	-	-
	Extratropical	-	-	-	1	1
	Unknown	-	1	-	-	1
	Total	2	2	3	3	10
B (Severe)	Hurricane	-	1	4	5	10
	Tropical	-	-	-	-	-
	Extratropical	-	-	2	4	6
	Unknown	1	1	2	-	4
	Total	1	2	8	9	20
C (Moderate)	Hurricane	-	7	20	10	37
	Tropical	-	-	1	1	2
	Extratropical	-	-	5	27(b)	32(b)
	Unknown	2	1	3	-	6
	Total	2	8	29	38(b)	77(b)
D (Threatened the area)	Hurricane	1	4	16	28	49
	Tropical	-	2	7	16	25
	Extratropical	-	-	7(b)	34	41(b)
	Unknown	-	3	6	-	9
	Total	1	9	36(b)	78	124(b)
TOTAL	Hurricane	3	13	43	45	104
	Tropical	-	2	8	17	27
	Extratropical	-	-	14(b)	66(b)	80
	Unknown	3	6	11	-	20
	Total	6	21	76(b)	128(b)	231

(a) Storms listed as Tropical are those which never reached hurricane intensity. Extratropical storm dates found by use of extreme high tide data since 1886 at The Battery, New York City.

(b) Includes one extratropical and hurricane combined.

A32. Table A4 shows the frequency of storm occurrence between 1801 and 1962 tabulated by months. Two storms of category D are excluded, since the month in which they occurred could not be determined. Of the 204 storms under consideration, over 50 percent occurred during the months of August, September, and October. For the damaging storms, categories A and B, 65 percent occurred during the months of September, October, and November.

TABLE 4 - OCCURRENCE OF STORMS BY MONTHS - 1801 TO 1962

Month	Category of Storms				Monthly total
	A Unusually severe	B Severe	C Moderate	D Threatened the area	
Jan.	0	0	5	8	13
Feb.	0	1	7	5	13
Mar.	1	2	2	6	11
Apr.	0	0	4	4	8
May	0	0	0	5	5
June	0	0	1	6	7
July	0	0	1	4	5
Aug.	0	3	5	19	27
Sept.	5	4	10	24	43
Oct.	0	2	20	19	41
Nov.	0	4	7	7	18
Dec.	0	1	5	7	13
	6	17	67	114	204

A33. RAINFALL ASSOCIATED WITH STORMS. Table A5 summarizes the precipitation at New York City associated with storms experienced at this location. The study area is reasonably close to make these data generally applicable to it. Where available the maximum rainfall during a storm and the place of its occurrence is given. In general, rainfall during hurricanes is heavier than that associated with extratropical storms. It is of interest to note that the greatest amount of observed precipitation, during the storm of September 1940, occurred at Ewan, N. J. while the hurricane was located some distance off the Virginia Coast.

TABLE A5 - RAINFALL ASSOCIATED WITH STORMS

Date storm passed study area	Category	Type[a]	Approximate period of rainfall in study area	Total rainfall (inches) for period of storm: Location New York City	Maximum rainfall center: Location	Maximum rainfall center: Amount
1901, Nov. 24	C	E	Nov. 23-26	1.0		
1903, Sept. 16-17	B	H	Sept. 16-18	2.0	No. Atlantic Region	3.0
1903, Oct. 8-11	C	H & E	Oct. 5-12	10.4	Paterson, N.J.	15.5
1904, Sept. 14-15	B	H	Sept. 13-15	2.9	Friesburg, N.J.	10.0
1904, Nov. 5-6	D	T	Nov. 5-6	0.1		
1904, Nov. 13-14	C	T	Nov. 13-14	1.5		
1909, Mar. 4	D	E	Mar. 2-4	0.7		
1913, Dec. 26	D	E	Dec. 21-26	2.0		
1914, Mar. 1	D	E	Mar. 1-3	3.1		
1914, Dec. 7	C	E	Dec. 5-9	1.7		
1915, Apr. 4	D	T	Apr. 3-4	1.2		
1915, Aug. 4-5	D	T	Aug. 1-9	3.9		
1917, Oct. 24	D	E	Oct. 24	2.1		
1918, Jan. 15	C	E	Jan. 14-15	0.8		
1918, Apr. 11-12	C	E	Apr. 8-13	1.3		
1920, Feb. 5	C	E	Feb. 3-7	4.5		
1920, Sept. 30	C	H	Sept. 27-30	2.1	Mt. Pocono, Pa.	6.7
1922, Jan. 28-29	D	E	Jan. 28-29	1.0		
1923, Oct. 22-24	C	H	Oct. 23-24	3.3	Setauket, L.I., N.Y.	6.7
1924, Aug. 25-26	C	H	Aug. 25-26	3.7	Kingston, R.I.	6.9
1925, Dec. 3-4	D	H	Dec. 1-5	2.8		
1927, Feb. 20	C	E	Feb. 18-22	1.8		
1928, Aug. 12-13	C	H	Aug. 11	1.6	St. Cloud, Fla.	14.5
1928, Sept. 19	D	H	Sept. 18-20	1.5	Darlington, S.C.	12.5
1929, Apr. 16	C	E	Apr. 9-18	2.9		
1929, Oct. 2-3	D	H	Oct. 1-4	2.4		
1931, Mar. 3-5	B	E	Mar. 4-5	0.5		
1932, Nov. 9-10	C	E	Nov. 5-12	3.4		
1933, Jan. 27	C	E	Jan. 25-30	0.2		
1933, Aug. 23-24	D	H	Aug. 21-24	5.4	Peekamoose, N.Y.	16.0
1933, Sept. 17-18	C	H	Sept. 14-16	5.8	Provincetown, Mass.	12.3
1934, Sept. 8-9	B	H	Sept. 6-8	5.3	Waterbury, Conn.	5.6
1935, Nov. 17	B	E	Nov. 15-20	1.2		
1936, Oct. 1	D	T	Oct. 1	1.2		
1936, Oct. 17	D	E	Oct. 13-17	2.4		
1938, Sept. 21	A	H	Sept. 17-21	7.8	Buck, Conn.	17.1
1940, Sept. 1-2	D	H	Aug. 31-Sept. 2	2.5	Ewan, N.J.	24.0
1943, Oct. 26	D	E	Oct. 25-28	5.4		
1944, Jan. 4-5	D	E	Jan. 3-6	5.0		
1944, Sept. 14	B	H	Sept. 12-14	8.2	New Brunswick, N.J.	12.0
1944, Nov. 30	C	E	Nov. 27-30	3.1		
1945, Nov. 22-29	C	E	Nov. 22-30	3.0		
1945, Dec. 6	C	E	Dec. 5-7	0.6		
1947, Dec. 26	D	E	Dec. 23-28	3.0		
1948, Oct. 5-6	D	E	Oct. 5-8	1.2		
1950, Nov. 25	B	E	Nov. 25-29	2.6	Oak Ridge Reservoir, N.J.	5.9
1950, Dec. 8	C	E	Dec. 7-8	0.9		
1952, Feb. 4	D	T	Feb. 4-5	1.3		
1952, Nov. 20-22	D	E	Nov. 19-22	1.7		
1953, Oct. 23	C	E	Oct. 23-24	trace		
1953, Nov. 6-7	B	E	Nov. 6-7	1.5		
1954, May 3	D	E	May 2-4	0.8		
1954, Aug. 31 (Carol)	B	H	Aug. 30-31	1.9	Eagles Mere, Pa.	6.2
1954, Sept. 11 (Edna)	C	H	Sept. 8-11	5.2	Upton, L.I., N.Y.	9.3
1954, Oct. 15 (Hazel)	C	H	Oct. 15	0.2	Big Meadows, Va.	11.2
1955, Aug. 13 (Connie)	C	H	Aug. 11-14	9.6	Slide Mountain, N.Y.	15.2
1955, Aug. 18-19 (Diane)	D	H	Aug. 18-19	1.6	Westfield, Mass.	19.8
1955, Oct. 14-16	C	E	Oct. 14-17	3.8		
1956, Jan. 9-11	C	E	Jan. 8-15	1.3		
1956, Mar. 16	C	E	Mar. 16-20	1.8		
1958, Mar. 19-22	C	E	Mar. 19-22	1.9		
1960, Feb. 13-14	C	E	Feb. 14-15	0.4		
1960, Feb. 18-19	C	E	Feb. 18-19	1.6		
1960, Sept. 12 (Donna)	A	H	Sept. 9-13	5.6	Cold Brook, N.Y.	8.4
1961, Apr. 13	C	E	Apr. 12-13	0.5		
1961, Sept. 21 (Esther)	C	H	Sept. 20-21	1.3		
1961, Oct. 21-22	C	E	Oct 21-22	0.2		
1962, Mar. 6-8	A	E	Mar. 6-8	0.1		
1962, Aug. 28-29 (Alma)	D	H	Aug. 28-29	2.0		
1962, Sept. 27-28	C	E	Sept. 27-28	1.7		

(a) Type of storm:
E - Extratropical.
H - Attained hurricane intensity somewhere along its path.
T - A storm of tropical origin which did not attain hurricane intensity.

A34. The rainfall data shown in table A5 were reviewed for all the hurricanes since 1900 which caused moderate to unusually severe damage in the study area. Of 16 such hurricanes (categories A, B, and C) only two, the October 1923 and September 1954 hurricanes (both category C) had centers of maximum precipitation of about 7 and 9 inches respectively on Long Island. Other high todal hurricane rainfall on Long Island (ranging between 5 and 13 inches) occurred during the storms of 17-21 September 1938 (category A), 12-14 September 1944 (category B), and 11-15 August 1955 (category C).

A35. The 1938 and 1944 hurricanes subjected the study area to high tidal surges associated with record rainfall for a category A or B storm. The total hurricane rainfall for these storms ranged from a maximum of 10-11 inches in western Long Island to about 5 inches in eastern Long Island. Mass curves of rainfall for these storms are shown on figure A5. For the September 1938 and September 1944 hurricane, a total rainfall of 11.3 inches and 5.3 inches respectively were reported at Patchogue, while 9.6 inches and 8.0 inches were reported at Babylon.

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1635, Aug. 15	A		Hurricane	1
1638, Aug. 3	A		Hurricane	1
1656, Dec. 28	C		Unknown	1
1667, Aug. 29	B		Unknown	1
1690-91, Winter	C		Unknown	1
1693, Oct. 19	D		Hurricane	3
1706, Oct. 3-5	C		Hurricane	3
1720, May 22	B		Unknown	1
1723, July 29	A		Unknown	1
1723, Oct. 30	B		Hurricane	1
1739, Oct. 5	D		Unknown	1
1749, Oct. 7-8	C		Hurricane	3
1757, June 30	D		Hurricane	2
1761, Oct. 24	C		Hurricane	1
1768, Dec. 11	D		Unknown	1
1770, Oct. 19-20	C		Hurricane	1
1773, Aug.	D		Hurricane	2
1780, Jan. 12	D		Unknown	1
1781, Jan. 23	C		Unknown	1
1782, Sept. 16	C		Hurricane	1
1783, Oct. 7-9	C		Hurricane	3
1783, Oct. 18-19	D		Hurricane	3
1785, Sept. 23-24	C		Hurricane	3
1787, Sept. 19	D		Tropical	1,2
1788, July 23-24	D		Tropical	1,2
1788, Aug. 19	A		Hurricane	1
1795, Aug. 2-3	D		Hurricane	3
1802, Oct. 29	C		Unknown	1
1804, Sept. 8-9	C		Hurricane	1,4
1804, Oct. 9-10	C		Hurricane	1
1811, Dec. 23-24	B		Unknown	1
1815, Sept. 22-23	A		Hurricane	1,4
1821, Sept. 3	A		Hurricane	1,4
1825, June 3-4	C		Hurricane	3
1829, July 24	D		Hurricane	2
1830, Aug. 17-18	D		Hurricane	3
1841, Oct. 2-6	C		Hurricane	1,2
1846, Oct. 13	C		Hurricane	1,4
1846, Oct. 31	C		Unknown	1
1849, Oct. 6	C		Hurricane	3
1850, July 18-19	C		Hurricane	3
1850, Aug. 25	D		Hurricane	3
1850, Sept. 7-8	D		Hurricane	3

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA (Cont'd)

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1851, Aug. 26	D		Tropical	2
1854, Apr. 16-18	D		Unknown	1
1854, Sept. 6-14	D		Tropical	1,2
1856, Aug. 19-20	D		Hurricane	3
1858, Sept. 14-15	D		Hurricane	3
1860, June	D		Unknown	1
1861, Nov. 2-3	B		Hurricane	3
1866, Oct. 29-30	C		Hurricane	1
1867, Aug. 1-2	D		Hurricane	3
1868, Mar. 20	D		Unknown	1
1869, Sept. 8	A		Hurricane	1
1869, Oct. 4	D		Hurricane	1,3
1874, Sept. 25-30	D		Hurricane	2
1877, Sept. 21	D		Hurricane	1
1877, Oct. 4-5	C		Hurricane	1
1878, Sept. 11-13	D		Unknown	1
1878, Oct. 18	D		Unknown	1
1878, Oct. 23-25	C		Hurricane	1
1878, Dec. 9-11	C		Hurricane	1
1879, Aug. 18-19	B		Hurricane	1
1880, Feb. 3	B		Unknown	1
1885, Nov. 24	D	5.3	Unknown	1
1886, Jan. 8-9	C		Unknown	1
1887, Oct. 20-21	C		Hurricane	1,4
1887, Nov. 15	D	4.2	Extratropical	1,4
1888, Mar. 11-14	B		Extratropical	1,4
1888, Aug. 21-23	C		Hurricane	1,4
1888, Sept. 11-12	D		Hurricane	4
1888, Sept. 26	D		Tropical	1,4
1888, Oct. 12	C		Hurricane	1,4
1888, Nov. 25-27	C	4.4	Hurricane	1,4
1889, May 20-21	D		Tropical	4
1889, Aug. 27	D		Hurricane	1,4
1889, Sept. 10-12	C	5.2	Hurricane	1,4
1889, Sept. 25	D		Hurricane	1,4
1890, Oct. 25	D	5.0	Extratropical	1
1891, July 8-9	D		Hurricane	4
1891, Oct. 12-13	C		Hurricane	1,4
1891, Oct. 20	D	4.7	Extratropical and hurricane combined	1,4
1892, Mar. 1	D	4.5	Extratropical	1
1893, Apr. 21	C	5.6,4.5F	Extratropical	1

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA (Cont'd)

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1893, June 17-18	D	4.3F	Tropical	4
1893, Aug. 23-24	B	5.1F	Hurricane	1,4
1893, Aug. 29	C		Hurricane	1,4
1894, Sept. 30	C	4.7F	Hurricane	1,4
1894, Oct. 10	B	4.8F	Hurricane	1,4
1894, Dec. 27	D	5.3,5.1F	Extratropical	1
1895, Jan. 26	D	4.8,4.7F	Extratropical	1
1896, Feb. 6	C		Extratropical	1
1896, Sept. 10	D	5.5F	Hurricane	1,4
1896, Oct. 12	C	5.6,5.3F	Hurricane	1,4
1897, Sept. 24	D	3.9F	Tropical	4
1897, Oct. 24-25	B	5.5,5.3F	Extratropical	1
1898, Oct. 19	D	5.3,5.1F	Extratropical	1
1899, Feb. 8	C	5.6,5.2F	Extratropical	1
1899, Nov. 1	D	4.0F	Hurricane	1,4
1900, Sept. 11-12	C	4.0F	Extratropical	1
1900, Sept. 16-17	D		Tropical	4
1900, Oct. 14	C		Tropical	1,4
1900, Dec. 4	D	5.0,4.7F	Extratropical	1,4
1901, Nov. 24	C	5.9,6.0F	Extratropical	1,4
1902, June 16-17	D		Tropical	4
1902, June 29	D		Hurricane	4
1902, Oct. 12	D		Hurricane	1,4
1903, Sept. 16-17	B	4.7F	Hurricane	1,4
1903, Oct. 8-11	C	5.7	Extratropical and hurricane combined	1,4
1904, Sept. 14-15	B		Hurricane	1,4
1904, Nov. 5-6	D		Tropical	4
1904, Nov. 13-14	C		Tropical	1,4
1905, Jan. 25	D	4.8,5.1F	Extratropical	1
1909, Mar. 4	D	4.9	Extratropical	1
1910, Feb. 12	D	4.9,4.9F	Extratropical	1
1911, Aug. 30-31	D		Hurricane	4
1912, Sept. 15-16	D		Hurricane	4
1913, Dec. 26	D	5.0,5.2F	Extratropical	1
1914, Mar. 1	D		Extratropical	1
1914, Dec. 7	C	5.7,5.2F	Extratropical	1
1915, Apr. 4	D		Tropical	1,4
1915, Aug. 4-5	D		Tropical	1,4
1916, July 20-21	D		Hurricane	4
1917, Aug. 10	D		Tropical	4
1917, Oct. 24	D	5.2,5.3F	Extratropical	1

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA (Cont'd)

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1918, Jan. 15	C	5.9	Extratropical	1,4
1918, Apr. 11-12	C	6.0,6.2F	Extratropical	1,4
1920, Feb. 5	C	6.1,5.8F	Extratropical	1,4
1920, Sept. 30	C		Hurricane	4
1922, Jan. 28-29	D	5.3F	Extratropical	1
1923, Oct. 18-19	D		Tropical	4
1923, Oct. 22-24	C	4.1,5.2F	Hurricane	1,4
1924, Aug. 25-26	C		Hurricane	1,4
1925, Dec. 3-4	D	4.4	Hurricane	1,4
1926, Feb. 10	D	4.8,4.6F	Extratropical	1
1927, Feb. 20	C	6.3,6.3F	Extratropical	1
1927, Aug. 24	D		Hurricane	1,4
1927, Oct. 4	D		Tropical	4
1928, Aug. 12-13	C	3.6F	Hurricane	1,4
1928, Sept. 19	D	5.3,4.9F	Hurricane	1,4
1929, Apr. 16	C	5.5,5.4F	Extratropical	1
1929, Oct. 2-3	D	5.3,5.3F	Hurricane	1,4
1930, Jan. 30	D	3.6F	Extratropical	1
1931, Mar. 3-5	B		Extratropical	1
1932, May 13	D		Tropical	4
1932, Sept. 16	D		Tropical	4
1932, Nov. 9-10	C	6.1,6.4F	Extratropical	1
1933, Jan. 27	C	5.7,6.2F	Extratropical	1
1933, Aug. 23-24	D		Hurricane	1,4
1933, Sept. 17-18	C	4.3F	Hurricane	4
1934, June 19	D		Hurricane	4
1934, Sept. 8-9	B	4.2,4.6F	Hurricane	4
1935, Nov. 17	B	5.8	Extratropical	1,4
1936, Sept. 18-19	C		Hurricane	1,4
1936, Oct. 1	D		Tropical	4
1936, Oct. 17	D	5.3,5.3F	Extratropical	1
1938, Sept. 21	A	6.4,6.4F	Hurricane	1,4,5
1938, Oct. 22-24	D	4.2	Tropical	4
1938, Oct. 28-29	D	4.4F	Extratropical	1
1939, Aug. 19	D		Tropical	1,4,5
1939, Nov. 25-26	C	4.4F	Extratropical	5
1940, Jan. 24	D	4.3F	Extratropical	1
1940, Feb. 20	D	4.3,4.5F	Extratropical	1
1940, Aug. 18	D		Hurricane	4
1940, Sept. 1-2	D		Hurricane	4
1942, Mar. 3	D	5.5	Extratropical	1
1943, Sept. 30	D	4.6F	Tropical	1

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA (Cont'd)

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1943, Oct. 26	D	5.3	Extratropical	1,4
1944, Jan. 4-5	D	5.1F	Extratropical	1
1944, Aug. 3	D		Hurricane	4
1944, Sept. 14	B	6.4,6.7F	Hurricane	1,4,5
1944, Oct. 21	D		Hurricane	4
1944, Nov. 30	C	5.8F	Extratropical	1
1945, Jan. 16	D	5.4,5.6F	Extratropical	1
1945, June 26-27	D		Hurricane	4
1945, Sept. 18-19	D	4.7F	Hurricane	4
1945, Nov. 22-29	C	5.5F	Extratropical	4,5
1945, Dec. 6	C		Extratropical	4,5
1946, May 29	D	4.7,5.2F	Extratropical	1
1947, Nov. 9-10	D		Extratropical	1
1947, Dec. 26	D		Extratropical	1
1948, Oct. 5-6	D	4.8,5.1F	Extratropical	1
1949, Aug. 24	D	3.9,4.0F	Hurricane	4
1950, Aug. 20-21	D	3.7F	Hurricane	4
1950, Sept. 11-12	D	4.9F	Hurricane	4
1950, Nov. 25	B	7.1,7.5F	Extratropical	1,4,5
1950, Dec. 8	C	5.9F	Extratropical	1
1951, Mar. 30-31	D		Extratropical	1,4
1951, Apr. 25-26	D	4.6	Extratropical	5
1951, Nov. 1	D	5.3,5.4F	Extratropical	1
1952, Feb. 4	D		Tropical	1,4
1952, May 11-12	D	4.7,5.0F	Extratropical	1
1952, Sept. 1-2	D		Hurricane	4
1952, Nov. 20-22	D	4.9,5.0F	Extratropical	1,4
1953, Aug. 14-15	D		Hurricane	4
1953, Sept. 7	D		Hurricane	4
1953, Sept. 21	D	5.1F	Tropical	4
1953, Oct. 23	C	6.0,6.0F	Extratropical	1
1953, Nov. 6-7	B	7.4,7.7F	Extratropical	1,4,5
1954, May 3	D	5.0,5.2F	Extratropical	1
1954, Aug. 31	B	5.8,5.9F	Hurricane	1,4,5
1954, Sept. 11	C	4.0	Hurricane	1,4,5
1954, Oct. 15	C	4.7,5.2F	Hurricane	1,4,5
1955, Aug. 13	C	4.4,3.9F	Hurricane	1,4
1955, Aug. 18-19	D	4.3F	Hurricane	4
1955, Sept. 20	D	3.8F	Hurricane	4
1955, Oct. 14-16	C	6.0,6.4F	Extratropical	1,4,5
1956, Jan. 9-11	C	5.6,5.7F	Extratropical	1
1956, Mar. 16	C	4.8F	Extratropical	1
1957, Oct. 6-7	D	5.1F	Extratropical	1,4,5

TABLE A6 - SUMMARY OF STORMS IN STUDY AREA (Cont'd)

Date	Category[a]	Height of storm tide[b] (ft, msl)	Type of storm	Source of data[c]
1958, Feb. 27-28	D	5.5F	Extratropical	1,4,5
1958, Mar. 19-22	C	5.8,5.8F	Extratropical	1,4,5
1958, Aug. 29	D		Hurricane	4
1958, Sept. 28	D	3.9,4.5F	Hurricane	4
1959, Dec. 7	C		Extratropical	1
1959, Dec. 28-29	D	5.7F	Extratropical	5
1960, Feb. 13-14	C		Extratropical	1,5
1960, Feb. 18-19	C	6.7,6.9F	Extratropical	1,5
1960, July 29-30	D	3.4,3.7F	Tropical	1,4
1960, Sept. 12	A	8.4,8.6F	Hurricane	1,4,5
1960, Dec. 12	D	4.2F	Extratropical	1,5
1961, Jan. 13-14	D	3.7F	Extratropical	1,5
1961, Jan. 16	C	5.9F	Extratropical	1,5
1961, Feb. 3-4	C	5.8F	Extratropical	1,5
1961, Apr. 13	C	6.7,6.7F	Extratropical	1,5
1961, Apr. 16	D	5.9	Extratropical	1,5
1961, Sept. 21	C	3.8	Hurricane	1,5
1961, Oct. 21-23	C	6.8F	Extratropical	1,5
1962, Mar. 6-8	A	7.1,7.5F	Extratropical	1,4,5
1962, Aug. 28-29	D		Hurricane	1,4,5
1962, Sept. 27-28	C	6.1F	Extratropical	1,4,5

(a) The following assigned categories pertain to the effect of a storm in the study area.

A. Unusually severe
B. Severe
C. Moderate
D. Threatened the area

(b) All tide data are for the Battery, New York City, except where followed by F which are for the Corps of Engineers' gage at Fort Hamilton, New York City. Available data on tides in the study area for the major storms since the hurricane of September 1938 are given in the description of the storms following paragraph A4 and are summarized in table A2.

(c) The source of data is as follows:

1. Local newspaper accounts, diaries, histories, etc.
2. Hurricanes - Their Nature and History, by I.R. Tannehill, (1956).
3. Early American Hurricanes, 1492-1870, by David M. Ludlum, (1963).
4. Material furnished by the U. S. Weather Bureau.
5. N. Y. District records.

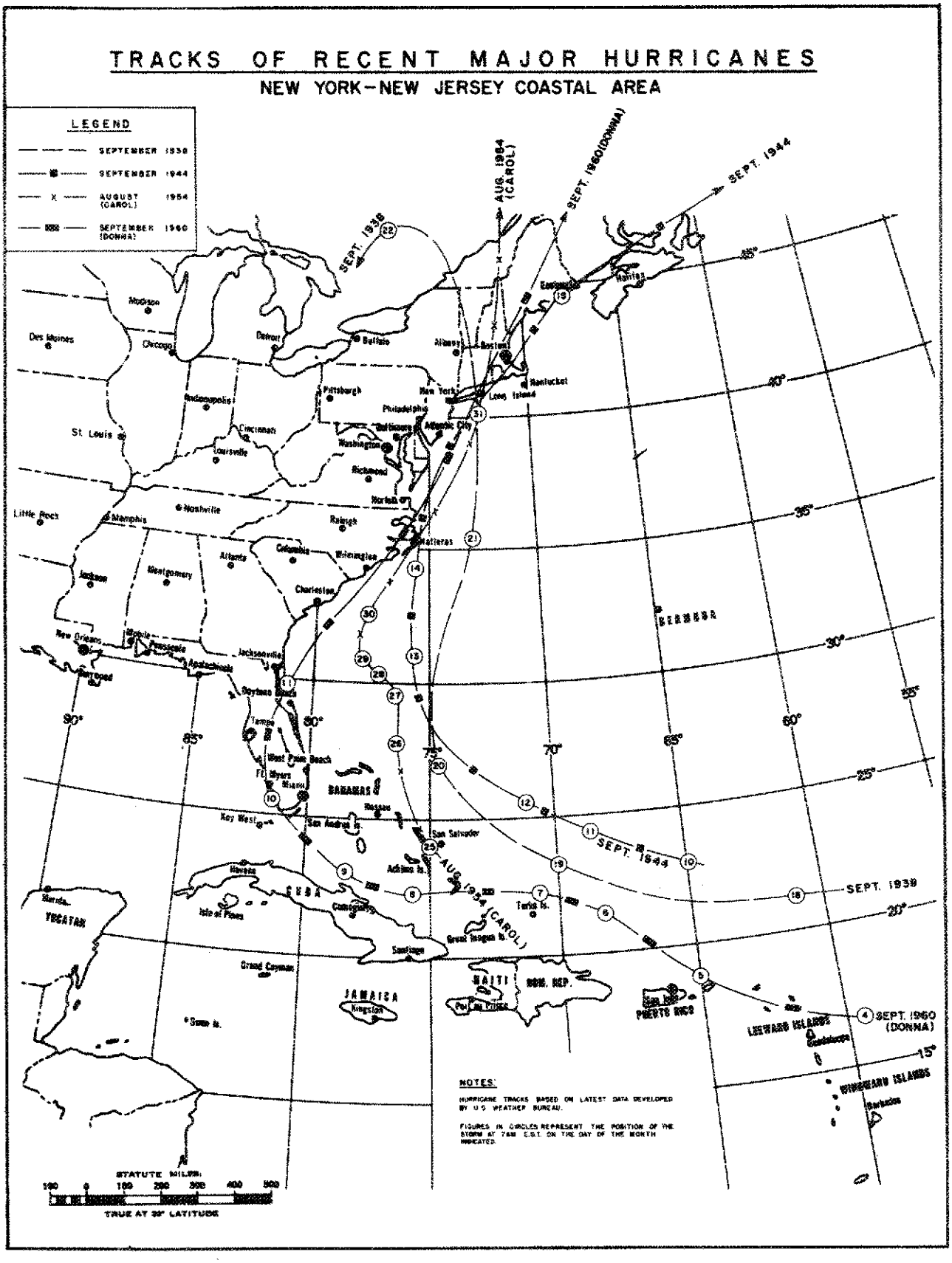
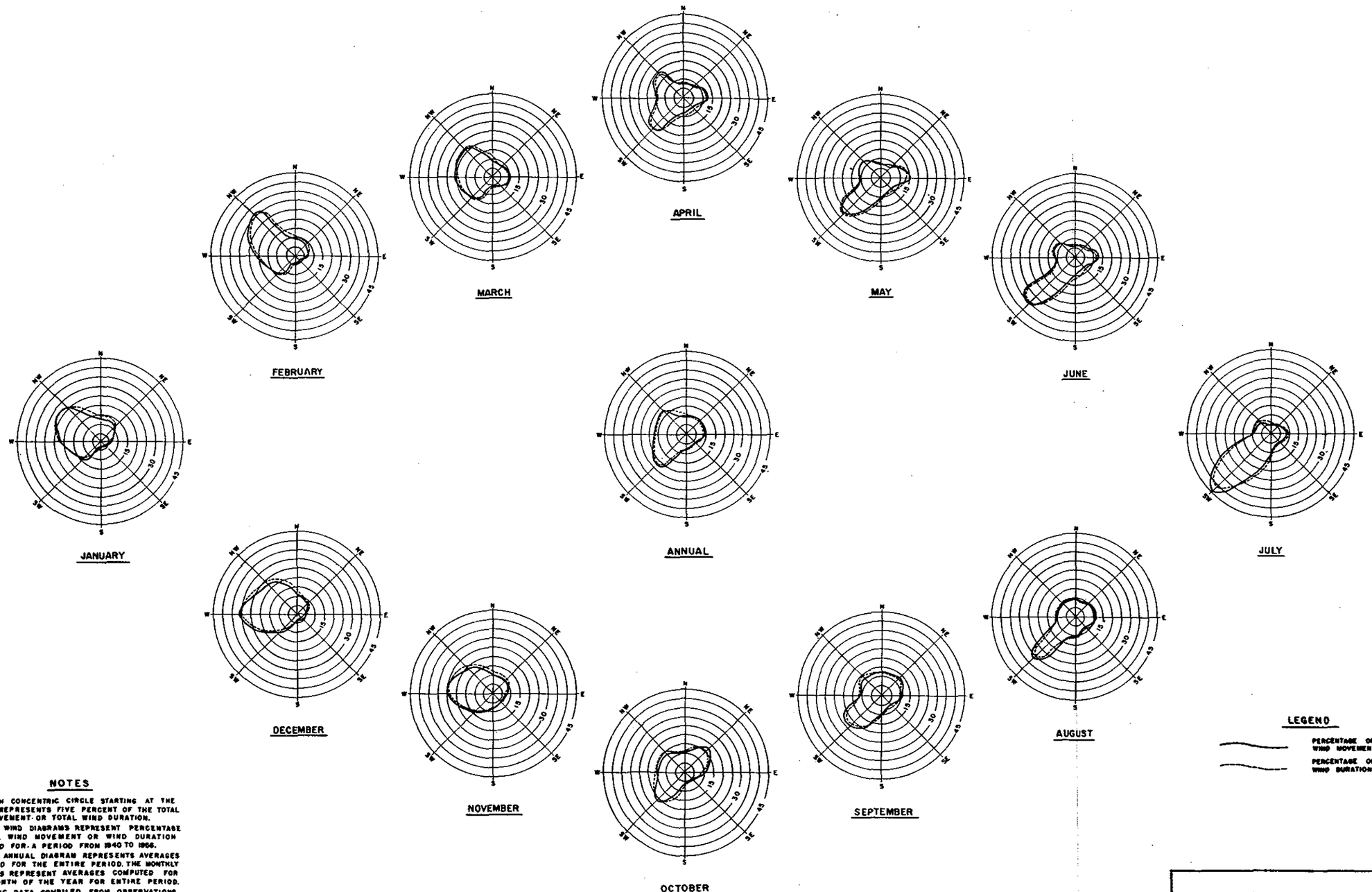

TRACKS OF RECENT MAJOR HURRICANES
NEW YORK-NEW JERSEY COASTAL AREA
LEGEND
SEPTEMBER 1938
SEPTEMBER 1944
AUGUST 1954 (CAROL)
SEPTEMBER 1960 (DONNA)
AUG. 1954 (CAROL)
SEPT. 1960 (DONNA)
SEPT. 1944
SEPT. 1938
Des Moines
Chicago
Detroit
Buffalo
Albany
Boston
Nantucket
Long Island
New York
Philadelphia
Atlantic City
Pittsburgh
Indianapolis
Cincinnati
Louisville
St. Louis
Washington
Richmond
Norfolk
Little Rock
Memphis
Nashville
Raleigh
Hatteras
Atlanta
Columbia
Wilmington
Jackson
Montgomery
Charleston
New Orleans
Mobile
Pensacola
Apalachicola
Jacksonville
Daytona Beach
Tampa
West Palm Beach
Ft. Myers
Miami
BAHAMAS
Nassau
Key West
San Andres Is.
San Salvador
Adkins Is.
Havana
CUBA
Isle of Pines
Comoguey
Turks Is.
Great Inagua Is.
Santiago
Grand Cayman
JAMAICA
Kingston
HAITI
Port au Prince
DOM. REP.
PUERTO RICO
San Juan
LEEWARD ISLANDS
Guadeloupe
WINDWARD ISLANDS
Barbados
BERMUDA
YUCATAN
Merida
Swan Is.
45°
40°
35°
30°
25°
20°
15°
90°
85°
80°
75°
70°
65°
60°
55°
NOTES:
HURRICANE TRACKS BASED ON LATEST DATA DEVELOPED BY U.S. WEATHER BUREAU.
FIGURES IN CIRCLES REPRESENT THE POSITION OF THE STORM AT 7AM E.S.T. ON THE DAY OF THE MONTH INDICATED.
STATUTE MILES
100 0 100 200 300 400 500
TRUE AT 30° LATITUDE

FIGURE A1



NOTES

EACH CONCENTRIC CIRCLE STARTING AT THE CENTER REPRESENTS FIVE PERCENT OF THE TOTAL WIND MOVEMENT OR TOTAL WIND DURATION.

THE WIND DIAGRAMS REPRESENT PERCENTAGE OF TOTAL WIND MOVEMENT OR WIND DURATION AVERAGED FOR A PERIOD FROM 1940 TO 1956.

THE ANNUAL DIAGRAM REPRESENTS AVERAGES COMPUTED FOR THE ENTIRE PERIOD. THE MONTHLY DIAGRAMS REPRESENT AVERAGES COMPUTED FOR EACH MONTH OF THE YEAR FOR ENTIRE PERIOD.

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. COAST GUARD FROM 1940 TO 1943 AT ITS TIAMA STATION AND FROM 1944 TO MARCH 1948 AT ITS SHINNECOCK STATION, AND OF THE SUFFOLK COUNTY HIGHWAY DEPARTMENT AT ITS WESTHAMPTON BEACH STATION FROM APRIL 1948 TO DECEMBER 1956.

WIND DATA
SOUTH SHORE OF LONG ISLAND

FIGURE A2

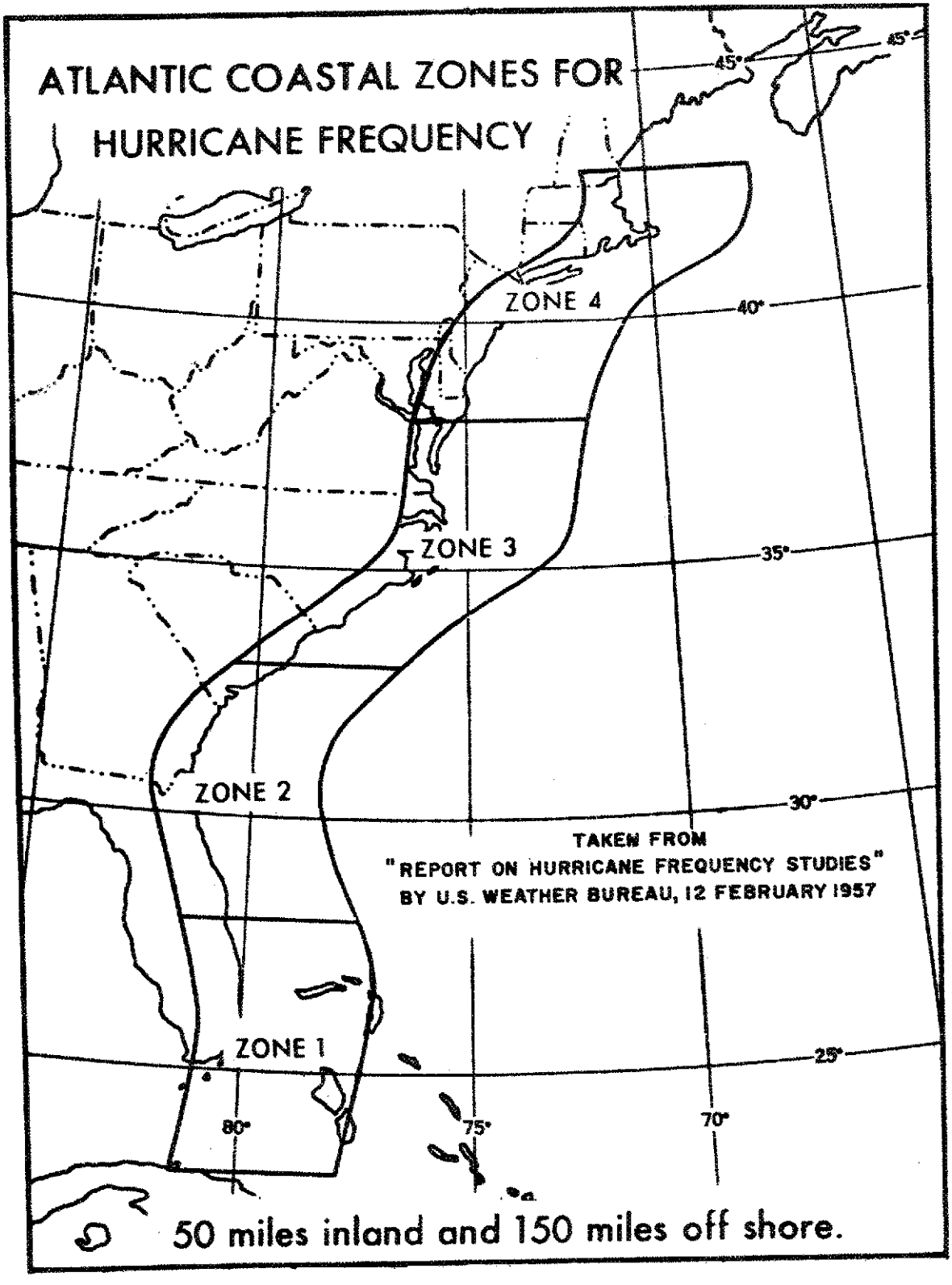
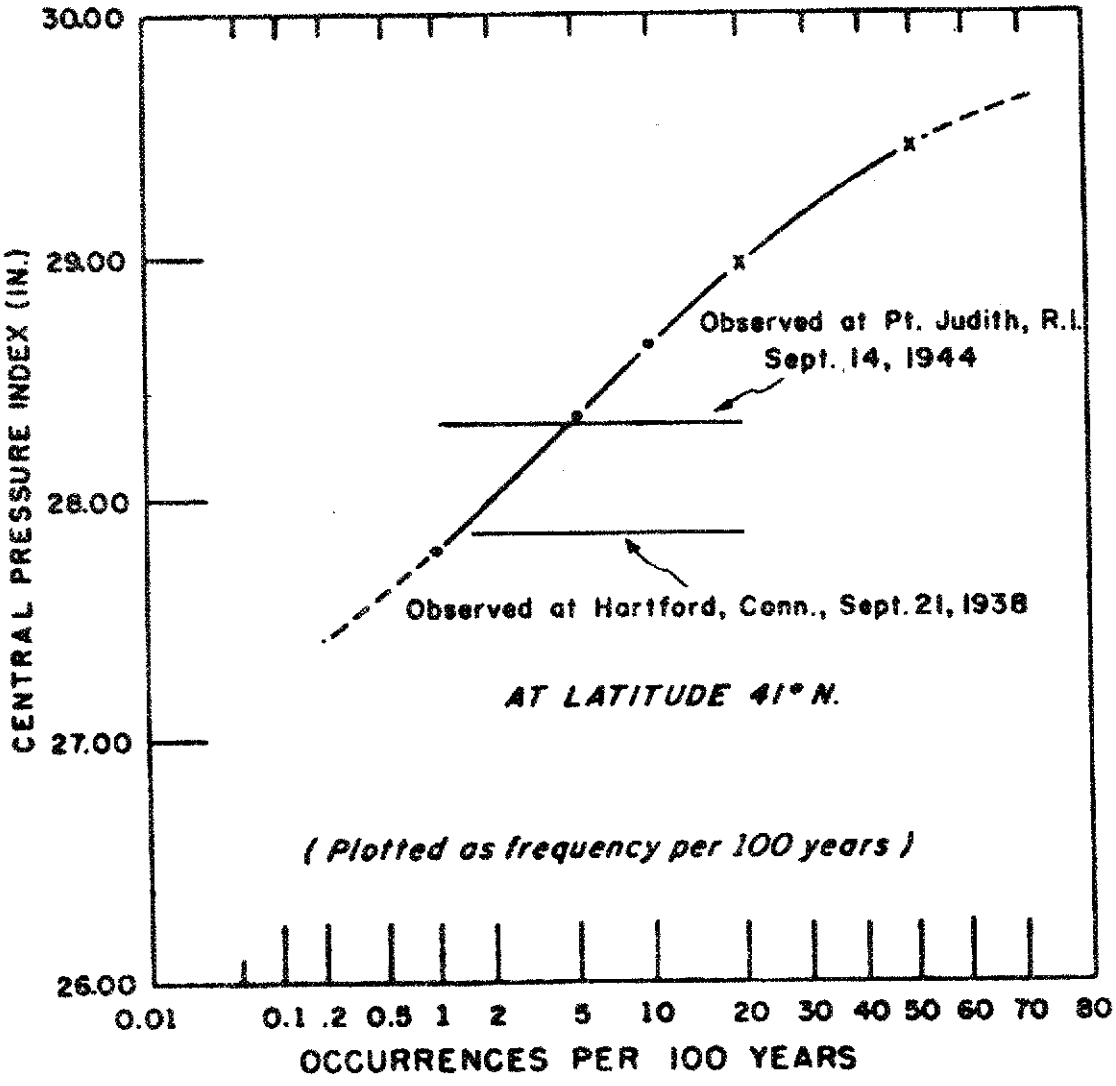

ATLANTIC COASTAL ZONES FOR
HURRICANE FREQUENCY
ZONE 4
ZONE 3
ZONE 2
ZONE 1
45°
40°
35°
30°
25°
80°
75°
70°
TAKEN FROM
"REPORT ON HURRICANE FREQUENCY STUDIES"
BY U.S. WEATHER BUREAU, 12 FEBRUARY 1957
50 miles inland and 150 miles off shore.

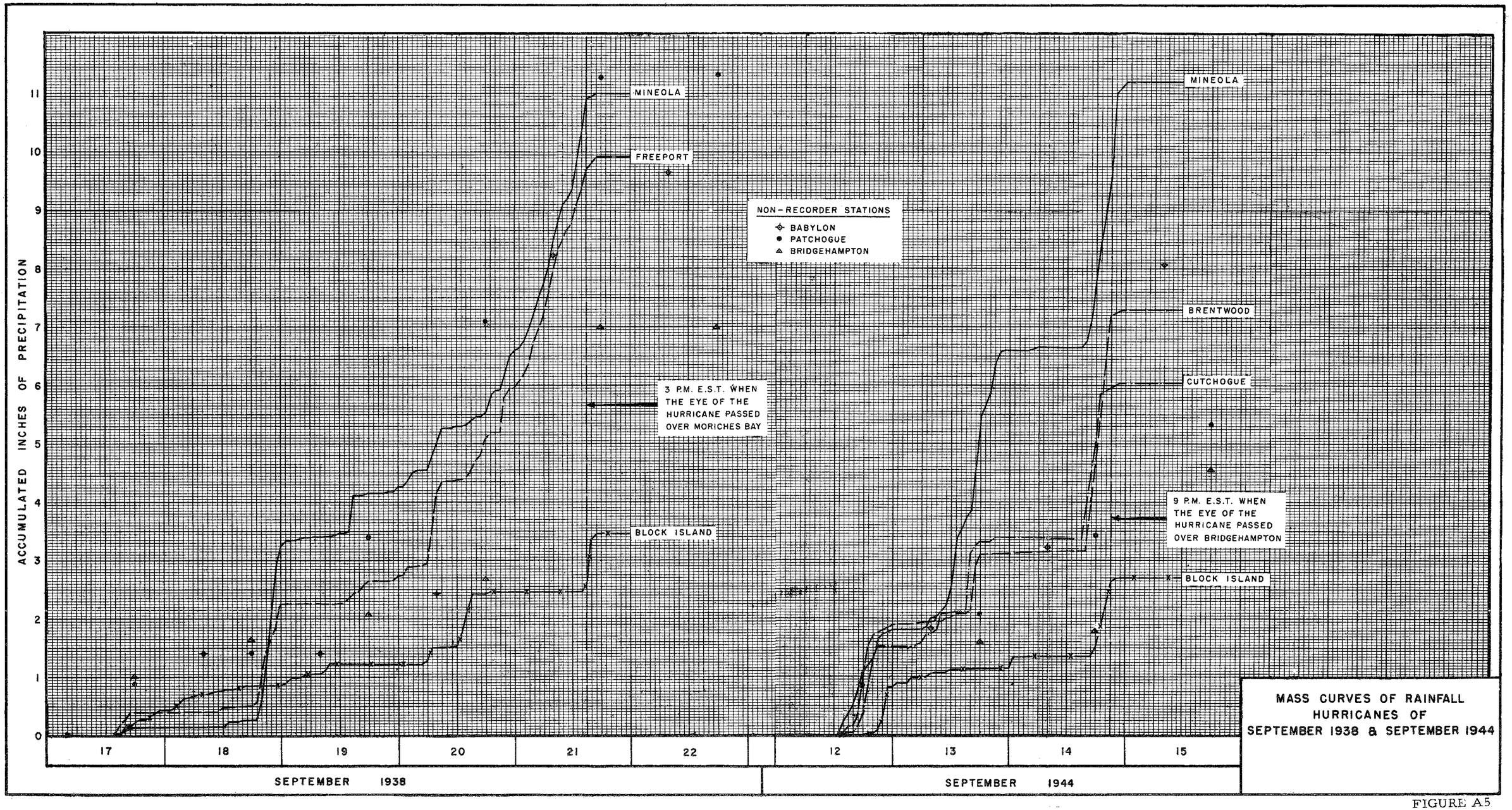
FIGURE A3



ACCUMULATED FREQUENCIES OF HURRICANE CENTRAL PRESSURE, 1900-1956

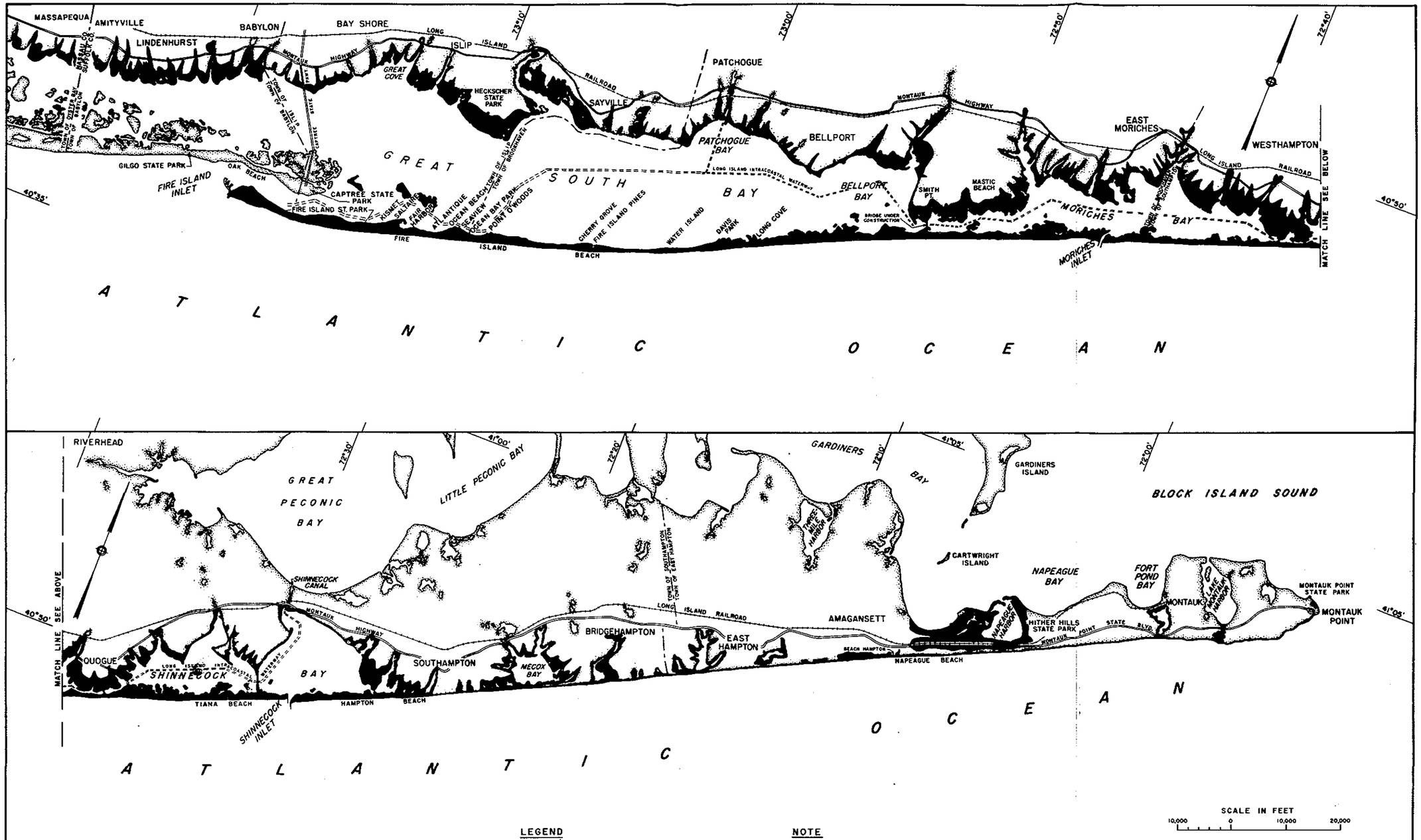
TAKEN FROM "REPORT ON HURRICANE FREQUENCY STUDIES" BY U.S. WEATHER BUREAU, 12 FEBRUARY 1957

FIGURE A4



MASS CURVES OF RAINFALL
HURRICANES OF
SEPTEMBER 1938 & SEPTEMBER 1944

FIGURE A5



LEGEND

SEPTEMBER 1938 FLOODED AREA, THE MAXIMUM OF RECORD.

NOTE

FLOODED AREAS ON BARRIER BEACH WEST OF FIRE ISLAND INLET NOT SHOWN.

EXTENT OF TIDAL FLOODING
SEPTEMBER 1938 HURRICANE

ATLANTIC COAST OF LONG ISLAND, N.Y. AND ADJACENT BAYS

FIRE ISLAND INLET TO MONTAUK POINT

FIGURE B1

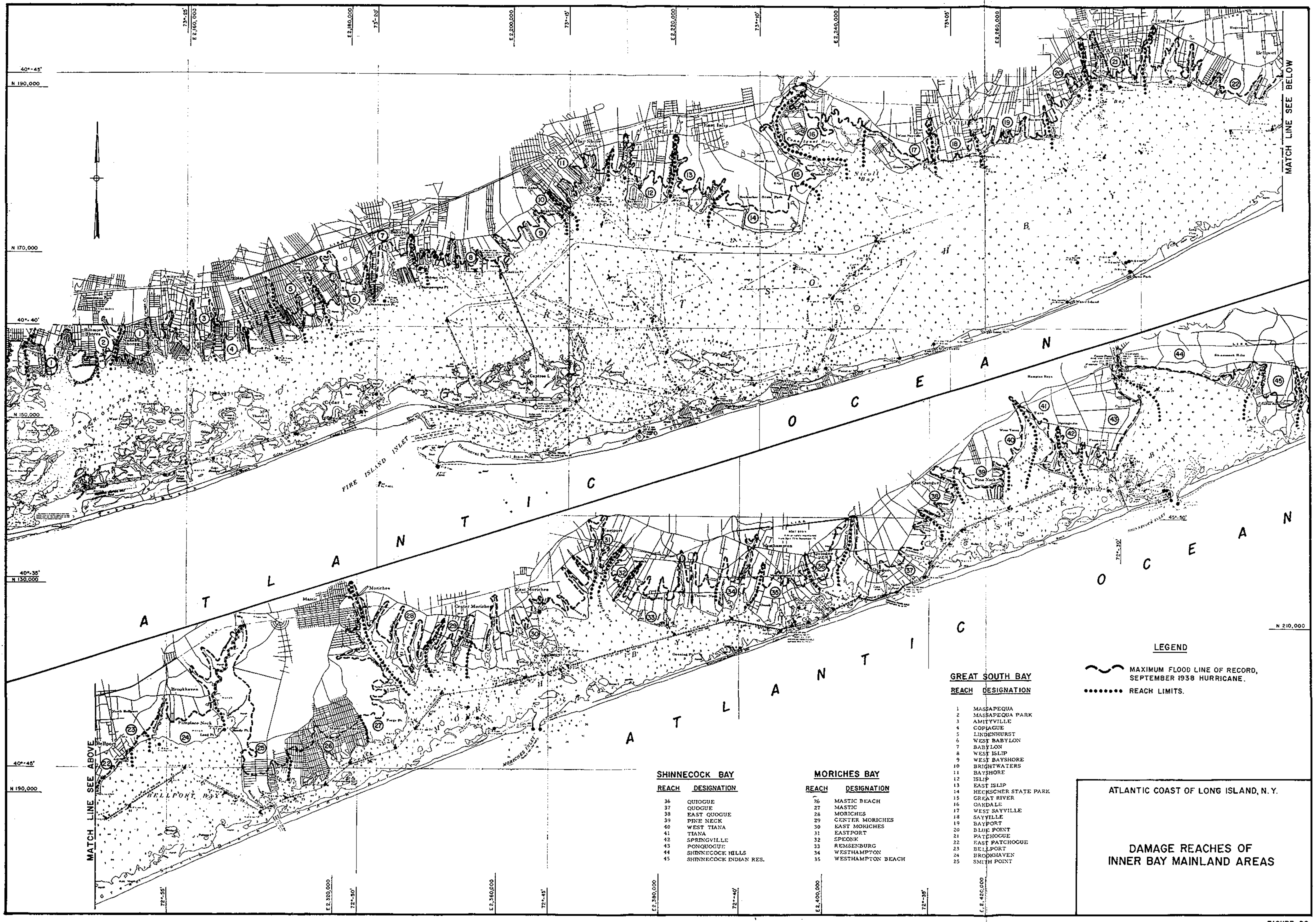
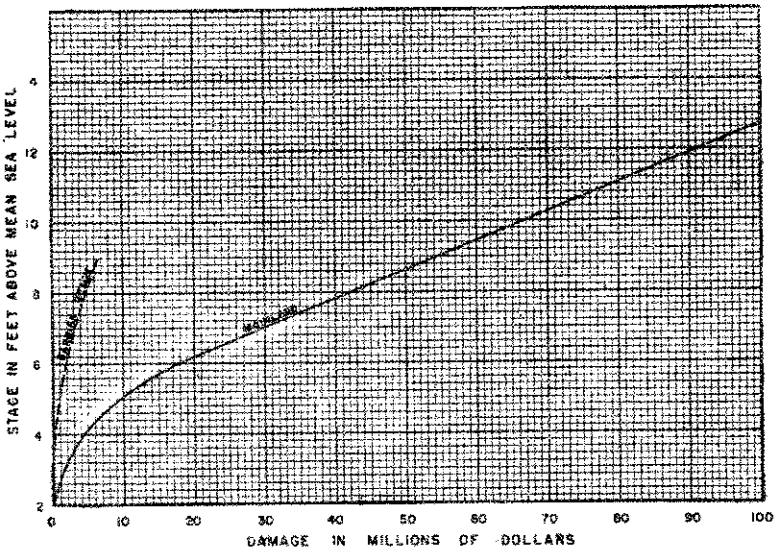
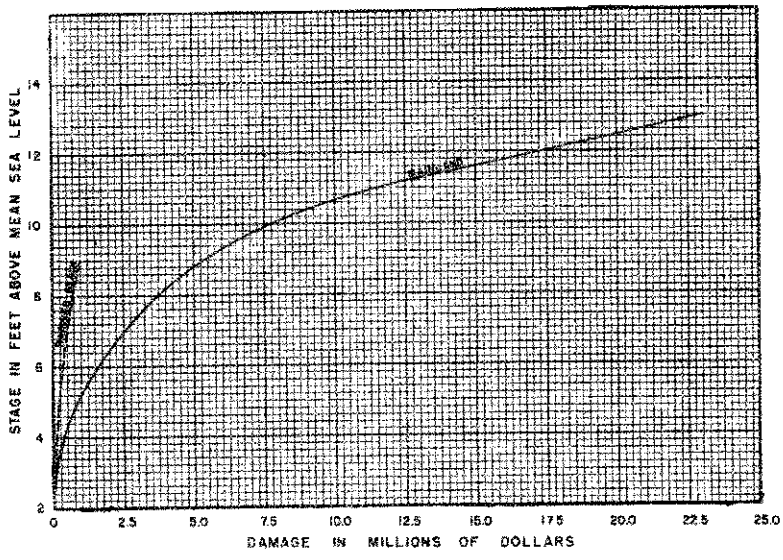

ATLANTIC COAST OF LONG ISLAND, N.Y.
DAMAGE REACHES OF INNER BAY MAINLAND AREAS
LEGEND
MAXIMUM FLOOD LINE OF RECORD, SEPTEMBER 1938 HURRICANE.
REACH LIMITS.
GREAT SOUTH BAY
REACH DESIGNATION
1 MASSAPEQUA
2 MASSAPEQUA PARK
3 AMITYVILLE
4 COPIAGUE
5 LINDENHURST
6 WEST BABYLON
7 BABYLON
8 WEST ISLIP
9 WEST BAYSHORE
10 BRIGHTWATERS
11 BAYSHORE
12 ISLIP
13 EAST ISLIP
14 HECKSCHER STATE PARK
15 GREAT RIVER
16 OAKDALE
17 WEST SAYVILLE
18 SAYVILLE
19 BAYPORT
20 BLUE POINT
21 PATCHOGUE
22 EAST PATCHOGUE
23 BELLPORT
24 BROOKHAVEN
25 SMITH POINT
MORICHES BAY
REACH DESIGNATION
26 MASTIC BEACH
27 MASTIC
28 MORICHES
29 CENTER MORICHES
30 EAST MORICHES
31 EASTPORT
32 SPEONK
33 REMSENBURG
34 WESTHAMPTON
35 WESTHAMPTON BEACH
SHINNECOCK BAY
REACH DESIGNATION
36 QUIOGUE
37 QUOGUE
38 EAST QUOGUE
39 PINE NECK
40 WEST TIANA
41 TIANA
42 SPRINGVILLE
43 PONQUOGUE
44 SHINNECOCK HILLS
45 SHINNECOCK INDIAN RES.
MATCH LINE SEE BELOW
MATCH LINE SEE ABOVE
ATLANTIC OCEAN
ATLANTIC OCEAN
FIRE ISLAND INLET
MORICHES INLET
BELLPORT BAY
PATCHOGUE
Nicoll Bay
40°-45'
40°-40'
40°-35'
N 190,000
N 170,000
N 150,000
N 130,000
N 210,000
E 2,160,000
E 2,180,000
E 2,200,000
E 2,220,000
E 2,240,000
E 2,260,000
E 2,320,000
E 2,360,000
E 2,380,000
E 2,400,000
E 2,420,000
73°-25'
73°-20'
73°-15'
73°-10'
73°-05'
72°-55'
72°-50'
72°-45'
72°-40'
72°-35'
72°-30'

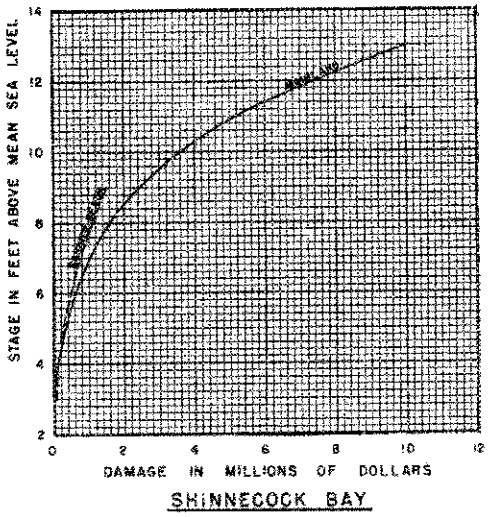
FIGURE B2



GREAT SOUTH BAY



MORICHES BAY



SHINNECOCK BAY

NOTE

THE STAGES DO NOT INCLUDE WAVE RUN-UP BUT THE EFFECT OF RUN-UP IS INCLUDED IN THE DAMAGES.

FOR A BREAKDOWN OF DAMAGES SEE TABLES; B1 AND B2.

STAGE-DAMAGE CURVES FOR INNER BAY AREAS

ATLANTIC COAST OF LONG ISLAND, N.Y.

FIGURE B3

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX B

ESTIMATES OF FLOOD DAMAGES

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX B - ESTIMATES OF FLOOD DAMAGES

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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX B - ESTIMATES OF FLOOD DAMAGES

B1. GENERAL. This section presents information on the conduct of tidal flooding damage surveys undertaken in connection with the hurricane study, classification of damage data obtained during the course of the surveys, losses experienced during recent major storms, and estimates of recurring damages.

B2. DAMAGE SURVEYS. In connection with the hurricane study authorized by Public Law 71, 84th Congress, approved 15 June 1955, a storm damage survey was completed in 1957 of the area from Jones Inlet to Montauk Point, including the barrier beach between Jones Inlet and Fire Island Inlet and the interior Great South, Moriches, and Shinnecock Bays. The survey was primarily a physical inventory of the area subject to tidal flooding. Since there were numerous residences of similar character in the area, a sampling method was used. Estimated evaluations of damages were generally furnished by property owners, but when these estimates appeared to be unrealistic or were not available, the investigators made their own evaluations. Recurring damage data were obtained for various stages of storm waters up to an elevation 3 feet above the maximum of record which occurred during the hurricane of September 1938. Where required, damage values for higher elevations were obtained by extrapolation of the resulting stage-damage curves with due regard given to the development of the area as shown on topographic maps and aerial photographs. The foregoing damage estimates have been updated by a price index to 1965 price levels.

B3. No attempt has been made to make adjustments for additional development in the area since 1957 as it has been determined that protective works would not be economically feasible. The barrier beach between Jones Inlet and Fire Island Inlet has adequate protection afforded by the existing Ocean Parkway and the authorized Federal beach erosion control project for Fire Island Inlet and Shore Westerly to Jones Inlet, which is designed to maintain the shore in a suitably stable condition. The Inner Bays will be afforded protection from protective works provided for under the authorized beach erosion and hurricane project between Fire Island Inlet and Montauk Point.

B4. LOSS CLASSIFICATION. Damage data were recorded by classification of loss and location. The loss classifications used were residential, commercial, recreational, highway, railroad, and utility. The classification of loss was also compiled by main areas and subdivisions to facilitate later use in stage-damage and benefit estimates.

B5. The losses evaluated are confined to tangible primary damages. Primary losses comprise (1) physical damages caused by inundation, and (2) non-physical losses, such as cost of evacuation and temporary quarters, unrecovered loss of business, and increased cost of operation.

B6. The primary loss resulting from physical damages and a large part of the related non-physical loss were determined by direct inspection of property and evaluation of losses by the property owners and field investigators or both. Local officials were interviewed in order to obtain the nature and scope of emergency measures and costs. Data on loss of business were obtained from owners of commercial property in the study area. The non-physical portion of the primary loss is sometimes difficult to estimate on the basis of information available at a given property. In areas where this condition exists, it was assumed that the damage would be 10 percent of the physical damages, which is equivalent to the minimum percentage as determined from damage surveys of similar areas made in connection with the hurricane study under Public Law 71, 84th Congress and in connection with flood control investigations.

B7. Secondary tangible losses, consisting of flood-related losses, such as loss of production and wages in areas outside the immediate flood areas, have not been determined. Intangible losses, including loss of life, health, security, and detrimental effects upon national defense, have not been monetarily evaluated.

B8. EXPERIENCED DAMAGES. The extensive damages experienced during the hurricanes of 21 September 1938, 31 August 1954 (Carol), and 12 September 1960 (Donna) are indicative of the severity of losses in the study area. Details on the effects of these storms are given in the following paragraphs. Additional data on the effects of other storms are contained in appendix A.

B9. Hurricane of 21 September 1938. This hurricane, the maximum of record, caused over $6,000,000 (1938 prices) of primary physical damage along the south shore of Long Island from Jones Inlet to Montauk Point. On the barrier beach between Jones Inlet and Fire Island Inlet, severe flooding was halted by Ocean Parkway, except at low-lying sections at Oak Beach and various Jones Beach parking areas. Figure B1 shows the extent of the flooded area between Fire Island Inlet and Montauk Point. According to newspaper accounts there were 45 known dead and missing in this area, including 24 known dead and 7 reported missing at Westhampton Beach, 2 dead at Quogue, 2 at Eastport, 1 at Captree Island, 1 at Sayville, and 1 at Mastic, a total of 38 dead and missing in the study area. If the storm had occurred two weeks earlier, before summer vacationists returned to their permanent homes, the loss of life would have been many times multiplied. If the storm had occurred after dark, some of those who did escape would have perished.

B10. Oak Beach suffered the most severe damage on the barrier beach between Jones Inlet and Fire Island Inlet. Waves destroyed 45 summer cottages and seriously damaged 100 others. Wave action also damaged the boardwalk and general landscaping at Jones Beach State Park. The total damage in this area was estimated at $220,000 based on 1938 price levels.

However, the barrier beach from Fire Island Inlet to Southampton sustained the greatest damage. This area suffered an estimated $4,800,000 in primary physical damage, of which 50 percent was to residential property. The seas washed over the barrier and destroyed or damaged over 1,000 houses (see photos 1 to 4). Some of the summer communities, such as Saltaire, Fair Harbor, Point O'Woods, and Westhampton Beach suffered greater damage than others due to being insufficiently protected by the sand dunes. In Westhampton Beach alone, 150 homes were destroyed, while at Saltaire, the total approached 100. All bridges leading to the beach and large stretches of roads were damaged. U. S. Coast Guard property was hit hard. Damage to all utilities was substantial. Power and communiciations failed and the water supply was not usable. The section of the Long Island Intracoastal Waterway channel from Westhampton Beach to Quogue was almost completely blocked by sand and debris carried into the waterway. According to a report made by the Superintendent of Highways of Suffolk County, about 90 percent of the dunes were levelled. Seven new inlets were formed in the barrier beach and numerous smaller breakthroughs occurred. Shinnecock Inlet was one of those formed during the storm (see photo 4). One fact of importance concerning the effect of this storm on the dunes is that, generally, dunes with a crest height of 18 feet or more above mean sea level withstood all attacks of the sea and storm and protected the leeward area. Those areas in which the dune crest height was less than 16 feet above mean sea level were generally damaged by wave overwash or breached. After the hurricane, Suffolk County spent about $1,000,000 including $250,000 financed by the Works Progress Administration for dune rehabilitation and closing of all of the inlets opened during the hurricane, except Shinnecock Inlet.

B11. As a direct result of the breaks through the barrier beach, severe damage approximating $800,000 was reportedly inflicted on the mainland. High tides and waves washing over the barrier beach inundated highly developed communities. At the Mastic Beach peninsula, a summer colony suffered considerable damage from inundation. Westhampton Beach and Quogue situated on similar peninsulas suffered the worst damage along the south shore of the mainland (see photo 5). The Ponquogue Bridge causeway suffered damage (see photo 6).

B12. Hurricane of 31 August 1954 (Carol). This hurricane caused over $1,500,000 of physical damage along the south shore of Long Island from Jones Inlet to Montauk Point. Along the barrier beach from Jones Inlet to Fire Island Inlet, damages were estimated at $68,000, while along the barrier beach from Fire Island Inlet to Southampton, damages of over $1,000,000 were sustained. On Fire Island, a number of minor breaks through the dunes occurred. Dunes were cut back in a few places with the greatest loss to the dunes occurring at Point O'Woods. The Suffolk County Department of Highways estimated the cost of restoring the beach to the condition existing before the storm at $55,000. The jetties at Shinnecock Inlet were damaged to the extent of $300,000 and the jetties at Moriches Inlet were slightly damaged (see photos 7 and 8). A U. S. Coast Guard light tower sustained $10,000 damages. At Westhampton Beach the storm made several breaks through the dunes including two deep 1000-foot wide

breaks, one of which washed out a section of Dune Road (see photo 9). In this locality, 14 homes were extensively damaged or destroyed, about 500 summer residents were evacuated, and damages were estimated at $500,000 including damage to a beach club in the area in the amount of $90,000. Ten breaks occurred through the dunes from Quogue to Shinnecock Inlet, causing the deposition of sand on Beach Road which made it impassable. Three houses were undermined and badly damaged in the area, power lines were down and 100 waterfront homes were evacuated. A number of breaks also occurred through the dunes in the barrier beach east of Shinnecock Inlet. Damage on the mainland, estimated at $200,000, occurred principally in Great South Bay between Babylon and Sayville, where numerous homes and 60 boats were damaged. Low lying areas along the bay were flooded (see photo 10).

B13. Hurricane of 12 September 1960 (Donna). This hurricane caused estimated damages of $1,900,000 to the oceanfront areas from Jones Inlet to Montauk Point. Over one million dollars of damages were incurred on the barrier beach between Jones Inlet and Fire Island Inlet. At Jones Beach, where tides were 7 feet above normal, Hurricane Donna sent waves over the boardwalk, caused a large gully in the beach, washed away protective dunes and sand fences, and damaged concrete parking fields (see photo 11 of the main report). At Tobay Beach, there was damage to shore structures and the beach. At Oak Beach, three small boats were lost at a fishing station, but no shore damage was reported. The Fire Island Inlet dike constructed in 1959 was effective in preventing damage at Oak Beach during this hurricane.

B14. On Fire Island four to five thousand people were evacuated to the mainland and the ocean cut through the dunes in nine places. At Westhampton Beach, the ocean and bay joined. Dune Road in this area was covered with sand and water in thirteen places averaging 50 feet in length, with a maximum length of 1,000 feet. The storm added to the damage of the inner and outer ends of the east jetty at Shinnecock Inlet which had been damaged during previous storms. Estimated damages of $850,000 were experienced in the Inner Bay areas. Between Amityville and Babylon several hundred families were evacuated from low-lying areas; some streets in Babylon were under 3 feet of water. At Bay Shore, 150 persons were sheltered. On Shinnecock Bay, the entire causeway of the Ponquogue Bridge was under water and a 50-foot concrete embankment section was broken up and washed ashore.

B15. RECURRING DAMAGES. Recurrence of the September 1938 hurricane under 1957 conditions of development, without improvement of the barrier beach, and current (1965) prices would cause an estimated $5,400,000 of primary damage to the barrier beach between Jones Inlet and Fire Island Inlet, and $68,000,000 of primary damage along the south shore of Long Island between Fire Island Inlet and Montauk Point, of which approximately two-thirds would be residential. About $56,000,000 would be due to ocean damage along the area of the authorized improvement from Fire Island Inlet to Montauk Point, including the bay areas along the barrier beach, and $12,200,000 would be due to damage on the mainland of the Inner Bays. The

latter figure consists of $3,600,000 along the mainland areas around Great South Bay; $6,600,000 around Moriches Bay; and $2,000,000 around Shinnecock Bay. The primary damages that would result from occurrence of the standard project hurricane was estimated at a total of $49,000,000 for the barrier beach between Jones Inlet and Fire Island Inlet and $159,000,000 along the south shore of Long Island between Fire Island Inlet and Montauk Point, of which about $98,000,000 would be due to ocean damage along the area of the authorized improvement from Fire Island Inlet to Montauk Point, including the bay areas along the barrier beach, and $61,000,000 would be due to damage on the mainland of the Inner Bays. The latter figure consists of $42,200,000 along the mainland area around Great South Bay; $14,300,000 around Moriches Bay; and $4,500,000 around Shinnecock Bay.

B16. Stage-damage relations for the various mainland areas of the Inner Bays shown on figure B2, based on 1957 conditions of development and current (1965) prices, are given in table B1 for elevations up to 9 feet above mean sea level. Summaries of the stage-damage relations of the mainland areas and of the barrier beaches east of Fire Island Inlet and along the Inner Bays are given in table B2. The latter data are plotted as stage-damage curves on figure B3 and reflect only damaging effects of inundation resulting from increased elevation in the bay waters. For the mainland areas the stage-damage curves were extrapolated for the higher elevations. No stage-damage curves were developed for the barrier beach between Jones Inlet and Fire Island Inlet since preliminary studies indicated that protection against tidal inundation was not warranted.

B17. Correlation of the stage-damage data discussed in the preceding paragraph with tide-frequency data described in paragraph C22 of appendix C resulted in a damage-frequency relation, which was converted to equivalent annual damages by mathematical integration. By use of this method, the average annual losses to the mainland communities of the study area, based on 1957 conditions of development and current (1965) price levels, are estimated at $440,000 without the authorized improvements to the barrier beach east of Fire Island Inlet, and $77,000 after completion of these improvements. It is also to be noted that the bay stages used exclude the effects of wind set-up in the bays, which under certain wind conditions may be appreciable and result in higher damages to some areas, while other areas would experience comparably lower damages.

TABLE B1 - DAMAGES FROM BAY INUNDATION ALONG MAINLAND AREAS[a]
(IN DOLLARS)

Reach	Stage in feet above mean sea level[b]						
	3	4	5	6	7	8	9
GREAT SOUTH BAY							
1. Massapequa	0	135,200	665,600	1,758,900	3,835,000	5,623,000	7,349,000
2. Massapequa Park	0	3,900	40,000	121,200	274,300	407,000	534,000
3. Amityville	213,200	533,000	1,144,000	1,807,000	2,535,000	3,104,000	3,672,000
4. Copiague	326,300	854,100	1,640,600	2,844,400	4,459,000	5,778,000	7,074,000
5. Lindenhurst	487,500	822,900	1,300,000	2,622,100	4,316,000	5,717,000	7,088,000
6. West Babylon	40,300	124,200	245,700	503,100	790,400	1,025,000	1,256,000
7. Babylon	202,800	471,900	867,100	1,634,100	3,068,000	4,283,000	5,461,000
8. West Islip	59,800	175,500	387,400	713,100	1,133,600	1,479,000	1,817,000
9. West Bayshore	9,400	38,000	99,500	181,000	275,000	351,000	426,000
10. Brightwaters	9,600	32,800	120,300	236,600	403,000	542,000	677,000
11. Bayshore	58,500	293,800	556,400	890,500	1,573,000	2,146,000	2,703,000
12. Islip	24,100	75,400	176,800	413,400	1,105,000	1,709,000	2,289,000
13. East Islip	1,000	4,000	12,000	27,200	64,400	97,000	128,000
14. Heckshar State Park	1,400	4,700	22,400	50,600	99,500	141,000	182,000
15. Great River	5,300	13,000	30,000	60,200	95,000	123,000	151,000
16. Oakdale	28,600	92,300	242,500	568,100	1,193,400	1,730,000	2,249,000
17. West Sayville	13,700	54,600	159,900	353,600	651,300	903,000	1,147,000
18. Sayville	31,100	80,100	182,700	352,300	594,400	796,000	992,000
19. Bayport	21,100	50,700	123,800	245,700	449,200	621,000	788,000
20. Blue Point	41,600	130,000	245,700	390,000	588,300	748,000	906,000
21. Patchogue	62,400	184,600	408,900	799,500	1,431,300	1,962,000	2,480,000
22. East Patchogue	14,000	59,000	146,300	298,400	552,000	766,000	975,000
23. Bellport	3,400	11,200	29,100	62,700	106,300	152,000	1,955,000
24. Brookhaven	8,500	46,800	112,500	205,400	351,000	516,000	675,000
25. Smith Point	0	32,500	139,100	258,700	465,400	816,000	1,306,000
Total	1,663,600	4,324,200	9,098,300	17,397,800	30,408,800	41,540,000	54,280,000
MORICHES BAY							
26. Mastic Beach	55,900	282,100	626,000	1,124,500	1,601,600	2,229,500	3,902,600
27. Mastic	0	18,200	76,700	157,300	223,600	296,400	421,200
28. Moriches	0	2,500	3,900	10,400	24,700	46,800	76,700
29. Center Moriches	3,900	14,300	33,200	62,400	101,400	136,500	198,900
30. East Moriches	7,800	19,500	37,700	61,100	85,800	124,800	170,300
31. Eastport	0	1,400	2,900	4,300	8,500	11,300	16,900
32. Speonk	0	800	1,300	1,600	5,600	6,100	9,100
33. Remsenburg	0	14,300	29,900	50,700	78,000	119,000	154,100
34. Westhampton	0	0	3,300	8,500	17,000	31,200	49,100
35. Westhampton Beach	0	0	58,500	117,000	208,000	351,000	520,000
Total	67,600	353,100	873,400	1,597,800	2,354,200	3,352,600	5,518,900
SHINNECOCK BAY							
36. Quiogue	0	4,300	9,800	20,300	37,100	52,700	73,500
37. Quogue	0	130,000	249,600	390,000	525,200	689,000	855,400
38. East Quogue	0	4,000	9,800	27,300	52,700	86,500	204,100
39. Pine Neck	0	1,300	3,600	8,500	15,600	30,300	63,400
40. West Tiana	0	100	2,500	6,000	12,200	21,300	36,000
41. Tiana	0	100	3,100	11,600	27,800	58,500	103,200
42. Springville	0	400	2,300	6,400	13,500	27,200	45,600
43. Ponquogue	0	700	16,100	45,000	94,600	183,300	316,300
44. Shinnecock Hills	0	5,200	48,000	111,300	216,200	376,900	608,300
45. Shinnecock Indian Reservation	0	0	900	3,000	6,500	14,400	28,100
Total	0	146,100	345,700	629,400	1,001,400	1,540,100	2,333,900

(a) Based on 1957 conditions of development and 1965 price levels.

(b) Does not include wave run-up, but the effect of run-up is included in the damage.

TABLE B2 - SUMMARY OF DAMAGES FROM BAY INUNDATION[a]
(IN THOUSANDS OF DOLLARS)

Stage in feet above mean sea level[b]	Great South Bay			Moriches Bay			Shinnecock Bay		
	Mainland	Barrier beach[c]	Total	Mainland	Barrier beach	Total	Mainland	Barrier beach	Total
3	1,664	76	1,664	68	43	111	0	33	33
4	4,324	502	4,634	353	122	475	146	119	265
5	9,098	1,331	10,084	873	222	1,095	346	264	610
6	17,398	2,522	19,329	1,598	343	1,941	629	468	1,097
7	30,409	4,865	33,609	2,354	497	2,851	1,001	744	1,745
8	41,540	6,616	46,291	3,353	701	4,054	1,540	1,112	2,652
9	54,280	9,006	60,813	5,207	934	6,141	2,334	1,503	3,837

(a) Based on 1957 conditions of development and 1965 price levels.

(b) Does not include wave run-up, but the effect of run-up is included in the damage.

(c) Includes the barrier beach between Jones Inlet and Fire Island Inlet.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX C

DESIGN CRITERIA AND IMPROVEMENTS CONSIDERED

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX C - DESIGN CRITERIA AND IMPROVEMENTS CONSIDERED

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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX C - DESIGN CRITERIA AND IMPROVEMENTS CONSIDERED

I. DESIGN CRITERIA

C1. GENERAL. The most positive means of protection from tidal flooding consists of the construction of structures which would physically reduce or prevent the inundation of properties resulting from high waters eminating in the ocean and the bays. The criteria which are applicable to the study of potential storm tide levels in the ocean and the Inner Bays are contained in the following paragraphs. These criteria were developed for the authorized plan of improvement for the combined beach erosion control and hurricane protection project for Fire Island Inlet to Montauk Point (see figure C8). This plan consists of restoration of the shore and dunes along the barrier beach east of Fire Island Inlet as described in paragraph 79 of the main report. The plan of improvement was designed to provide protection against the maximum design storm (standard project hurricane) developed by the U. S. Weather Bureau for the Atlantic Coast of Long Island from Fire Island Inlet to Montauk Point, the September 1944 hurricane transposed and modified. Improvements considered for protection of the mainland communities fronting the Inner Bays of the study area are discussed in Section II of this appendix. No improvements were considered for protection of the barrier beach between Jones Inlet and Fire Island Inlet, since adequate protection is afforded the area by the existing Ocean Parkway.

C2. HURRICANE WATER LEVELS. As a hurricane progresses over the open water of the ocean, a tidal surge is built up, not only by the force of the wind and the forward movement of the storm wind field, but also by differences in atmospheric pressure accompanying the storm. This surge is further increased as the storm approaches land over a gradually shoaling ocean bed and is influenced by the contours of the coastline. An additional rise may occur when the tidal surge invades a bay or estuary and hurricane winds drive waters to higher levels in the shallow waters. Tidal surges are greater and the tidal flooding more severe in areas which lie to the right of the storm path, due to the counterclockwise spiraling of the hurricane winds and the forward movement of the storm.

C3. September 1938 hurricane (actual). Recorded data on the maximum height of the still water level in the open ocean along the study area are not available for the hurricane of September 1938, the maximum of record. However, based on information obtained from local interests during the damage survey made in connection with the hurricane study under Public Law 71, 84th Congress, 1st Session, it has been determined

that the still water level was generally about 10 feet above mean sea level. This elevation corresponds approximately to the highest tide levels recorded in the Atlantic Ocean in the general vicinity of the study area.

C4. Estimates of the still water elevations for the ocean at Fire Island, Moriches, and Shinnecock Inlets were made for the 1938 hurricane on the basis of Reid's approximate theory presented in Beach Erosion Board Technical Memorandum No. 83 and wind and pressure data prepared by the U. S. Weather Bureau in Memorandum HUR 7-8 dated 1 June 1956.

C5. In order to compute the surge it was necessary to develop certain basic conditions as to bottom profiles off the south shore of Long Island. Profiles were drawn normal to the south shore (figure C2) to obtain the h_o and h_1 (average depth near shore, and at the edge of continental shelf) in the following formula which was used to calculate the wind set-up.

$$\eta_m = \left[K \frac{T}{C_1} \left(\frac{h_1}{h_o} \right)^{\frac{1}{4}} \right] W_m^2 S$$

Using h_o = 36 feet

h_1 = 340 feet

L = 70 nautical miles or 80.6 statute miles for the length of continental shelf

$C_o = \sqrt{gh_o}$ = 34 feet per second or 23.1 mph.

$C_1 = \sqrt{gh_1}$ = 104.6 feet per second or 71.3 mph.

$\overline{C} = \frac{1}{2}(C_o + C_1)$ = 47.2 mph.

$T = \frac{80.6}{47.2}$ = 1.71 hours

$K = 3.3 \times 10^6$ when T is in seconds and W_m in feet per second; or .01746 when T is in hours and W_m in miles per hour. (Assumed value based on Lake Okeechobee study).

then $\eta_m = 7.32 \times 10^{-4} W_m^2 S$

C6. Using the above one step method to obtain an approximation of the still water level for the 1938 hurricane (actual) gives a η_m of 8.1 feet based on a forward velocity of 40 miles per hour and a maximum speed of 96 miles per hour. Although the latter maximum wind velocity occurred a considerable distance to the east of the study area, its use was considered advisable to offset the edge wave effect which could not be computed. By adding the barometric pressure difference of 1.7 feet and the astronomical tide of 1.1 feet (see paragraph C7), a total surge exclusive of wave run-up of 10.9 feet is obtained, which is in general agreement with the 10 feet referred to in paragraph C3.

C7. In order to reproduce the still water stage history for the 1938 hurricane at the south shore of Long Island and to refine the results obtained by the one step method in the preceding paragraph, the multi-step method set forth by Reid in Beach Erosion Board Technical Memorandum No. 83 and described in paragraphs C9 and C10 was used. A graphical integration was used in order to obtain values for each half hour the storm affected the coast of Long Island. Parameters for the hurricane were given by the U. S. Weather Bureau in Memoranda HUR 7-8 and HUR 7-12. Maximum wind speed was taken at 96 miles per hour as discussed in the preceding paragraph. Forward velocity was 40 miles per hour with the R, radius of maximum winds, set at 50 nautical miles from the eye of the storm. The central pressure of the storm as it crossed the south shore of Long Island was estimated by the Hydrometeorological Section of the Weather Bureau as 27.86 inches. To obtain the effective pressure difference which would most nearly reproduce the pressure profile over a span from 20 to 60 nautical miles from the center, the Weather Bureau indicated that a central pressure of 28.00 inches and a normal pressure of 30.14 inches would be appropriate parametric values. This gives a pressure difference of 2.14 inches. The pressure center was found to be displaced 16 nautical miles to the northeast of the eye of the hurricane. Fetch length was 150 nautical miles. The maximum ocean surge exclusive of run-up was then computed as 10.0 feet (see figure C3) in the vicinity of Moriches Inlet (ocean). This elevation, which checks exactly the elevation referred to in paragraph C3, occurred at 3 p.m. on 21 September 1938 or 2.5 hours after the leading edge of the storm fetch hit the continental shelf. The components of the computed surge are summarized below in table C1.

TABLE C1 - 1938 HURRICANE SURGE (ACTUAL)

Item	Feet
Wind surge	7.2
Barometric pressure deficit	1.7
Stage of tide	1.1
Total set-up exclusive of run-up	10.0

C8. Computation of ocean surge for hurricanes of various intensity. For the purpose of design, for checking the extreme high tide frequency curve shown in figure C6 and described in paragraph C25, and for enabling the routing of various ocean surges through the inlets into the interior bays, computations were made by the same method as described in the preceding paragraph of the ocean surges that would result from the design hurricane, September 1938 hurricane (recurring), and a moderate hurricane coincidental with mean high and mean low tide conditions. The results are shown on figures C4 and C5. It was considered reasonable to use the average of the aforementioned two conditions in checking the surge frequency data and for evaluating benefits from reduction of damages that would result from the considered improvements. The parameters that were used for each of the hurricanes are described in the following paragraphs.

C9. Design (standard project) hurricane. The estimate of the ocean surge for the design hurricane was based on the 1944 hurricane transposed and the 1938 hurricane wind pattern as shown in Memoranda HUR 7-8 and HUR 7-12 of the U. S. Weather Bureau dated 1 June 1956 and 6 July 1956, respectively. This gave a maximum wind speed of 112 miles per hour and a barometric pressure deficit of 2.78 inches between the center of the storm, 27.50 inches (see HUR 7-12), and a normal pressure of 30.28 inches. The R, or radius to maximum winds, used for the design is 50 nautical miles. The pressure pattern was displaced from the center of the hurricane by use of Shaw's theoretical separation of the centers for a moving circular depression:

$$d = \frac{V}{2\omega \sin\phi + \zeta}$$

where d equals the displacement, V is the spread of movement of the storm, $2\omega\sin\phi$ the Coriolis parameter, and ζ the angular velocity of the storm. For the design forward speed determined by the New York District as 35 miles per hour the displacement equals 17.5 nautical miles. The pressure pattern was moved with the same forward velocity as the eye of the hurricane, 35 miles per hour, and a pressure deficit for each half hour the storm affected a specific area was obtained in inches. This deficit was converted into feet of water using the factor 1.14 feet of water to each inch of mercury. The fetch of the storm was computed as 150 nautical miles by the method outlined by Reid in Technical Memorandum No. 83.

C10. The wind set-up was obtained by the graphical integration method as shown in Beach Erosion Board Technical Memorandum No. 83. The first approximation obtained by this method was multiplied by 0.75 to obtain a second approximation which is probably better than the first up to the time of maximum, according to Reid in Technical Memorandum No. 83. A normal high tide was added to the set-up and atmospheric pressure deficit, to give a total ocean surge of 14.7 feet above mean sea level, exclusive of wave run-up (see figure C3). This surge elevation was adopted for the design of the authorized beach fill and dunes. The tide used was for Moriches Inlet (ocean) which is approximately in the center of the study area and therefore the total ocean surge is representative of average conditions for the area. Values will range slightly lower towards the east

and slightly higher towards the west from Moriches Inlet, as may be seen by the ocean mean tide curves shown in figure C3. The total design hurricane ocean surge, including wave run-up discussed in paragraph C24, is 20 feet above mean sea level, as shown in table C2. Results of a similar computation under mean low tide conditions are summarized in paragraph C14.

TABLE C2 - DESIGN HURRICANE SURGE COINCIDENTAL WITH MEAN HIGH TIDE

Item	Feet
Wind surge	11.2
Barometric pressure deficit	1.9
Stage of tide	1.6
Run-up	5.3
Total design hurricane surge	20.0

C11. 1938 hurricane (recurring). The parameters used in paragraph C7 in the graphical integration method for obtaining the half-hourly ocean stage history of the 1938 hurricane under actual conditions were also used for computing the heights that would be produced by a similar storm recurring coincidental with an astronomical mean high tide. The results are shown in table C3. Results of similar computations under mean low tide conditions are summarized in paragraph C14.

TABLE C3 - 1938 HURRICANE SURGE (RECURRING COINCIDENTAL WITH MEAN HIGH TIDE)

Item	Feet
Wind surge	7.2
Barometric pressure deficit	1.7
Stage of tide	1.6
Total set-up exclusive of run-up	10.5

C12. Moderate hurricane. In order to establish a hurricane surge frequency relationship for computation of benefits resulting from reduction of damages along the ocean front and the interior bay areas on the mainland, it was necessary to supplement the design and 1938 hurricane surge data referred to in the preceding paragraphs with data on a moderate storm whose surge would just about start to cause slight cutting of the present dunes with resulting property damage. This height is approximately 7 feet.

C13. A graphical integration was made for a moderate storm using a fetch length of 129 statute miles, a wind speed of 80 miles per hour, and R, radius to maximum wind, of 33 nautical miles. The latter figure was based on the average F/R ratio taken as 3.4 (B.E.B. Technical Memorandum No. 83). This gave a maximum wind set-up of 5.0 feet. Adding a mean high tide of 1.6 gives a set-up of 6.6 feet exclusive of pressure

deficit. Adding a mean low tide of -1.6 gives a set-up of 3.4 feet. Adding a barometric pressure deficit of 1.7 feet gives a total surge of 6.7 feet under average tide conditions. The pressure deficit was obtained by using a normal pressure of 29.82 inches and a central pressure of 28.25 inches. Multiplying the difference of 1.57 inches by 1.14 yields 1.74 feet. The above assumed values of R and central pressure fall within the limits as shown on figure 3-5 (North Atlantic), in report No. 5 of the National Hurricane Research Project "Survey of Meteorological Factors Pertinent to Reduction of Loss of Life and Property in Hurricane Situations" issued by the U. S. Weather Bureau in March 1957. The results obtained for mean high tide conditions are shown in table C4. Results for mean low tide conditions are summarized in paragraph C14.

TABLE C4 - MODERATE STORM SURGE COINCIDENTAL WITH MEAN HIGH TIDE

Item	Feet
Wind surge	5.0
Barometric pressure deficit	1.7
Stage of tide	1.6
Total surge exclusive of run-up	8.3

C14. Summary of ocean surge computations. A summary of the ocean surge computations for the design hurricane, September 1938 hurricane (recurring), and the moderate hurricane for both mean high and mean low tide conditions at Fire Island, Moriches, and Shinnecock Inlets is given in table C5. The corresponding ocean stage histories are shown in figures C4 and C5.

TABLE C5 - TOTAL OCEAN SURGE ELEVATION IN FEET ABOVE MEAN SEA LEVEL (EXCLUSIVE OF RUN-UP)

Inlet	Design		1938 recurring		Moderate	
	Low tide	High tide	Low tide	High tide	Low tide	High tide
Fire Island	11.0	15.1	6.6	12.0	4.5	8.6
Moriches	11.4	14.7	8.1	10.5	4.9	8.2
Shinnecock	11.6	14.5	7.3	10.0	5.1	8.0

C15. Computation of bay stages. The ocean stage histories for the design hurricane, the September 1938 hurricane (recurring), and the moderate hurricane referred to in the preceding paragraph were routed through Fire Island, Moriches, and Shinnecock Inlets and over the barrier beach to obtain corresponding stage histories in Great South Bay, Moriches Bay, and Shinnecock Bay under existing and improved conditions with no overtopping. The results shown on figures C4 and C5 do not include wind set-up or wave run-up in the bays. The approximate water areas for Great

South Bay, Moriches Bay, and Shinnecock Bay are 100, 20, and 15 square miles respectively. The increased bay areas resulting from the rise of bay level during routing of the storm surge, was obtained by planimetering the area from mean sea level to the +10 feet mean sea level contour and assuming a straight line relation between these two elevations.

C16. The hurricane surge was routed through the inlets in accordance with the following formula: $Q = 0.5A\sqrt{2gH}$, where Q equals flow in cubic feet per second; A equals the cross-sectional area of the inlets at bay level; g equals 32.2; and H equals the head between the ocean and bay elevations. The coefficient of 0.5 in the above formula was used on the basis of verification with computations made of actual conditions in Moriches Inlet by use of current meter observations and ocean and bay tide readings in 1949.

C17. From field observations, talks with eye witnesses, and all available data on the 1938 hurricane, it can definitely be established that the hurricane surge overtopped the dunes along the major length of the barrier beach east of Fire Island Inlet, lowered the dunes considerably, and cut numerous sluiceways and inlets through the barrier. To account for this situation in routing the waters into the bays, a schedule was set up as described below. An average weir elevation was assumed at 7 feet, mean sea level. When the ocean stage reached this elevation cutting down of the barrier beach was assumed to begin. The percentage of the barrier cut down to the assumed +7-foot level for various ocean surge elevations was estimated as shown in table C6.

TABLE C6 - OCEAN ELEVATION VERSUS PERCENT OF BARRIER CUT TO AN ASSUMED 7-FOOT ELEVATION

Ocean elevation ft., m.s.l.	Percent of barrier cut to assumed +7-foot level
8	11
9	23
10	34
11	45
12	57
13	68
14	79
15	91

C18. Total lengths of the barrier used in all routing computations are as follows:

Great South Bay - From Kismet to opposite Smith Point	121,000 feet
Moriches Bay	53,000 feet
Shinnecock Bay	48,000 feet

C19. The formula used for routing the waters over the barrier is the standard broad crested weir formula $Q = 2.8\ WH^{3/2}$, where Q equals cubic feet per second, W equals length of weir overtopped, and H equals head of water either between the barrier and the ocean stage when the bay level is below 7 feet or between the bay level and the ocean stage when the bay is above the barrier level.

C20. All routings up to 7 feet were through the inlets only. After 7 feet the flow obtained by the inlet formula $Q = 0.5A\sqrt{2gH}$ was added to that obtained by the weir formula $Q = 2.8\ WH^{3/2}$. The total inflow or outflow was then divided by the area of the bay to obtain the rise or fall in bay elevation.

C21. Raising of the dunes to 20 feet above mean sea level as provided for in the authorized improvement would eliminate any dune overtopping or cutting, hence all water would then only come through the inlets, and consequently the bay rise after the improvement was computed by the formula $Q = 0.5A\sqrt{2gH}$.

C22. Summary of bay stage computations. A summary of the bay stage computations for Great South Bay, Moriches Bay, and Shinnecock Bay obtained by routing of the ocean surges computed for the design hurricane, September 1938 hurricane (recurring), and the moderate hurricane is given in table C7. The averages of the results obtained for the mean high and mean low tide conditions were used in plotting the bay stage frequency curves without and with the authorized improvement as shown on figure C7. The results were correlated with composite ocean frequency curve shown in figure C6 and described in paragraph C25.

C23. WIND SET-UP AND WAVE RUN-UP IN BAYS. In addition to the elevations obtained by routing of storm waters into Great South, Moriches, and Shinnecock Bays, there is an added effect which causes an appreciable increase in the bay water level. This is the effect of wind blowing over the bay in the direction of its long axis, east-west in the case of these bays. Figure C9 gives some indication of the set-up which might occur at the east and west ends of the bays by assumed winds blowing at 40, 60, and 75 miles per hour acting over an average bay depth from 4 to 15 feet. The graphs on this figure were computed using the one step method as outlined in Project CW-167, "Waves and Wind Tides in Shallow Lakes and Reservoirs", Corps of Engineers, U. S. Army, Office of the District Engineer, Jacksonville, Florida, June 1955 and Section 3 (revised) - "Design Memorandum, Wind Tides Produced by Hurricanes" Central and Southern Florida Project, Part IV, Lake Okeechobee and Outlets, Corps of Engineers, 26 July 1956. Greater accuracy can be obtained by use of the cross-sectional integration procedure or the segmental method as outlined in the abovementioned publications. However, for the purpose of this study it was not considered advisable to undertake the additional work involved in the latter methods. In addition to the wind set-up, wave run-up would increase the extent of flooding along the bay areas. The height of wave run-up is variable depending upon the wave height and period, shore slope, and type of protective structures.

TABLE C7 - MAXIMUM BAY STAGES IN FEET ABOVE MEAN SEA LEVEL
(EXCLUSIVE OF WIND SET-UP AND WAVE RUN-UP)

Item	Great South Bay	Moriches Bay	Shinnecock Bay
Design hurricane			
Maximum ocean surge elevation coincidental with high tide	15.1	14.7	14.5
Maximum bay stages			
Without improvement	11.3	12.6	12.5
With improvement	3.5	3.8	4.2
Maximum ocean surge elevation coincidental with low tide	11.0	11.4	11.6
Maximum bay stages			
Without improvement	4.6	7.4	8.4
With improvement	3.5	3.7	4.3
1938 hurricane (recurring)			
Maximum ocean surge elevation coincidental with high tide	12.0	10.7	10.0
Maximum bay stages			
Without improvement	4.8	5.4	4.8
With improvement	3.3	3.1	3.3
Maximum ocean surge elevation coincidental with low tide	6.6	7.1	7.3
Maximum bay stages			
Without improvement	2.2	2.3	2.5
With improvement	2.2	2.3	2.5
A moderate hurricane			
Maximum ocean surge elevation coincidental with high tide	8.6	8.2	8.0
Maximum bay stages			
Without improvement	2.8	2.3	2.5
With improvement	2.1	2.2	2.5
Maximum ocean surge elevation coincidental with low tide	4.5	4.9	5.1
Maximum bay stages			
Without improvement	1.3	1.4	1.7
With improvement	1.3	1.4	1.7

C24. OCEAN WAVE RUN-UP. According to the solitary wave theory, the ratio of wave height to depth has the critical value of 0.78. This means that when the wave height reaches a value of 0.78 times the depth, the wave will break. Analysis by the Beach Erosion Board in a wave tank study using an average beach slope of 1 on 20 from 0 to +14 feet, mean sea level, and a dune having a variable slope with its toe at the +14-foot level shows that the run-up with a high tide storm surge of 14 feet would be in the order of 5.3 feet on the dune face. This figure when added to the design elevation of 14.7 feet obtained as the surge in the design hurricane gave a total water elevation of 20 feet above mean sea level (see table C2). This suggested a design dune crest elevation of 20 feet. No freeboard was allowed since the added height weighed against the frequency of occurrence of the design hurricane coincidental with mean high tide would not warrant the added expense.

C25. OCEAN STAGE FREQUENCY. One of the most difficult tasks is the development of an extreme high tide frequency relationship. Therefore, in preparing the ocean tide frequency curve shown on figure C6, use was made of all available information having a bearing on this matter. The lower part of the curve has been developed on the basis of available tide records for Sandy Hook, New Jersey in the general vicinity of the study area for the period 1933 to 1953. For the upper part of the curve use was made of the hurricane central pressure frequency relationship for latitude 41°N developed by the U. S. Weather Bureau and contained in its "Report on Hurricane Frequency Studies" dated 12 February 1957 and Memorandum HUR 2-1 dated 18 June 1957 (see figure A4 of appendix A) and the formula $h_{max}=0.154\ (1019-P_o)$ developed by W.C. Conner, R.H. Kraft and D. Lee Harris of the Weather Bureau in the article "Empirical Methods for Forecasting the Maximum Storm Tide Due to Hurricanes and Other Tropical Storms" published in the April 1957 issue of Monthly Weather Review, where h_{max} is the storm surge in feet above astronomical tide and P_o is the hurricane central pressure in millibars. The results obtained from the latter Weather Bureau data were divided by two in arriving at the upper part of the composite frequency curve. This was considered reasonable in view of the fact that the study area is about one-half the length of the band used by the Weather Bureau for the hurricane central pressure frequency relationship (see figures A3 and A4 of appendix A) and therefore the frequency for the study area may be expected to be only one-half of the frequency for the entire band. It is to be noted that elevations on the tide frequency curve shown on figure C6 refer to mean sea level, which is the average condition for astronomical tide.

II. IMPROVEMENTS CONSIDERED

C26. GENERAL. The authorized Federal beach erosion control project for Fire Island Inlet and Shore Westerly to Jones Inlet (described in paragraph 7 of the main report) is designed to maintain the shore of this section of the study area in a suitable stable condition. Hurricane protection is afforded by Ocean Parkway, which runs practically the entire length of the island. The parkway is at an elevation of about 14 feet above mean sea level, approximately 4 feet above the highest tide experienced in the area. Some sections of the ocean front south of the parkway

are subject to tidal inundation during extreme storm tides, but the extent of potential damage is not great. The barrier beach east of Jones Inlet affords much protection to the mainland communities of the study area during severe storms. After completion of the authorized beach erosion control and hurricane protection project for Fire Island Inlet to Montauk Point, described in paragraph 79 of the main report, tidal damages will be minimized. The mainland communities will not be subject to direct ocean wave attack and to additional inundation from high ocean tides overtopping and breaking through the barrier beach. However, some inundation of low areas would still be possible due to remaining flow through the inlets, wind set-up, and wave run-up. In order to eliminate the residual damage, consideration was given to local protective measures.

C27. PROTECTIVE MEASURES. Protective measures fall into the following categories: (a) hurricane warning and emergency flood mobilization measures, including plans for evacuation, (b) revised zoning regulations and building codes, and (c) protective structures. Details of (a) and (b) are contained in paragraphs 87 to 95 and 106 and 107 of the main report and discussed further in appendix F, "Flood Plain Zoning", and appendix G, "A Model Hurricane Plan for a Coastal Community". Although hurricane warnings, mobilization measures, and revised zoning regulations and building codes will abate the extent of flood damages, they will not eliminate the inherent danger from tidal flooding. The most positive means of protection consists of structures which would physically reduce or prevent the inundation of properties by tidal floodwaters during severe storms. Protective structures considered for the elimination of the residual flood damages are described in the following paragraphs.

C28. STRUCTURES CONSIDERED. Consideration was given to construction of hurricane barriers with navigation openings for the eastern end of Great South Bay at Smith Point, at the western end of Moriches Bay at Mastic Beach, at the eastern end of Moriches Bay west of Westhampton Beach, and at the western end of Shinnecock Bay at Quogue as shown on figure C10. Preliminary studies showed that such barriers, while providing adequate protection for the low-lying Smith Point-Mastic Beach and Westhampton Beach-Quogue peninsulas, would not be economically justified even though additional development has taken place, and some future development is expected. Furthermore, local interests are opposed to such structures because of detrimental effects they might produce, such as added pollution to the waters, hazards to navigation, possible increased flooding on the windward sides of the barriers, and obstructions to bay privileges, as stated in the letter from New York State Department of Public Works of 9 December 1958 included in appendix D. Although this letter refers to a 50-foot navigation opening, a larger opening of 100 feet was subsequently also considered. However, the original objections by local interests still hold, as stated in their letter of 7 September 1965 contained in appendix D.

C29. Consideration was also given to protecting all the bay reaches shown on figure B2 of appendix B, with floodwalls and levees to hold back the high waters, and pumps to remove runoff of the inland areas resulting from severe storms with considerable rain intensity. It was determined

in the preliminary studies that protection by means of such structures in any of these reaches would be most extensive and costly and not economically justified even with consideration to future possible development in the area.

C30. HURRICANE BARRIERS. Heights. With the dunes along the barrier beach east of Fire Island Inlet raised to 20 feet, as part of the authorized beach erosion control and hurricane protection project, the height of each of the considered hurricane barriers in the bays was computed by routing the design (standard project hurricane) storm to produce the maximum storm water elevation at each of the barriers and allowing additional freeboard for wave action. The height of the Smith Point hurricane barrier was calculated to be 14 feet above mean sea level based on a design still water bay elevation of 11 feet above mean sea level, including wind set-up, while the height for the barriers at Mastic Beach, Westhampton Beach, and Quogue was 10 feet based on a design storm still water bay elevation of 8 feet. These elevations were arrived at by orienting the design (standard project hurricane) storm in such a manner as to create the largest wind set-up effect in the bays.

C31. Navigation opening. To allow for uninterrupted passage of vessels along the Federally maintained intracoastal waterway, ungated navigation openings would be required in each of the barriers. Preliminary calculations for the barrier design were initially based on 50-foot wide openings, the navigation width of the bridge spans along the waterway. Since local interests considered this too narrow and a hazard to boat traffic, especially at night, calculations were also made for barriers with 100-foot wide openings. The stage level in the pool area between the Smith Point and Mastic Beach barriers, which is the most vulnerable section of the study area, was computed for openings of 50 feet and 100 feet wide and 6 feet deep. Comparison of the stage histories under improved conditions for a 100-foot permanent navigation opening as against a 50-foot opening for this area, as shown on figures C11 and C12, indicates a maximum difference in pool level resulting from the greater flow through the 100-foot opening of about 1 foot. A similar study of the pool area between Westhampton Beach and Quogue barriers was not undertaken, since unlike the Smith Point-Mastic Beach area which initially showed possible justification, it was learned early in the preliminary study that protection of the Westhampton Beach-Quogue area was definitely economically not justified. The economic analysis for the latter area was based on the assumption that the barrier would afford complete protection. Flow during severe storms through the permanent openings, whether 50 feet or 100 feet, may raise the level in the pool somewhat above the no significant damage stage and cause some damages, thus making the improvement even less justified.

C32. Gated openings. Besides having the ungated navigation openings, additional gated openings would be required for normal tidal interchange. A total width of at least 150 feet of gated openings would be required for each barrier with a 100-foot permanent opening and at least 200 feet for the barrier with a 50-foot permanent opening.

C33. Barrier lengths and tie-in. The barriers would have to tie into the dunes on the barrier beach side, and into high ground on the mainland. The tie-in would have to be such that cross-currents resulting from set-up and breakers against the barrier do not wash ashore aggravating flood conditions immediately adjacent to the tie-in, and endangering the barrier and continuity of the dunes. Lengths of the barriers were estimated to be approximately 11,600 feet, 8,200 feet, 8,800 feet, and 6,500 feet for the Smith Point, Mastic Beach, Westhampton Beach, and Quogue barriers respectively.

C34. Annual cost. Preliminary estimates show that the annual cost of the Smith Point-Mastic Beach barriers is more than $100,000, while those of the Westhampton Beach-Quogue barriers is more than $80,000.

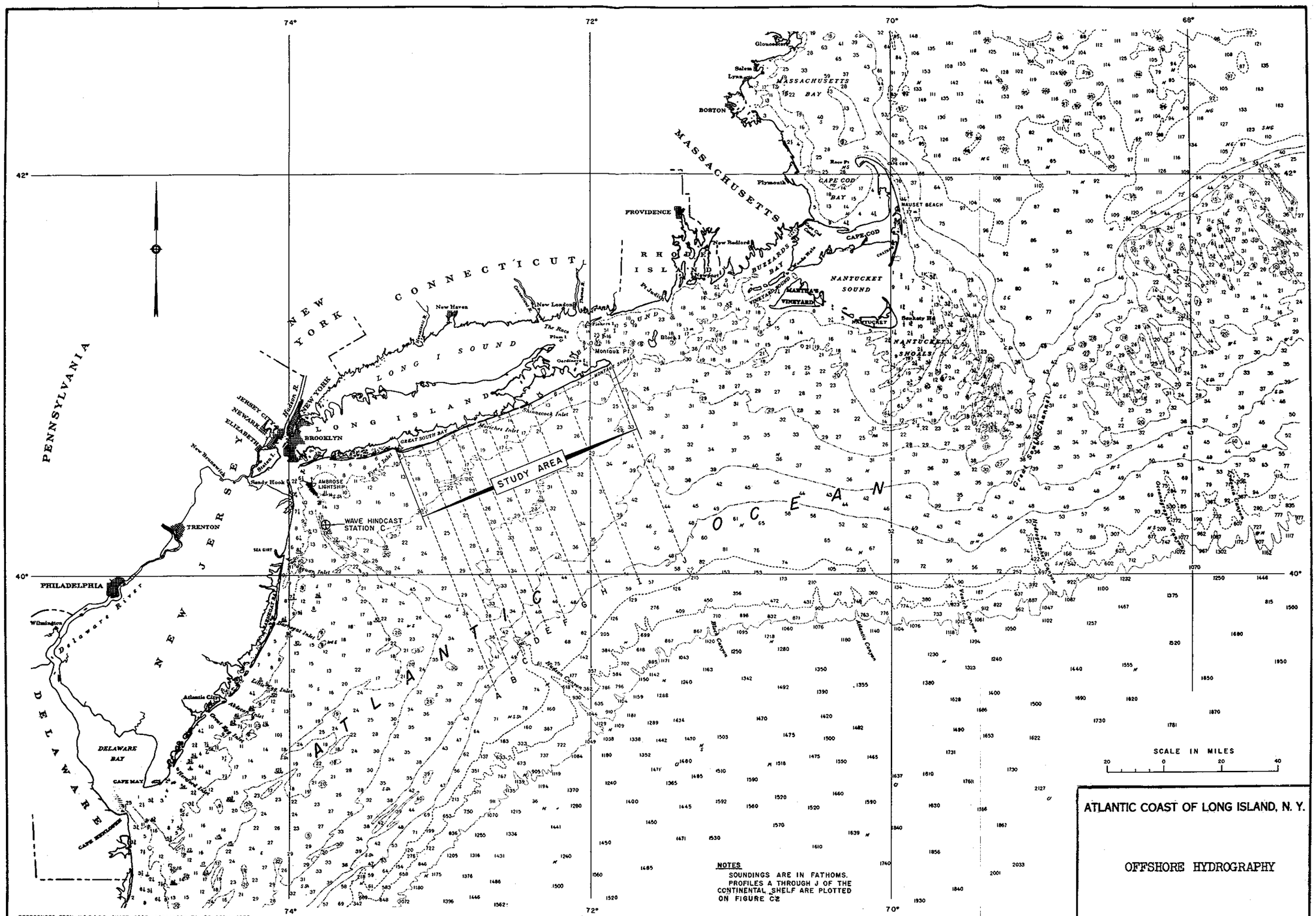
C35. Annual benefits. With the use of stage-damage relationships for the areas protected by the hurricane barriers, annual benefits that would accrue from these structures were computed assuming the frequency of occurrence of the re-oriented design storm, used for determining the barrier heights, the same as that of the standard project hurricane orientation used for developing the surge heights along the ocean front as described in paragraphs C9 and C10. Annual benefits for the Smith Point-Mastic Beach area were computed to be less than $50,000 and those of the Westhampton Beach-Quogue area less than $25,000. Future development in these areas may result in greater benefits, but not sufficient to warrant the installation of the hurricane barriers. Furthermore, since frequency of occurrence of the design storm for the barriers, oriented in each case for maximum wind set-up as described in paragraph C30, is less than that of the standard project hurricane, annual benefits would be even lower than the aforementioned values.

C36. Economic justification. A comparison of the annual cost and annual benefits as described in the preceding paragraphs, indicates that the ratio of benefits to cost from the proposed barriers is considerably less than unity. Consequently, these structures are economically not justified.

C37. FLOODWALLS AND LEVEES. General. These structures are primarily constructed for local protection by holding back the high waters that occur during severe storms and hurricanes, and thus preventing damages from tidal inundation. A preliminary analysis was made to determine the feasibility of constructing these structures for local protection of each of the reaches shown on figure B2 of appendix B. The length of bulkheads and levees were determined for each reach and the need for pump installations to remove runoff from extreme rain intensities accompanying severe storms was also considered.

C38. Economic analysis. Preliminary estimates of costs were made for local protection of each damage reach. These costs revealed that such protection would be highly uneconomic. Annual benefits computed for the most vulnerable reach in each of the bays, namely Lindenhurst,

Mastic Beach, and Quogue were less than one-tenth the annual costs of any local protection. Considering possible future additional development and the resulting additional benefits that would accrue, protection of these areas would still not be warranted.



ATLANTIC COAST OF LONG ISLAND, N. Y.

OFFSHORE HYDROGRAPHY

FIGURE C1

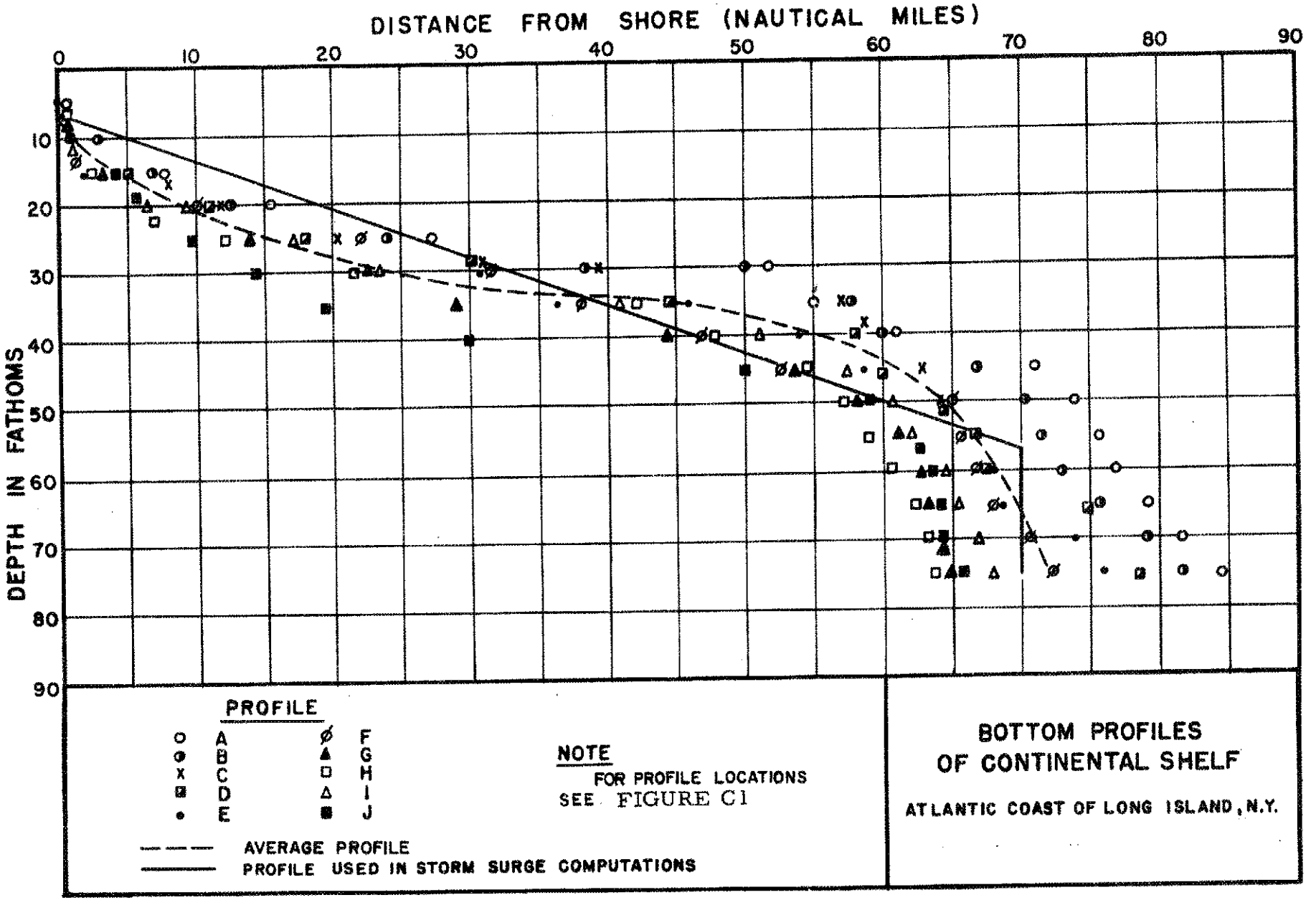
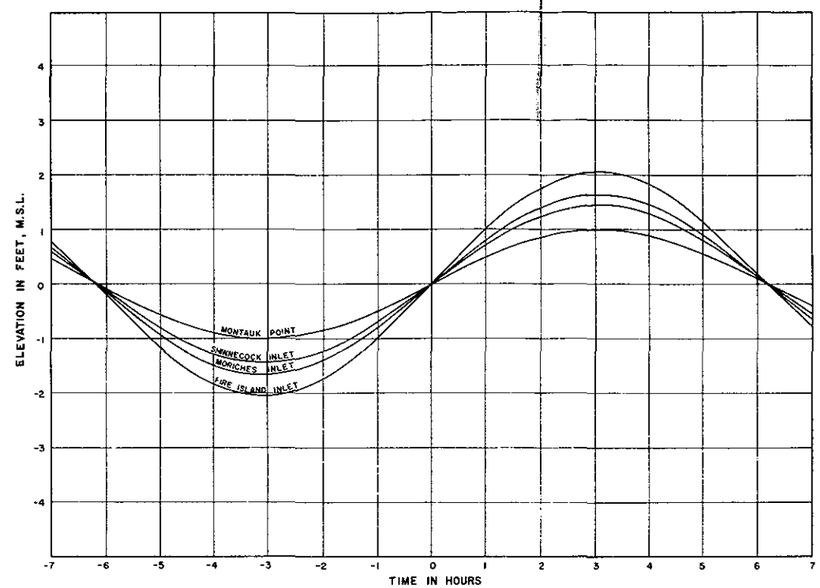
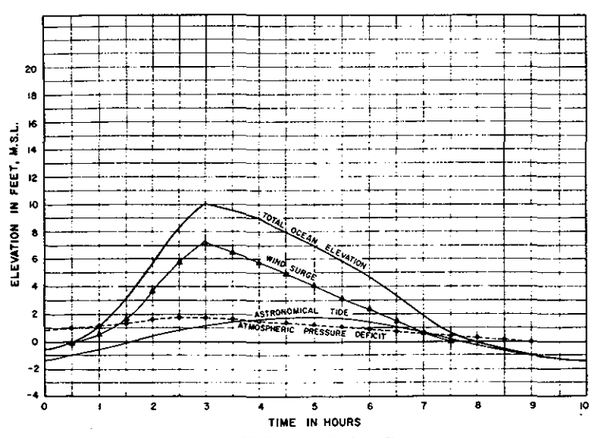

DISTANCE FROM SHORE (NAUTICAL MILES)
0
10
20
30
40
50
60
70
80
90
DEPTH IN FATHOMS
10
20
30
40
50
60
70
80
90
PROFILE
A
B
C
D
E
F
G
H
I
J
AVERAGE PROFILE
PROFILE USED IN STORM SURGE COMPUTATIONS
NOTE
FOR PROFILE LOCATIONS
SEE FIGURE C1
BOTTOM PROFILES
OF CONTINENTAL SHELF
ATLANTIC COAST OF LONG ISLAND, N.Y.

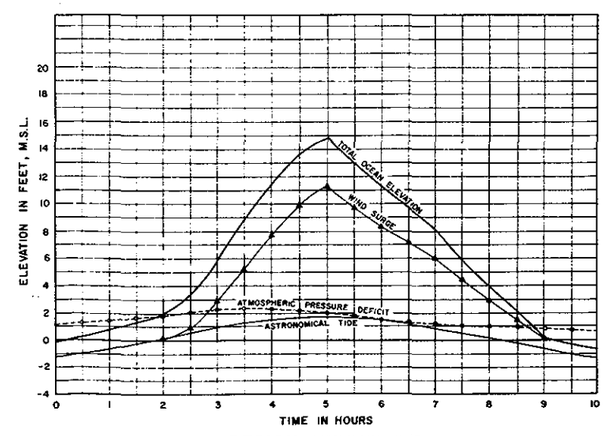
FIGURE C2



OCEAN MEAN TIDE CURVES



1938 HURRICANE



DESIGN HURRICANE

OCEAN STAGE HISTORY

NOTES

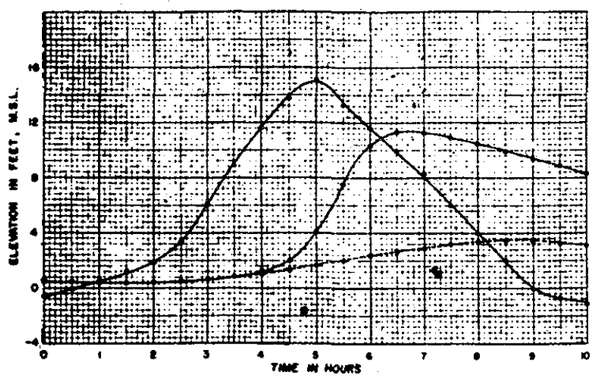
ZERO HOUR ON THE TIDE CURVES CORRESPONDS TO THE TIME WHEN THE TIDE REACHES MEAN SEA LEVEL ON THE RISING TIDE.

ZERO HOUR ON THE OCEAN STAGE HISTORY CURVES CORRESPONDS TO THE TIME WHEN THE FRONT OF THE STORM FETCH REACHES THE EDGE OF THE CONTINENTAL SHELF.

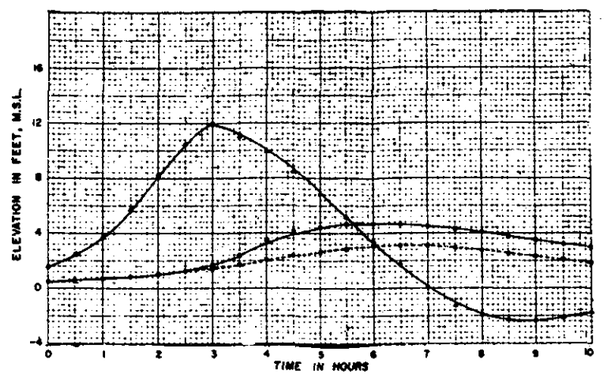
THE ASTRONOMICAL TIDE ON THE OCEAN STAGE HISTORY CURVES IS FOR THE VICINITY OF MORICHES INLET WHICH IS ABOUT MIDWAY OF THE STUDY AREA.

OCEAN STAGE HISTORY
1938 AND DESIGN HURRICANES
AND
OCEAN MEAN TIDE CURVES
ATLANTIC COAST OF LONG ISLAND, N.Y.

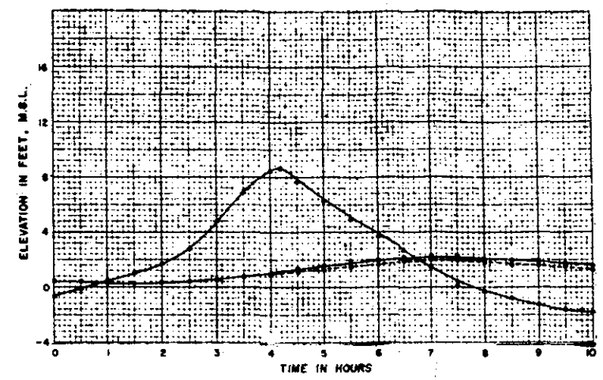
FIGURE C3



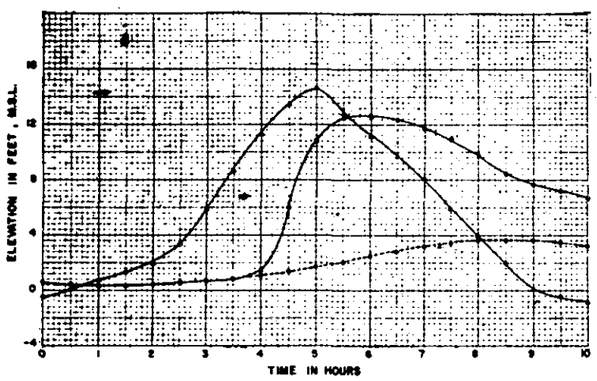
GREAT SOUTH BAY



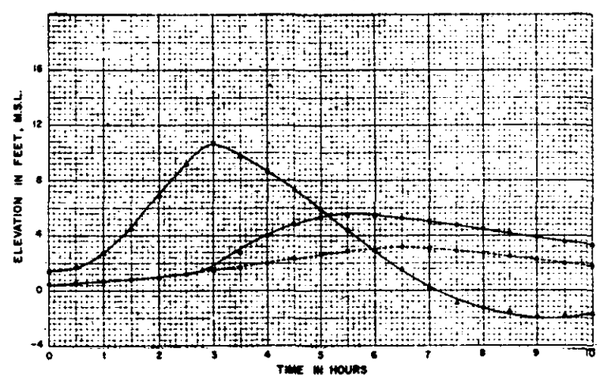
GREAT SOUTH BAY



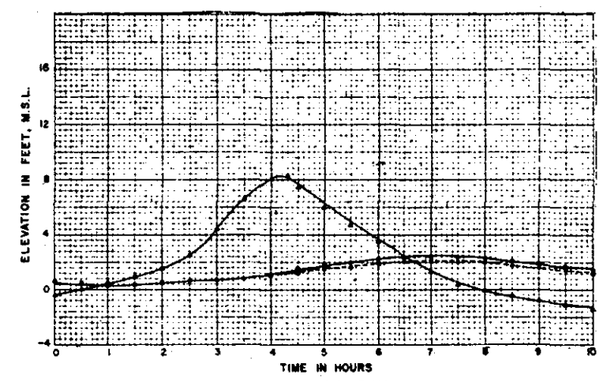
GREAT SOUTH BAY



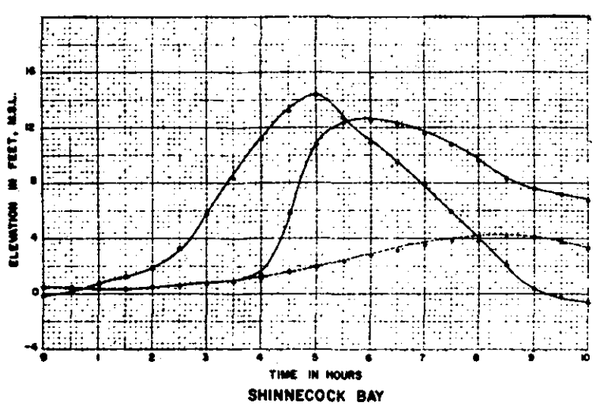
MORICHES BAY



MORICHES BAY

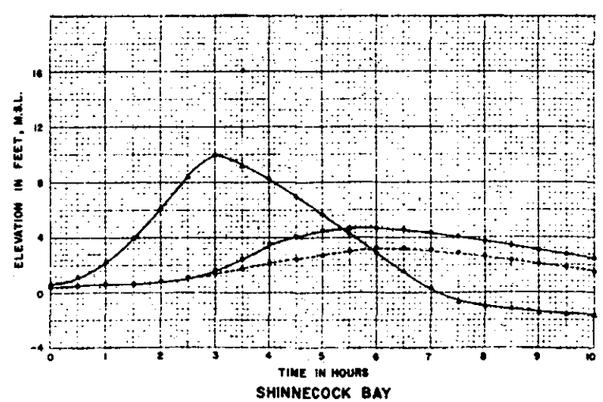


MORICHES BAY



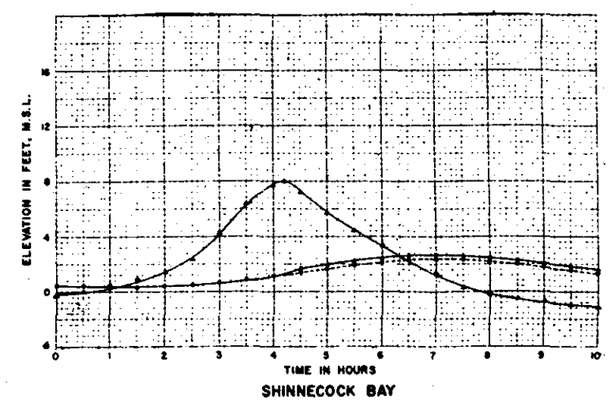
SHINNECOCK BAY

DESIGN HURRICANE



SHINNECOCK BAY

1938 HURRICANE (RECURRING)



SHINNECOCK BAY

MODERATE HURRICANE

NOTE

ZERO HOUR CORRESPONDS TO THE TIME WHEN THE FRONT OF THE STORM FETCH REACHES THE EDGE OF THE CONTINENTAL SHELF.

LEGEND

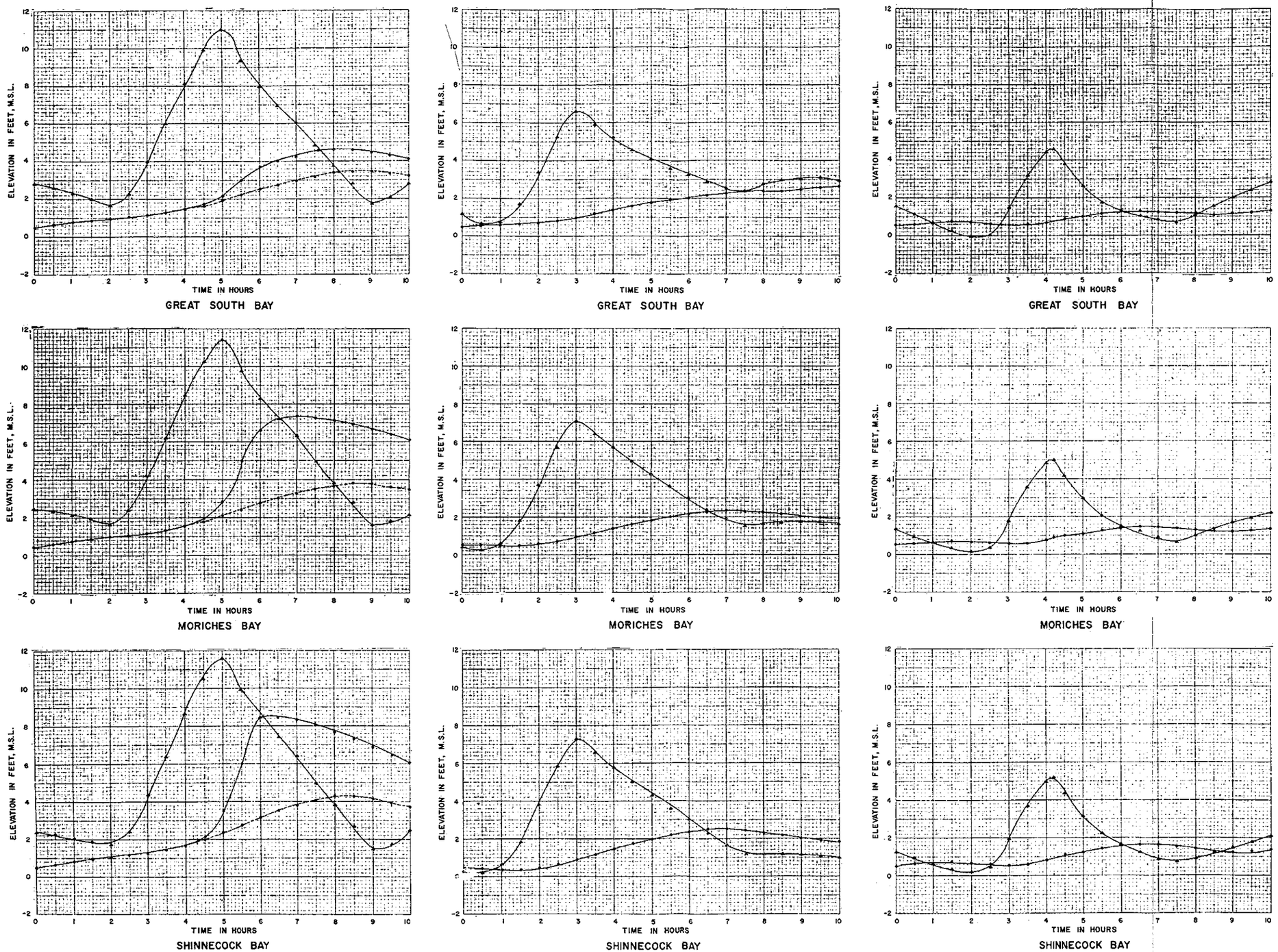
- OCEAN STAGE HISTORY
- BAY STAGE HISTORY (WITHOUT IMPROVEMENT)
- BAY STAGE HISTORY (WITH IMPROVEMENT)

OCEAN AND BAY STAGE HISTORY

MAXIMUM OCEAN SURGE
COINCIDENTAL WITH HIGH TIDE

ATLANTIC COAST OF LONG ISLAND, N.Y.

FIGURE C-4



NOTE

ZERO HOUR CORRESPONDS TO THE TIME WHEN THE FRONT OF THE STORM FETCH REACHES THE EDGE OF THE CONTINENTAL SHELF.

LEGEND

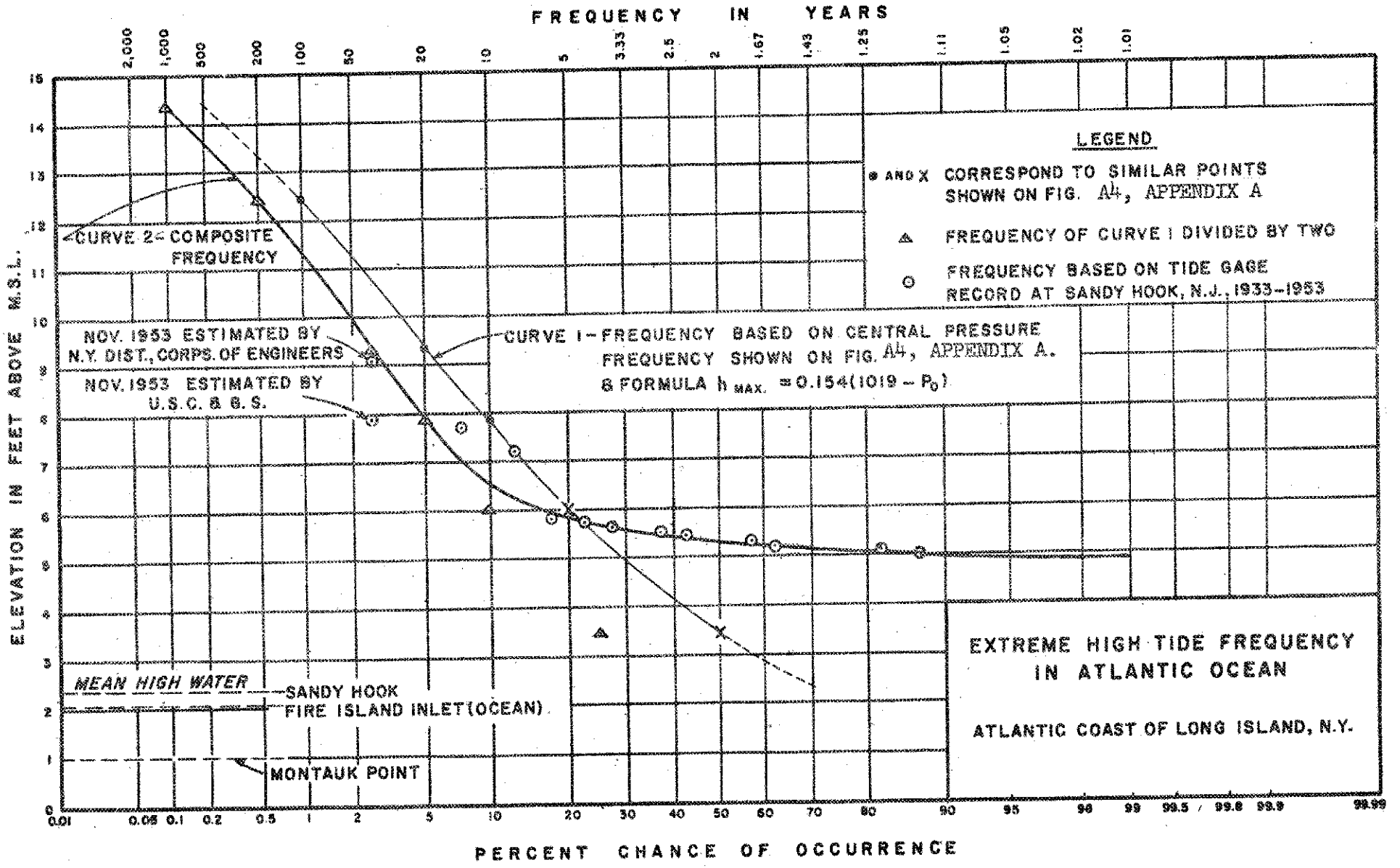
- OCEAN STAGE HISTORY
- BAY STAGE HISTORY (WITHOUT IMPROVEMENT)
- BAY STAGE HISTORY (WITH IMPROVEMENT)

OCEAN AND BAY STAGE HISTORY

MAXIMUM OCEAN SURGE
COINCIDENTAL WITH LOW TIDE

ATLANTIC COAST OF LONG ISLAND, N.Y.

FIGURE C5


FREQUENCY IN YEARS
2,000
1,000
500
200
100
50
20
10
5
3.33
2.5
2
1.67
1.43
1.25
1.11
1.05
1.02
1.01
ELEVATION IN FEET ABOVE M.S.L.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
LEGEND
⊗ AND X CORRESPOND TO SIMILAR POINTS SHOWN ON FIG. A4, APPENDIX A
△ FREQUENCY OF CURVE I DIVIDED BY TWO
⊙ FREQUENCY BASED ON TIDE GAGE RECORD AT SANDY HOOK, N.J., 1933-1953
CURVE 2 - COMPOSITE FREQUENCY
NOV. 1953 ESTIMATED BY N.Y. DIST., CORPS. OF ENGINEERS
NOV. 1953 ESTIMATED BY U.S.C. & G.S.
CURVE I - FREQUENCY BASED ON CENTRAL PRESSURE FREQUENCY SHOWN ON FIG. A4, APPENDIX A. & FORMULA h MAX. = 0.154(1019 - P0)
MEAN HIGH WATER
SANDY HOOK
FIRE ISLAND INLET (OCEAN)
MONTAUK POINT
EXTREME HIGH TIDE FREQUENCY IN ATLANTIC OCEAN
ATLANTIC COAST OF LONG ISLAND, N.Y.
0.01
0.05
0.1
0.2
0.5
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
99.5
99.8
99.9
99.99
PERCENT CHANCE OF OCCURRENCE

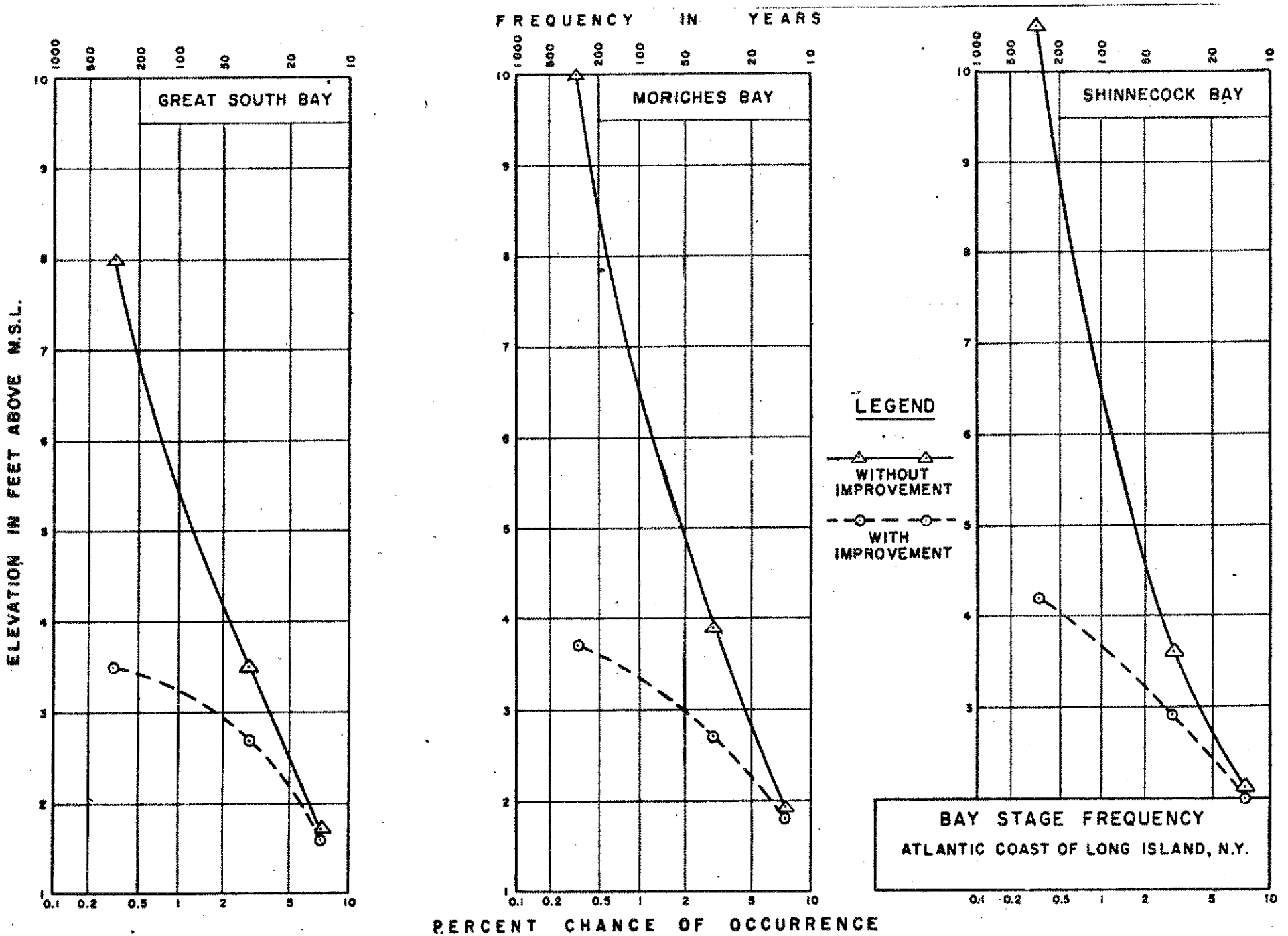
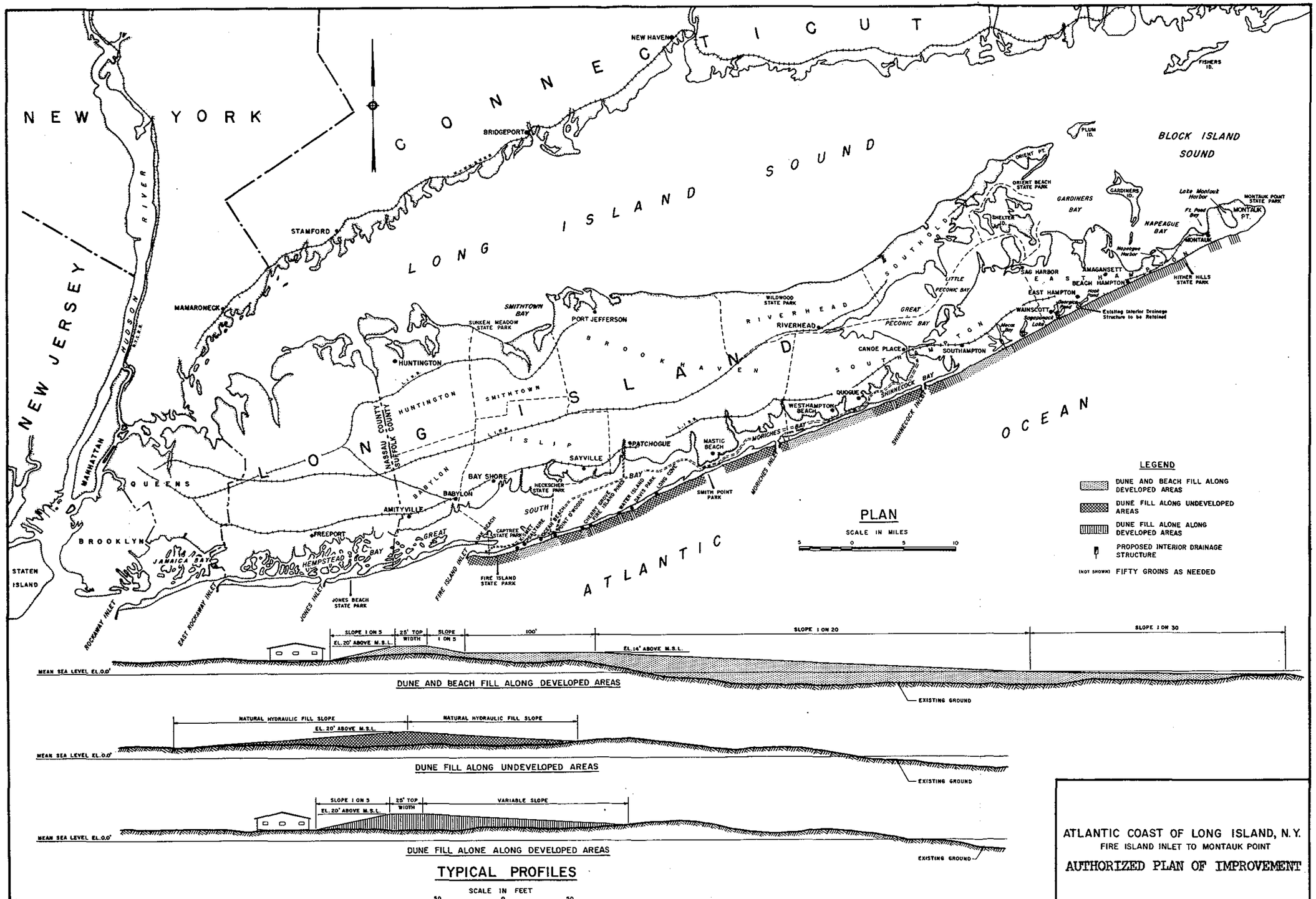

FREQUENCY IN YEARS
1000
500
200
100
50
20
10
GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
ELEVATION IN FEET ABOVE M.S.L.
10
9
8
7
6
5
4
3
2
1
0.1
0.2
0.5
1
2
5
10
PERCENT CHANCE OF OCCURRENCE
LEGEND
WITHOUT IMPROVEMENT
WITH IMPROVEMENT
BAY STAGE FREQUENCY
ATLANTIC COAST OF LONG ISLAND, N.Y.

FIGURE C-7



ATLANTIC COAST OF LONG ISLAND, N.Y.
FIRE ISLAND INLET TO MONTAUK POINT
AUTHORIZED PLAN OF IMPROVEMENT

MAY 1959

FIGURE C8

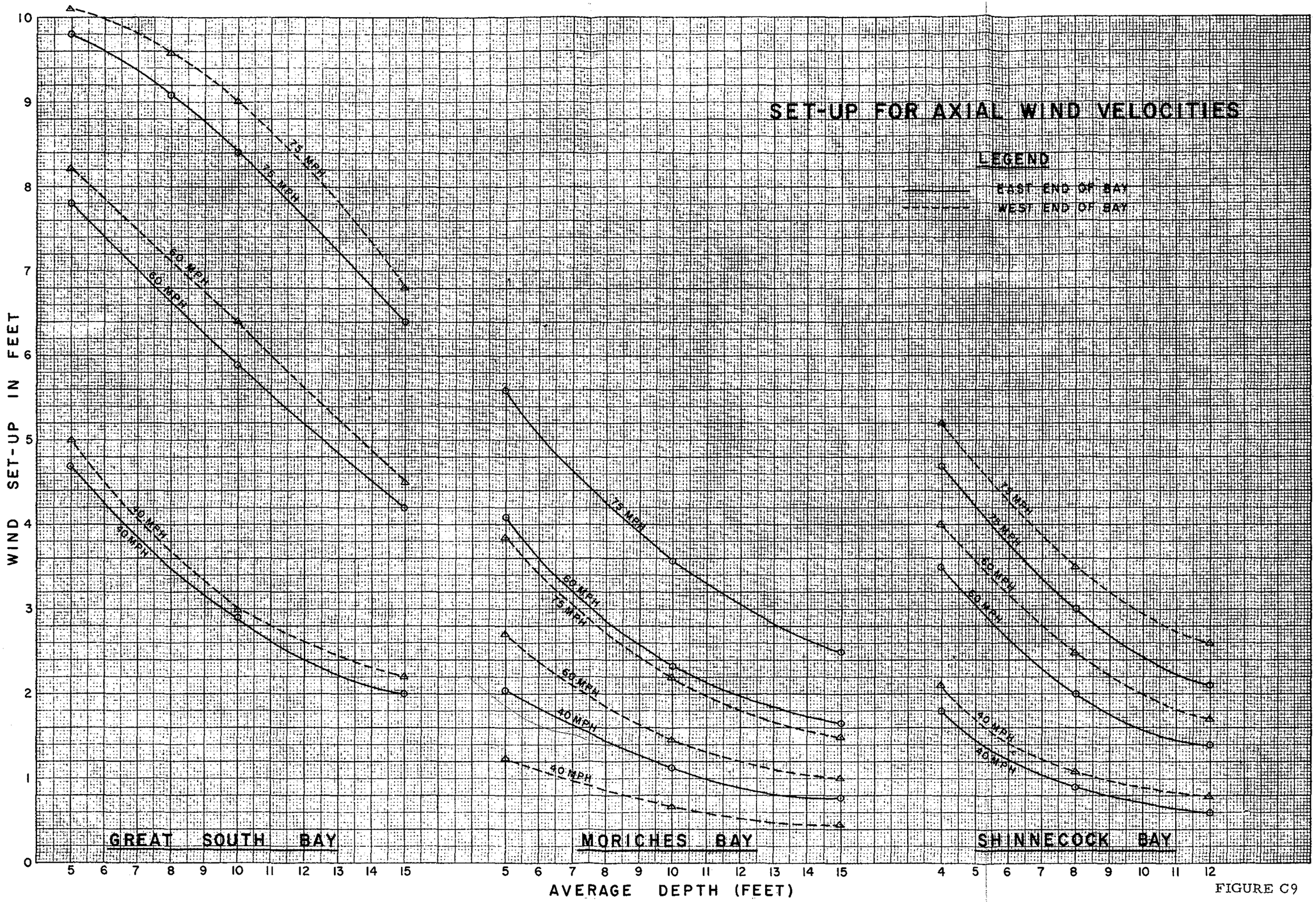
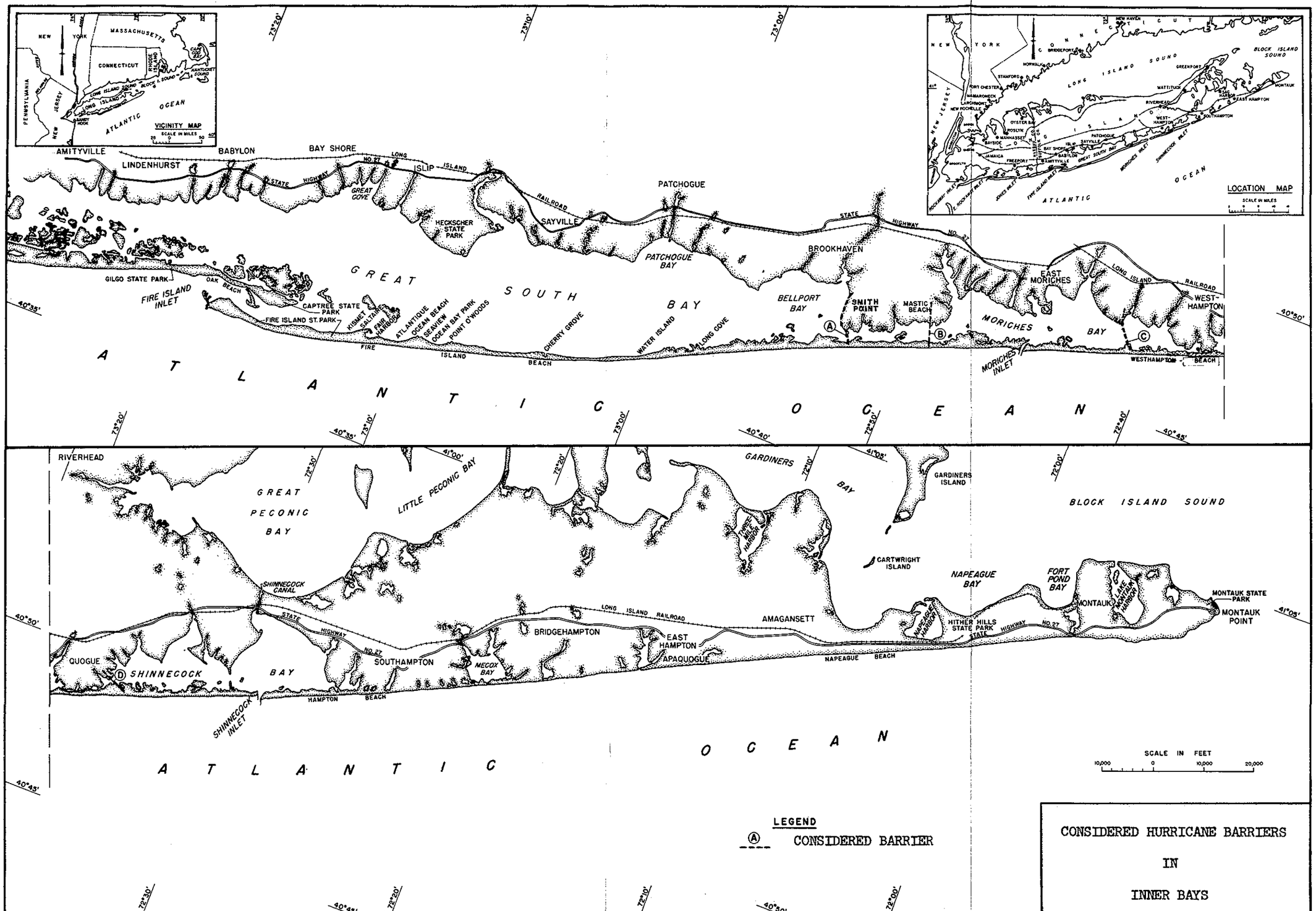
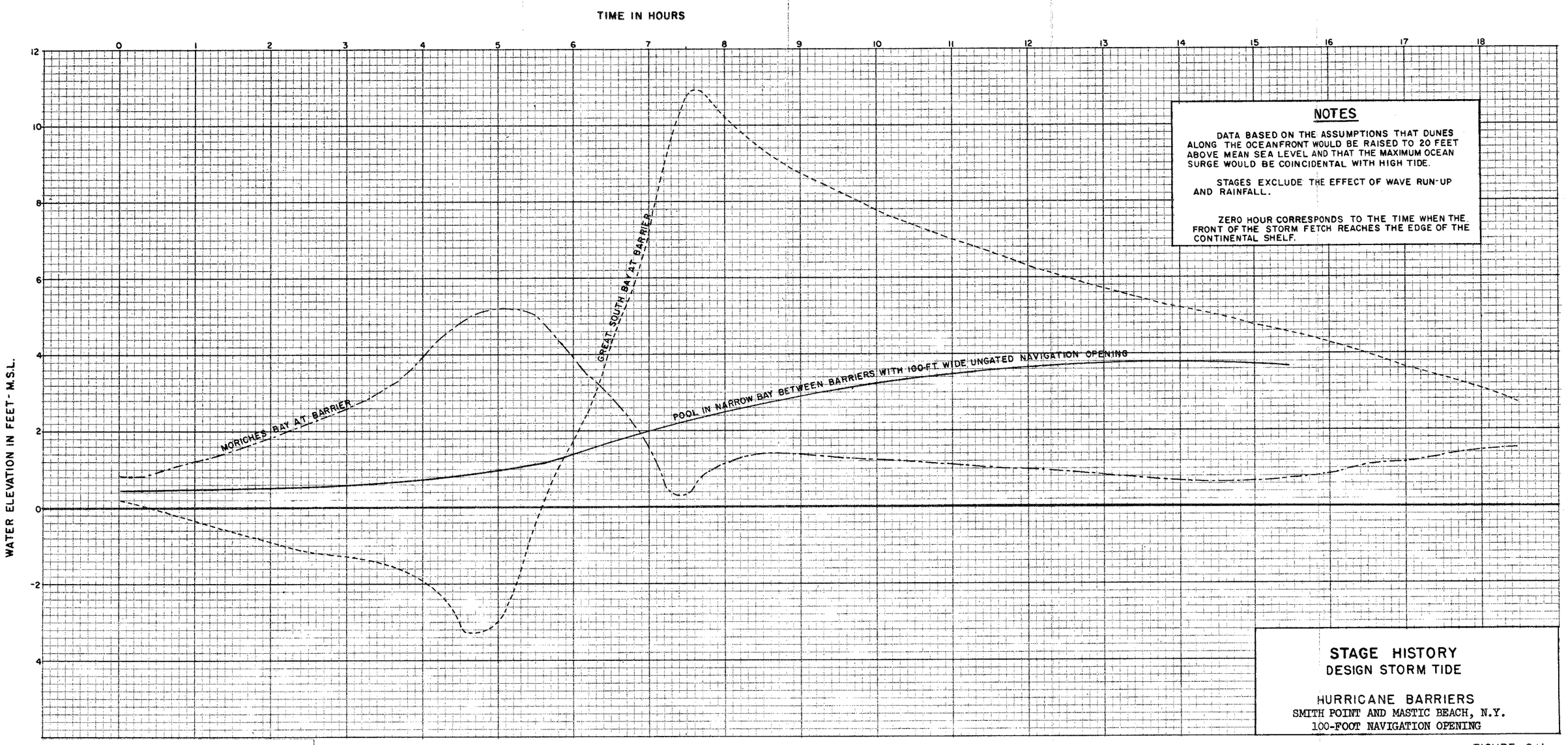

SET-UP FOR AXIAL WIND VELOCITIES
LEGEND
EAST END OF BAY
WEST END OF BAY
WIND SET-UP IN FEET
AVERAGE DEPTH (FEET)
GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
75 MPH
60 MPH
50 MPH
40 MPH

FIGURE C9



CONSIDERED HURRICANE BARRIERS IN INNER BAYS

FIGURE C10



STAGE HISTORY
DESIGN STORM TIDE

HURRICANE BARRIERS
SMITH POINT AND MASTIC BEACH, N.Y.
100-FOOT NAVIGATION OPENING

FIGURE C11

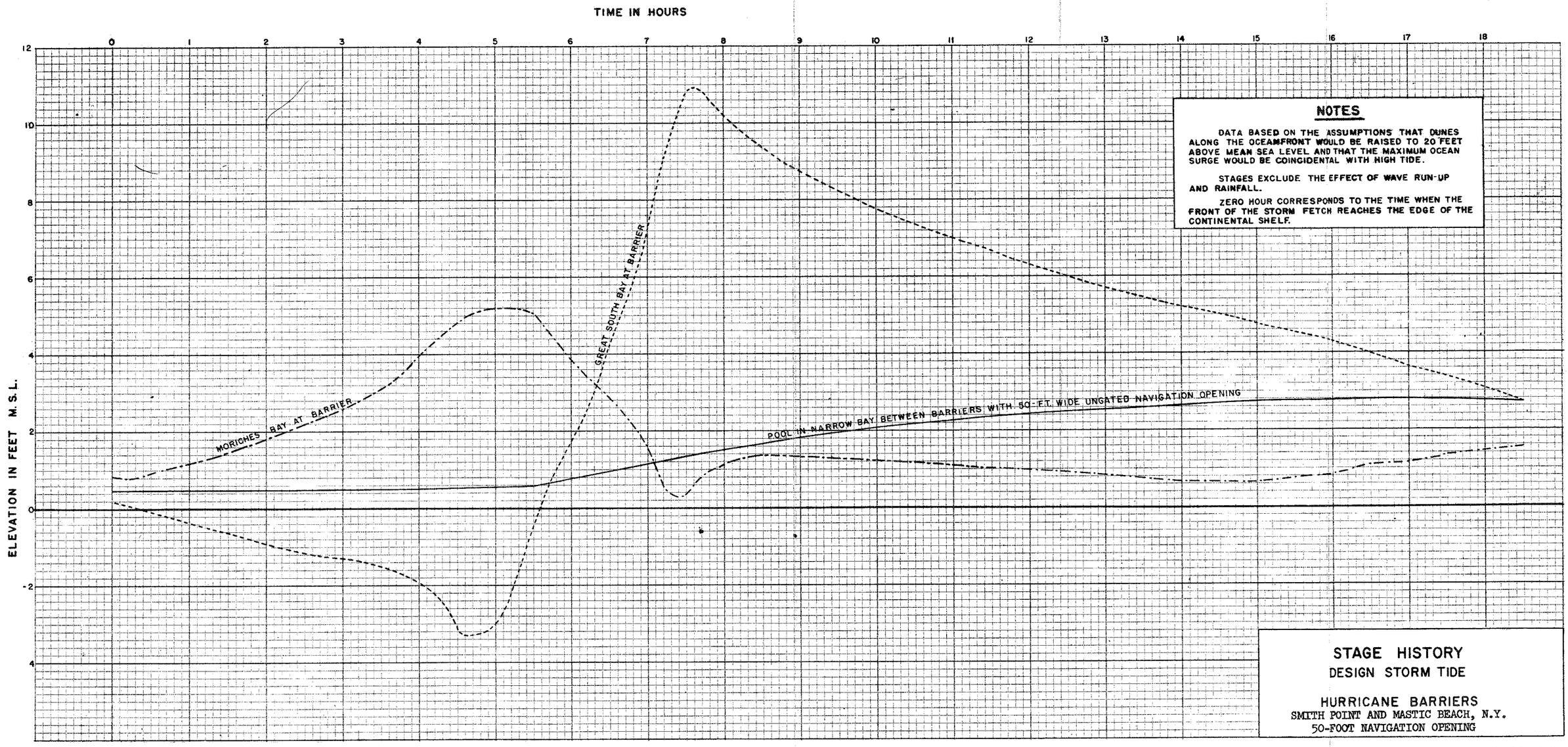

TIME IN HOURS
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
ELEVATION IN FEET M.S.L.
12
10
8
6
4
2
0
-2
-4
MORICHES BAY AT BARRIER
GREAT SOUTH BAY AT BARRIER
POOL IN NARROW BAY BETWEEN BARRIERS WITH 50-FT. WIDE UNGATED NAVIGATION OPENING
NOTES
DATA BASED ON THE ASSUMPTIONS THAT DUNES ALONG THE OCEANFRONT WOULD BE RAISED TO 20 FEET ABOVE MEAN SEA LEVEL AND THAT THE MAXIMUM OCEAN SURGE WOULD BE COINCIDENTAL WITH HIGH TIDE.
STAGES EXCLUDE THE EFFECT OF WAVE RUN-UP AND RAINFALL.
ZERO HOUR CORRESPONDS TO THE TIME WHEN THE FRONT OF THE STORM FETCH REACHES THE EDGE OF THE CONTINENTAL SHELF.
STAGE HISTORY
DESIGN STORM TIDE
HURRICANE BARRIERS
SMITH POINT AND MASTIC BEACH, N.Y.
50-FOOT NAVIGATION OPENING

FIGURE C12

U. S. DEPARTMENT OF COMMERCE
Lewis L. Strauss, Secretary
WEATHER BUREAU
F. W. Reichelderfer, Chief

NATIONAL HURRICANE RESEARCH PROJECT

REPORT NO. 28

A Model Hurricane Plan for a Coastal Community

Prepared by the Weather Bureau in collaboration with the Corps of Engineers, U. S. Army, with the advice of other interested agencies and organizations, and in accordance with the authorization of Public Law 71, 84th Congress, First Session.

Washington, D. C.
April 1959

NATIONAL HURRICANE RESEARCH PROJECT REPORT

Reports by Weather Bureau units, contractors, and cooperators working on the hurricane problem are pre-printed in this series to facilitate immediate distribution of the information among the workers and other interested units. As this limited reproduction and distribution in this form do not constitute formal scientific publication, reference to a paper in the series should identify it as a pre-printed report.

No. 1. Objectives and basic design of the NHRP. March 1956.
No. 2. Numerical weather prediction of hurricane motion. July 1956.
Supplement: Error analysis of prognostic 500-mb. maps made for numerical weather prediction of hurricane motion. March 1957.
No. 3. Rainfall associated with hurricanes. July 1956.
No. 4. Some problems involved in the study of storm surges. December 1956.
No. 5. Survey of meteorological factors pertinent to reduction of loss of life and property in hurricane situations. March 1957.
No. 6. A mean atmosphere for the West Indies area. May 1957.
No. 7. An index of tide gages and tide gage records for the Atlantic and Gulf coasts of the United States. May 1957.
No. 8. Part I. Hurricanes and the sea surface temperature field.
Part II. The exchange of energy between the sea and the atmosphere in relation to hurricane behavior. June 1957.
No. 9. Seasonal variations in the frequency of North Atlantic tropical cyclones related to the general circulation. July 1957.
No. 10. Estimating central pressure of tropical cyclones from aircraft data. August 1957.
No. 11. Instrumentation of National Hurricane Research Project aircraft. August 1957.
No. 12. Studies of hurricane spiral bands as observed on radar. September 1957.
No. 13. Mean soundings for the hurricane eye. September 1957.
No. 14. On the maximum intensity of hurricanes. December 1957.
No. 15. The three-dimensional wind structure around a tropical cyclone. January 1958.
No. 16. Modification of hurricanes through cloud seeding. May 1958.
No. 17. Analysis of tropical storm Frieda, 1957. A preliminary report. June 1958.
No. 18. The use of mean layer winds as a hurricane steering mechanism. June 1958.
No. 19. Further examination of the balance of angular momentum in the mature hurricane. July 1958.
No. 20. On the energetics of the mature hurricane and other rotating wind systems. July 1958.
No. 21. Formation of tropical storms related to anomalies of the long-period mean circulation. September 1958.
No. 22. On production of kinetic energy from condensation heating. October 1958.
No. 23. Hurricane Audrey storm tide. October 1958.
No. 24. Details of circulation in the high energy core of hurricane Carrie. November 1958.
No. 25. Distribution of surface friction in hurricanes. November 1958.
No. 26. A note on the origin of hurricane radar spiral bands and the echoes which form them. February 1959.
No. 27. Proceedings of the Board of Review and conference on research progress. April 1959.

PREFACE

The model community hurricane preparedness plan which follows is intended to offer local authorities in cities and communities along the Gulf of Mexico and Atlantic Coasts vulnerable to hurricanes suggestions as to planning and organization to minimize hurricane losses.

The value of advance planning for effective action in emergencies is widely recognized. Leadership in preparation for hurricane emergencies must come principally from local authorities. They direct municipal and community planning, control most of the facilities which would be used in meeting an emergency, possess the necessary detailed knowledge of the local area, and have the immediate responsibility for the welfare of their community and its residents.

The principal factor that discourages community hurricane preparedness planning has been the difficulty of evaluating the risk of a hurricane disaster. Some coastal cities have not been visited by a severe hurricane within the lifetime of most, if not all, their residents. Statistically the risk to a given locality will be small. On the other hand the destruction wrought by a hurricane, when it does occur, can be tremendous and in many coastal areas the potential for loss of life and property in a severe hurricane continues to increase year by year. It is therefore believed that the time and effort spent in developing and maintaining a realistic community hurricane preparedness plan is definitely worthwhile.

The hurricane preparedness plan presented herein is for a fictitious city, Homeport, in Achilles County, on the Atlantic Coast. The plan is equally applicable elsewhere. The plan deals with real hazards associated with hurricanes and shows what might be done to minimize death and destruction.

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7. Plan B - Expected Tide 9-12 Ft. M.S.L.	20-22
8. Plan C - Expected Tide 13-16 Ft. M.S.L.	22-24
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HOMEPORT - GENERAL INFORMATION

Homeport, with a population of about 25,000, is laid out on land ranging from 3 to 20 ft., m.s.l. The eastern edge of the business section is about 500 ft. from the beach and lies in the 5-10 ft. m.s.l. range.

While Homeport is an old city, it is progressive. There are at least six fairly new office and store buildings with two to four floors that have been designed to withstand severe hurricanes and floods. The oldest part of the city is on the beach. Most of the stores and homes are one-story frame buildings constructed long before any stringent building codes were in effect. The most exposed part of the city is the residential section known as Homeport Beach, (pop. about 700), located on a key about one mile from the mainland. A two-lane causeway about 4 ft. above mean high water connects it with the rest of the city. A drawbridge on this causeway has to be raised for almost all boat traffic. The highest elevation on the key is 5 ft. m.s.l. Almost all homes are small one-story wooden buildings of relatively light construction.

The city is well managed. It has adequate police and fire protection and public transportation (busses). It operates a marina, which is in a small lake about 2 miles inland on the northern edge of the city. The inlet to the lake is shallow and at mean tide accommodates boats drawing less than 4 ft. Practically all locally owned smaller pleasure boats are kept at the marina. The larger fishing craft and yachts are usually tied up at the beach piers near the mouth of the inlet.

The electric power (Diesel-operated) and gas plants are in the older section of the city on land 6 ft. m.s.l. The power lines are generally overhead except in the business section and in the newest residential areas. The only radio station (WXYZ) in the city is located in the business section atop one of the most substantial buildings in the city, the four-story Triangle Building. Unfortunately, it has no standby power plant. The local Civil Defense and Red Cross Units are well organized and active.

1. HURRICANE PREPAREDNESS COMMITTEE

1.1.1 A permanent Hurricane Preparedness Committee is hereby set up to provide the city of Homeport and suburban communities with adequate protection to minimize death and property losses usually associated with hurricanes. This Committee consists of the following:

City Director, Civil Defense, Chairman

Mayor
County Director, Civil Defense
Chapter Chairman,
Homeport Chapter, Red Cross
District Chief, State Police
Sheriff, Achilles County
Chief of Police
City Engineer
Supt. Public Works
Supt. Street Dept.
Supt. Schools

Disaster Chairman,
Homeport Chapter, Red Cross
Newspaper official
Telephone Co. official
Power & Gas Co. official
Manager, Public Transit
Local representative of press,
National Assoc. of Broadcasters,
and of American Radio Relay
League

The following state and area officials have agreed to be available for consultation by the Committee and to serve in a liaison capacity to the Committee when requested:

Governor's representative
State Director, Civil Defense

Disaster Service Representative,
Red Cross
Director, State Public Health

The following federal officials have agreed to be available for consultation by the Committee and to act in a liaison capacity when requested:

Meteorologist in Charge,
Weather Bureau Airport Station,
Homeport
Area Engineer, Corps of
Engineers, Homeport

Commanding Officer, U. S. Coast
Guard Station, Homeport
Commanding Officer, Inland
Air Force Base

1.1.2 The Committee has the following responsibilities for the Homeport Hurricane Preparedness District (Chart 1):

(1) To direct a program designed to educate the public on the hazards of hurricanes and the protective measures to be effected.

(2) To keep the city and suburbs continually prepared for a hurricane emergency.

(3) To make recommendations regarding construction projects and changes in building codes required to lessen danger and destruction from

hurricanes.

(4) To effect evacuation when authorized.

(5) To direct rescue work.

1.1.3 The Committee shall meet as often as need indicates until a satisfactory preparedness plan has been completed. Thereafter the Committee shall meet at least once a year just before the beginning of the hurricane season (early June) to review the plan and to make sure each member is well acquainted with the duties his organization is expected to perform in case of emergency. In other words, this meeting is in the nature of a "dry run". Other meetings shall be called as required. The Committee shall convene every time a HURRICANE WATCH indicates a threat to its area of responsibility, or earlier when suggested by the Weather Bureau's local Meteorologist in Charge, and will remain in session or on call until the emergency or threat is ended.

1.1.4 The Chairman of the Committee, the Mayor, and the County Director of Civil Defense will function as an executive group of the Hurricane Preparedness Committee to oversee the execution of evacuation plans and to deal with other emergency matters which may arise and require immediate decision and which are not otherwise provided for in the plan. The final authority for execution of evacuation plans in the City is the Mayor and in the County the County Director of Civil Defense.

2. APPRAISAL OF POTENTIAL DANGER

Introduction

2.1.1 The Homeport area has been particularly fortunate in that it has not been visited by disastrous hurricanes for many years. However, this is no indication that it is immune to hurricane disasters. The Atlantic coast has been visited many times by hurricanes, and the losses in life and property have both been tremendous. These losses would have been much greater had not protective measures been taken. The losses would have been still less had today's hurricane warning facilities been available for tracking and predicting the behavior of all these hurricanes. The best hurricane warning service in the world is of little use, however, unless adequate protective measures are taken. Experience has disclosed the type of information required for the planning of adequate protective measures. This report contains the necessary information for the preparation of such a plan. The large increase of population and property value in the Homeport area during recent years makes a hurricane preparedness plan more important than ever.

Coastal Hurricanes

2.2.1 An opinion of the degree of disaster associated with hurricanes can best be obtained by a review of major coastal hurricanes of recent years.

The hurricane of September 18-20, 1926, is said to have been one of the most destructive hurricanes of the century. The property damage was estimated at $100,000,000. Approximately 4700 homes were destroyed and 9100 damaged. The Red Cross estimated that 15,700 families were homeless. The storm tide was 10.5 ft. m.s.l.

2.2.2 Second only to the Galveston, Texas, hurricane of September 8, 1900, in order of deaths was the hurricane of September 15-17, 1928. The Red Cross estimated 1836 lives lost, 1870 injured, and property damages of $25,000,000. Loss of life and property resulted mainly from waters of Lake Okeechobee overflowing the southeast bank. Winds were in excess of 100 mph.

2.2.3 Hurricane "Carol" crossed Long Island and southeastern New England August 31, 1954 causing enormous destruction to communication and power lines, buildings, automobiles, small craft, marine facilities, and crops. The hurricane moved inland at time of normal high tide resulting in extensive coastal flooding. Property losses were estimated at over $400,000,000.

Hurricanes Affecting Homeport Area

2.3.1 Some residents of the Homeport area believe that the area is immune from hurricanes. This belief has no scientific basis. This area has come under the influence of several hurricanes during the period of record. That none of these hurricanes passed directly over Homeport and that those coming very near were of relatively weak intensity is merely due to chance.

2.3.2 On October 2, 1898 a hurricane entered the coast within 70 miles of Homeport. The resulting high water at Goodhaven, 35 miles north of Homeport, reached 10.8 ft. m.s.l. or 7.8 ft. above mean high water. Luckily, this was not a particularly potent hurricane. Its lowest pressure was only 28.82 inches, as compared with 26.35 inches for the Labor Day Hurricane of September 2, 1935; 27.66 inches for hurricane "Hazel" of October 15, 1954; 27.62 and 27.59 inches for the hurricane of September 15-17, 1928, and September 18-20, 1926, respectively.

2.3.3 Other hurricanes have entered the coast not far from Homeport, but Homeport and vicinity have thus far been particularly fortunate in not having had to bear the brunt of a direct hurricane assult during the period of record.

Storm Tides and Floods

2.4.1 Storm tides and floods, which account for over three-fourths of the deaths and much of the destruction associated with hurricanes, deserve special attention. Much of their destructiveness results from the rapidity of rise in the tide. Studies indicate a relation between the central pressure of the hurricane as it enters the coast and the maximum departure of the tide from its normal value along the open coast. The relation, which indicates a maximum storm tide of 20 ft. for the minimum observed pressure of record, 26.35 inches, is valid only for tides on the open coast. Near the head of an estuary the highest tides may be as much as twice the height of those on the open coast.

2.4.2 The highest tide of record in the Homeport area is the 10.8 ft. m.s.l. observed at Goodhaven during the October 2, 1898 hurricane described above. Homeport, itself, has a fairly short record of tide measurements. The longest record (12 years) is at the Municipal Pier, which recorded a record maximum of 5.0 ft. m.s.l. in connection with the October 18, 1950, hurricane.

2.4.3 It is estimated that a hurricane like "Hazel" which passed over Myrtle Beach, South Carolina, on October 15, 1954, could produce a storm tide of 13 ft. if located directly over Homeport. If this storm tide coincided with the mean high water level, the storm tide would reach 16 ft. m.s.l. While a tide of this magnitude would undoubtedly be a rarity for Homeport, it is possible. Protective measures should be taken with this possibility in mind.

2.4.4 The intense rainfall associated with hurricanes could cause all streams in the county to overflow their banks and swamp water levels could be raised as much as 2 ft.

Wave Heights

2.5.1 The wave heights that might occur along the beach are dependent upon the topography of the ocean bottom near the beach, wave direction, depth of water, and the direction, speed, and duration of the winds. The waves are not limited to the actual vicinity of the hurricane but may be hundreds of miles away. On September 8, 1951, 11-ft. waves were observed at Melbourne Beach, Florida, with the hurricane still 700 miles away. At Homeport Beach the waves would probably break offshore. Studies indicating wave heights to be limited to about three-fourths of the water depth suggest that wave heights of the order of 12 ft. could be expected at the mean shore line with a 16-ft. storm tide.

Wind Speeds

2.6.1 Maximum wind speed to be expected at the shore line is 150 mph -- in an onshore direction. Duration of winds of 60 mph or higher could be as much as 8 hours.

Delineation of Predicted Threatened Areas

2.7.1 The extent of coast line endangered by an approaching hurricane can be estimated on the basis of forecasting experience. The accuracy of Weather Bureau forecasts of Atlantic hurricanes in the period of 1950-56 indicates that protective measures must be initiated over 250 miles of coast line at least 12 hours and over 150 miles at least 6 hours before the hurricane is forecast to cross the coast to insure that the area affected by the hurricane is protected about 90 percent of the time.

Emergency Control Center

2.8.1 The Homeport Hurricane Preparedness Committee has established an Emergency Control Center at Burr High School. Direct underground telephone lines connect the Center with all agencies represented in the committees.

The Center is equipped with several battery-powered radio receivers to receive broadcasts on all assigned wave lengths and with two receivers adapted for CONELRAD monitoring. A monitoring unit will listen to and record on tape all broadcasts from all sources serving the area in order to ascertain that the hurricane information being broadcast is based on the latest official information. Stations broadcasting obsolete information will be immediately informed of the latest releases available. Those broadcasting unofficial hurricane information will be asked to broadcast official releases only. If they persist, they will be asked to announce very clearly that the information is unofficial and to name the source of the information.

2.8.2 The Center has no transmitting equipment of its own, but Commercial Station WXYZ and the police and fire department transmitters have direct line microphones at the Center so direct broadcasts are possible. In emergencies, Civil Defense, police and fire department mobile transmitters will be stationed at the Center to insure against breakdown of communications should other means fail.

2.8.3 Burr High School has set up a meteorological station for instruction purposes. This makes a very convenient auxiliary weather station that can be activated during emergencies.

2.8.4 The Center is also equipped with sufficient portable battery-powered lamps to provide good lighting if power fails.

Emergency Communications Network

2.9.1 Commercial Station WXYZ is the only station in the vicinity. Its management has agreed to broadcast all information provided by the Committee during an emergency. While the station is usually permitted to operate only from 6 a.m. to midnight, broadcasting on a 24-hour basis during emergencies has been approved. The emergency is considered to begin when a HURRICANE WATCH indicates a threat to the Homeport area. Unfortunately, Station WXYZ has no standby power plant. In the event of a power failure, Station WMET at Metropolis has agreed to broadcast all information presented by the Homeport Hurricane Preparedness Committee. The information would be sent to WMET via police teletypewriter and radio and Civil Defense radio. Both stations WXYZ and WMET have agreed to preface emergency weather warnings with the CONELRAD attention signal when so requested by the Weather Bureau.

2.9.2 Tape recordings should be made of all broadcasts and retained for at least two weeks after the emergency has ended. These tape records would be very useful in an investigation of a disaster. Failure to transmit warnings properly is a frequent complaint. More often than otherwise, such a complaint is not justified, and the tape record would help to vindicate the source of the warning and the broadcasting station should they be criticized.

2.9.3 All organizations, offices, and agencies represented in the Homeport

Hurricane Preparedness Committee are equipped with CONELRAD alert receivers. Consequently, they can receive emergency weather warnings broadcast following the CONELRAD attention signal at any hour of the day or night.

2.9.4 Mobile communications equipment, together with operating personnel, is kept in a ready status at Coast Guard District Headquarters and some other Coast Guard units within the District. This equipment varies in size from hand portable type to a completely self-contained communications truck. The Coast Guard District Commander will deploy this equipment to assist Homeport and other communities. Available equipment will be deployed so as to insure maximum effective utilization throughout the threatened area.

2.9.5 The Coast Guard Station maintains a two-way radio station which can be utilized until evacuation becomes necessary. (Many are included in teletypewriter distress net.)

Safe Buildings

2.10.1 The City Engineer has indicated to the Red Cross the following buildings as being suitable for shelter purposes for various degrees of potential danger.

Expected Tide Height (ft., m.s.l.)
(Assuming maximum wind speeds and wave heights consistent with tide)

Section of City	4-8	9-12	13-16
Downtown	Acme Bldg. Apex Bldg. Triangle Bldg. King Hotel Adams Hotel Christ Church	Acme Bldg.* Apex Bldg.* Triangle Bldg.* King Hotel* Adams Hotel* Christ Church	Acme Bldg.* Apex Bldg.* Triangle Bldg.* King Hotel* Adams Hotel*
North End	City High School Masonic Hall Gem Theatre	City High School Masonic Hall Gem Theatre	City High School* Masonic Hall*
South End	City Hall Court House Elementary School Armory	City Hall* Court House* Elementary School Armory	City Hall* Court House*
The Ridge	Burr High School First Church City Hospital City Auditorium Primary School	Burr High School First Church City Hospital City Auditorium Primary School	Burr High School First Church City Hospital City Auditorium Primary School

* Denotes "above first floor."

Evacuation Areas, Shelters, and Routes

2.11.1 The City Engineer has prepared 5 maps showing areas to be evacuated when expected tide height is (a) 4-8, (b) 9-12, and (c) 13-16 ft. m.s.l. Locations of shelters, emergency bus loading points, and routes are also shown. These maps have been printed and distributed to all residents of the Homeport area. Additional supplies of these maps, revised if necessary, will be printed and distributed in early June of each year.

2.11.2 The large number of persons to be evacuated under Plan C necessitated setting up shelters outside Homeport. Arrangements have been made with the officials of the towns of Fairhaven, Mound City, and Crossville for the use of their schools as shelters.

Contamination of Water Supply

2.12.1 The old city water supply plant in the North End would be contaminated if tides exceeded 8 ft. m.s.l. The new plant on The Ridge would retain its normal purity even with the highest possible tides. The temporary elimination of the old plant would necessitate drastic rationing of water, but there would be enough to supply the entire city with enough water for drinking and cooking until the old plant could be reactivated.

2.12.2 Flooding of wells or septic tanks would contaminate well water. Consequently, such water should not be consumed until purified. Care should be exercised as the contamination could occur even though the storm tide might not be high enough to endanger the homes themselves.

3. CONTINUAL PREPAREDNESS

3.1.1 The Emergency Control Center and emergency radio network will be checked in early June and monthly throughout the hurricane season to insure that everything is in readiness for an emergency. The Hurricane Preparedness Committee has also set up a program of public education and precautionary measures for the purpose of minimizing hurricane hazards.

Public Education

3.2.1 Radio Station WXYZ will present in late May and early June of each year a series of at least five 15-minute broadcast interviews with authorities on various phases of hurricane preparedness. The Superintendent of Schools is directed to instruct his teachers to inform their charges of these radio broadcasts and to quiz them on the information broadcast. The Homeport Herald will publicize these broadcasts and publish summarizations of the interviews.

3.2.2 When the Hurricane Preparedness Committee meets in early May, it will hold at least one evening meeting where several members or guest hurricane disaster experts can review the local hurricane problem for the public and answer any questions that might be asked.

3.2.3 The broadcasts and newspaper articles should include mention of continual precautionary measures that not only tend to reduce danger and damage during an emergency but to maintain properties from depreciating through neglect. The public will be asked to take the following precautionary measures:

1. Check homes. Secure loose shingles. Repair window shutters and shaky chimneys.

2. Check yards. Trim or remove dead or dying trees. Anchor removable objects such as dog houses, chicken coops, lumber piles, etc.

3. Maintain supply of boards for boarding up picture and show windows.

4. Always keep at hand at least one flashlight in good condition.

5. Promptly raze condemned buildings.

6. Obtain radio receivers equipped as CONELRAD monitors and battery-powered sets for emergency use.

3.2.4 Also to be broadcast and published are instructions on what should be done when a hurricane is expected to strike the area. These include the following:

1. Keep your radio or television on and listen for latest Weather Bureau warnings and advisories. If power fails, use your car radio or other battery-powered receivers. Keep radio tuned in on WXYZ and observe its instructions. Keep CONELRAD monitors on at all times if not actually listening to broadcasts. Keep your radioless neighbors informed. All persons operating small boats and vessels maintain guard on calling and distress frequency 2182 kc for warnings and advisories. Those without radios maintain lookout for signals or messages from Coast Guard vessels or aircraft. Return to safest mooring available and secure all equipment possible.

2. Avoid being misled by rumors.

3. Get away from low-lying beaches or other locations which may be swept by high tides or storm waves. If passage to high ground is over a road likely to be under water,

leave early. Don't run the risk of being marooned.

4. If your house is out of danger from high tides and is well built then it is probably the best place to weather the storm. However, please act promptly if asked to evacuate.

5. Be alert for high water in areas where streams or rivers may flood after heavy rains.

6. Board up windows or put storm shutters in place. Use good lumber securely fastened. Makeshift boarding may do more damage than none at all. Have strong bracing for outside doors.

7. Get in extra food, especially things which can be eaten without cooking or with very little preparation. Electric power may be off and you may be without refrigeration. Place dry ice in deep freezers and refrigerators to keep food from spoiling.

8. If emergency cooking facilities are necessary, be sure they are in working order.

9. Sterilize the bathtub, jugs, bottles, cooking utensils, and fill with drinking water, as city water service may be interrupted and wells may be polluted.

10. If in one of the evacuation areas, move furniture and other valuables to upper floors to minimize flood damage.

11. Have flashlights and/or other emergency lights in working condition and keep them handy.

12. Be sure to have gasoline in your car. If electric power is off, filling stations may not be able to operate pumps for several days.

13. Check on everything that might blow away or be torn loose. Garbage cans, garden tools, toys, signs, porch furniture, awnings, and other objects become weapons of destruction in hurricane winds. Store them all inside if possible.

14. Be sure that a window or door can be opened on the lee side of the house . . . the side opposite the one facing the wind.

15. Make provisions for children and adults requiring special diets. If anyone in your home has to be removed by ambulance, phone the Emergency Control Center, EM 1-1111.

16. If possible, arrange for the safe keeping of pets and other animals by friends living in quarters that will not have to be evacuated. No pets or animals of any kind will be allowed in evacuation busses or trucks nor in shelters.

17. If the center or "eye" of the storm passes directly over, there will be a lull in the wind lasting from a few minutes to half an hour or more. Stay in a safe place. Make emergency repairs during the lull if necessary, but remember the wind will return suddenly from the opposite direction, frequently with even greater violence.

18. Be calm. Your ability to meet emergencies will inspire and help others.

19. When your Hurricane Preparedness Committee advises evacuation, follow instructions promptly.

    a) Shut off main gas valve and pull main switch before leaving home.

    b) Head for the proper shelters or evacuation points indicated for your area. (These are shown on your Evacuation Maps, but the information will also be broadcast at the time of emergency.) Bring whatever clothing is absolutely necessary but do not try to bring household equipment. Follow routes indicated on maps. Drive right up to shelter entrance, unload, and park car as police instruct. If on foot, proceed to nearest loading station and board busses. No fare will be charged.

c) Evacuated areas will be policed to prevent looting.

d) At shelter, follow instructions of Red Cross personnel in charge. Volunteer your assistance, especially if you are a doctor or nurse.

e) Remain at shelter until informed that you may leave. Re-entry into evacuated areas will not be permitted until Public Health officials and building inspectors have had a chance to make their inspections and have given their approval. Evacuees will then be given passes providing for re-entry into the areas from which they were evacuated.

f) Keep calm at all times. If instructions are observed promptly, there is little personal danger involved. The local hazards from hurricanes have been carefully evaluated, and the measures taken for your protection have been well planned.

Precautionary Measures

3.3.1 The precautionary measures to be taken were mentioned above under Public Education. The city will keep its buildings and trees in good order. The Tree Division of the Street Department will trim or remove privately owned trees at cost. The Fire Department will make a survey of the city in the early part of the year and notify home-owners of trees, chimneys, etc. that need attention. The City Engineer will check to see that all gas and gasoline storage tanks and radio towers are securely anchored to prevent dislocation by wind or flood. The Police Department will enforce City Ordinance No. 492, which obligates owners of condemned buildings to have them razed within 90 days of Condemnation Notice. The Public Works Department will ascertain that all drawbridges and piers are in good condition before the beginning of the hurricane season. The Street Department will schedule its maintenance so that no evacuation route has to undergo extensive repairs during the hurricane season.

Planning and Construction to Minimize Hazards

3.4.1 Until there are enough shelters in the Homeport area to accommodate all its evacuees, future city and county buildings will be built so they can serve as hurricane shelters. The new one-story Junior High in the North

End is useless as a shelter because its floor would be under water with a tide of only 7 ft. m.s.l. Furthermore, the large glass panels, which make up most of the walls, would offer a real hazard in a high wind. New buildings will be limited to ordinary-sized windows with walls to be of solid construction. All buildings on land that might possibly be flooded will have at least one floor above the highest possible tide height. The City Engineer will work with the Planning Commission on a revision of the building codes for all types of buildings including homes.

3.4.2 The new coastal 4-lane highway (Route 17) providing main exits to the north and south of Homeport is bottlenecked on the north end of the city by the 2-lane drawbridge across the inlet to the marina. Steps have been taken to replace this bridge with a raised, fixed 4-lane structure, which will allow most boats to pass underneath. Boats with masts over 20 ft., of which there are no more than six now using the marina, will have to tie up at the ocean piers.

3.4.3 The power plant is in a fairly vulnerable location. If it is ever relocated, it should be built on higher ground well removed from the water front. The Homeport Power and Gas Company estimates that the output of the plant will have to be increased in about two years and has agreed to build the new auxiliary plant on the western edge of the city on land now owned by the city. This plot is about 15 ft. m.s.l. and is 2 miles from the beach. All buildings set aside for shelters, the hospital, Emergency Control Center, and Station WXYZ will be supplied with electricity by underground cable from the new power plant. The possibility of power failure at these important posts during an emergency would be practically eliminated.

3.4.4 New sewers and septic tanks will be designed and located so as to minimize the health hazards associated with their malfunctioning during high storm or hurricane tides. Wells will be designed and located to minimize risks of pollution from malfunctioning sewers or septic tanks.

Military Assistance

3.5.1 Military assistance from any of the branches of the Armed Forces is furnished under the responsibility of the Department of the Army; this responsibility has been delegated to Army Commanders having jurisdiction over continental army areas. Direct assistance from local military installations is authorized when extreme emergency conditions do not permit delay for receipt of instructions from higher authority, and local officials are unable to cope with the situation. The primary objectives in supplementing local resources are to save lives, prevent suffering, and reduce damage to Federal property, without assuming functions which normally are performed locally. Military assistance does not extend to rehabilitation, except as requested and authorized by the Office of Civil And Defense Mobilization. Liaison with military forces will be maintained through the Commanding Officer, Inland Air Force Base, Homeport. Motion pictures and other instructive material regarding military assistance may be made available through request to the State Civil Defense Director.

4. EXECUTION OF EMERGENCY PREPARATIONS

4.1.1 When a HURRICANE WATCH is issued for the Homeport area, the local Weather Bureau Office will immediately notify the chairman of the Hurricane Preparedness Committee. The chairman will call an immediate meeting of the Committee to review preparations for emergency procedures.

> HURRICANE WATCH: An announcement issued by the U. S. Weather Bureau to the public and all other interests via press and radio and television broadcasts whenever a tropical storm or hurricane becomes a threat to a coastal area. The "Hurricane Watch" announcement is not a warning; it indicates that the hurricane is near enough that everyone in the area covered by the "Watch" should listen for subsequent advisories and be ready to take precautionary action in case hurricane warnings are issued.

4.1.2 The Weather Bureau will immediately send emergency assistants to supplement the staff at the local office. No local action is required to effect this. The local office will notify all on its hurricane alert list.

4.1.3 The Fire and Police Departments will place all their personnel on 24-hour on-call duty and recall those who might be on leave outside the area. They will also check all equipment.

4.1.4 All members of the emergency communications network will be notified to prepare for emergency procedures. The Homeport Herald and Station WXYZ will publicize the threat and issue new warnings promptly. Only official Weather Bureau warnings will be publicised.

4.1.5 The disaster representative of the Red Cross will call in reinforcements from cities outside the threatened area.

4.1.6 Both railroad companies operating in the area will move all rolling stock in the yards to inland cities. Both airlines serving the area will give priority on incoming reservations to representatives of the Weather Bureau, Civil Defense, Red Cross, Corps of Engineers, State and local police, local firemen, Florida National Guard (Homeport's Co. G), and Homeport Coast Guard Station.

4.1.7 The Homeport Coast Guard Station, assisted by the Coast Guard Auxiliary, will notify all ships tied up at the piers or anchored offshore of the threat. The Coast Guard District Radio Station, plus any other Coast Guard Radio Station designated by the Commander of the Coast Guard District will broadcast warnings and advisories on standard marine frequencies. Coast Guard aircraft from the nearest Coast Guard air unit will cover coastal and inland waterways and isolated land areas, dropping messages to vessels and persons who may not have received warnings by any other method.

4.1.8 The Homeport Transit Company will ready all its spare busses and alert its spare drivers.

4.1.9 The CAP will patrol the coastal area to ascertain that warnings have been heeded. Any boats that are not headed for Homeport will be reported immediately to the Coast Guard by radio.

4.1.10 State Police will set up check points on main highways leading into threatened area to control entry and re-entry. The Homeport Hurricane Preparedness Committee will issue special passes to persons who have to pass through the police lines in the performance of their emergency duties. Evacuees will receive another type of pass so they can be the first to re-enter the evacuated areas after decontamination forces and building inspectors have indicated that re-occupation is safe. The State Police will also patrol the beaches (outside the city limits) 20 miles north and south of Homeport to warn beach campers to leave.

4.1.11 The County Sheriff will send his force out to alert all exposed settlements and trailer camps to maintain a constant radio watch for further instructions. They should also be told where to go if they are warned to evacuate. The settlements and trailer camps to be alerted are indicated on the evacuation maps, but there is a list posted in the Sheriff's Office of the settlements for which he is responsible. The Sheriff's men should also be on the lookout for temporary settlements or trailer camps of roving fruit-pickers which are not shown on the map.

4.1.12 The highway, street and public works departments will take immediate steps to open all streets and roads where construction or repairs are in progress. Where this is not possible, the street or road will be barricaded at an intersection, so as to avoid a dead-end, and DETOUR signs prominently posted. Heavy movable equipment, such as bulldozers, rollers, earth movers, etc., will be taken to the city lot on the western edge of the city.

4.1.13 Each of the agencies involved in the emergency preparations has a schedule of the actual duties it is expected to perform. These schedules will be followed to the letter unless countermanded by the Hurricane Preparedness Committee because of some unpredictable development.

5. EXECUTION OF EMERGENCY PROCEDURES

5.1.1 Emergency procedures will be initiated when a HURRICANE WARNING indicates a hurricane will reach the Homeport area within 24 hours.

> HURRICANE WARNING: A warning indicating that hurricane winds of 74 miles per hour (64 knots) or higher or a combination of dangerously high water and very rough seas (with winds as low as 60 miles per hour) are expected in a specified coastal area. When a Hurricane Warning is announced hurricane conditions are considered imminent and may begin immediately or at least within 24 hours. It is of utmost importance that precautionary actions be instituted immediately when a Hurricane Warning is announced.

5.1.2 The radio emergency network will go on emergency schedule and operate continuously until the emergency has ended. Broadcasts will be made directly from the Emergency Center and Weather Bureau Office. The following agencies will each station one mobile broadcast unit in the parking lot at Burr High School: Civil Defense, city police, state police, sheriff's office, fire department, and power company. These mobile units will enable the Emergency Control Center to keep in direct touch with all emergency groups at all times.

5.1.3 The broadcasts should remind the public to remain calm, to remain at home, to stay tuned in continuously, and to begin precautionary measures. The following information will be broadcast:

1. "Hurricane Safety Precautions", U. S. Weather Bureau, 1958

2. "Hurricane Preparedness in Homeport, " Homeport Hurricane Preparedness Committee, 1957

3. "Tornado and Hurricane Tips", American Red Cross (4 1/2 minute tape recording)

5.1.4 The broadcasts will also remind the public to call EM 1-1111 if there are any invalids, aged, or infirm to be moved by ambulance in case of evacuation.

5.1.5 All official Weather Bureau warnings and instructions from the Emergency Control Center will be broadcast as soon as issued.

5.1.6 All agencies and individuals on the hurricane warning lists will be notified immediately. The Weather Bureau has one list and the Emergency Control Center has another.

5.1.7 The Superintendent of Schools will immediately cancel all classes for the duration of the emergency. The announcement will be broadcast from the Emergency Control Center.

5.1.8 The Emergency Control Center will put one of three plans in operation, the plan to be selected depending on the maximum tide height expected. Evacuation from various areas should be authorized by the Homeport Hurricane Preparedness Committee on a schedule that will permit evacuees to reach designated shelters at least 9 hours before time of expected flooding.

6. PLAN A -- EXPECTED TIDE 4-8 FT. M.S.L.
(See Charts 1 and 3)

Areas to be Evacuated and Time Required*	Shelters	Routes
Turtle, King, Barracuda, and Shark Keys (3 hrs.)	Masonic Hall	Boats to Marina then bus via Marina Rd. to 5th St.; E on 5th St.
All settlements east of Route 17 from Northville to Homeport (4 hrs.)	City High School	S on Route 17, E on 7th St.
All settlements east of Route 17 from Southville to Homeport (4 hrs.)	Elementary School	N on Route 17, E on 25th St.
Homeport Beach (3 hrs.)	Armory	Causeway, S on A St., W on 30th St., S on R St.
Area A (3 hrs.)	City Auditorium	W on 15th St.

* Time required to evacuate and reach shelter

6.1.1 Buildings west of D Street need not be evacuated above street floor. Tenants of upper floors are requested to provide refuge for occupants of street-level floors and basements.

6.1.2 First Church, which has a well-equipped kitchen in the attached parish hall, at 17th and Crescent Streets, is the Emergency Hospital. All persons requiring ambulance transportation will be taken there.

Emergency Duty Assignments for Evacuation Plan A

6.2.1 Communications: No unusual troubles expected. Station WXYZ will broadcast hurricane warnings and pertinent information exclusively.

6.2.2 Civil Defense: As soon as warnings to evacuate are broadcast, block wardens will make door-to-door checks in areas to be evacuated to ascertain that everyone is warned. Will immediately phone EM 1-1111 if ambulance service is required. Will also assist police if requested. When evacuation is completed, wardens will take posts in indicated safe buildings in their area and assist National Guardsmen in maintaining guard against fire and looting.

6.2.3 The Civil Defense mobile rescue units will operate as ambulances in taking incapacitated persons to the Emergency Hospital at First Church. Ambulances will get their radioed orders from the Emergency Control Center via the Civil Defense mobile transmitter stationed there.

6.4.2 Red Cross: Will be responsible for care including emergency clothing and feeding at indicated shelters. Ambulances will assist in moving incapacitated persons to the Emergency Hospital at First Church. This emergency hospital will be manned by volunteer doctors and nurses, and the Red Cross will supplement the medical and nursing staff as needed.

6.2.5 Transportation agencies: Airlines have agreed to operate additional trips if necessary to fly in emergency personnel. They will, however, cancel all incoming trips and remove all flying equipment from Homeport to unthreatened airports as soon as the first signs of the hurricane are felt.

6.2.6 The Homeport Transit Company will do the following when instructions are received from the Emergency Control Center:

1. Station 4 busses at the Marina to take evacuees from the Keys to the Masonic Hall.

2. Operate 9 busses at 10-minute intervals from Northville to Homeport on Route 17 with pick-up stops at all villages (three) east of the route. Destination will be City High.

3. Operate 8 busses at 10-minute intervals from Southville and Homeport on Route 17 with pick-up stops at all villages (three) east of the route. Destination will be Elementary School.

4. Operate 10-minute service in Area A in Homeport. Regular routes will be used in the Area but terminal will be City Auditorium and 15th Street will be one-way westward beginning at B Street.

These emergency schedules will operate until the Emergency Control Center advises their cancellation or when instructed by police to seek shelter at protected City Park. Fares will not be collected. Passengers will not be carried on outgoing trips except for police, firemen, and those having Emergency Control Center credentials.

6.2.7 Police: City police will be stationed at every other intersection along approaches to shelters, which will be temporarily one-way during the emergency with no parking permitted. Emergency vehicles will be permitted to travel in the opposite direction on the Causeway. Elsewhere, when entering evacuation areas they should use streets not designated as evacuation routes. The chief duty of the police will be to expedite evacuation traffic to the shelters and to prevent parking on approaches and within two blocks in any direction from a shelter.

6.2.8 In the evacuation areas police and National Guardsmen will be posted to prevent looting. When the storm strikes, all policing forces in the evacuation area will take posts in designated safe buildings and wait out the storm. Some National Guardsmen will be equipped with walkie-talkie radios to report fires or cases of looting.

6.2.9 State Police will set up road blocks on all routes into the Homeport area and will divert tourist and truck traffic to cities outside the threatened area. They will make a final patrol of the beach to ascertain that it is deserted and will also assist the Sheriff's force in warning settlements and supervising the evacuation.

6.2.10 The Sheriff and his men are primarily responsible for seeing to it that all settlements, trailer camps, etc., are duly advised of the evacuation. They will be assisted by the State Police and National Guard. Stranded persons whose cars have been disabled or have missed the evacuation busses will be picked up by National Guard personnel carriers dispatched by radio from the Emergency Control Center.

6.2.11 Fire Department: The equipment at Station No. 1 will be moved to the vicinity of the Field House in City Park. The Station's battery operated receiver will be taken along so men can take shelter in the Field House. The Station will not be abandoned, however, until winds reach about 30 mph., by which time all evacuees should be in shelters.

6.2.12 Each of the Department's three stations will be operating at half strength. The remaining half will be on guard duty (in uniform) in their home neighborhoods to watch for fires and fallen live wires, and to give first aid if required. The Department's two ambulances will be used to evacuate incapacitated persons.

6.2.13 Coast Guard: At the discretion of the Commanding Officer boats will be sent as available to ascertain that the Keys have been evacuated. Only Shark Key requires assistance in the way of additional boats. Boats will be dispatched to evacuate about 40 persons from Shark Key.

6.2.14 In addition to seeing that the Keys have been evacuated, the Coast Guard will stand by to tow any boats that may become disabled during the actual evacuation. The CAP will operate two planes over the water areas under Homeport jurisdiction to make sure all boats have sought protection. The planes will notify the Homeport Coast Guard Station by radioing to the FAA station at Homeport Airport, which will relay the message to the Coast Guard Station.

6.2.15 The Coast Guard Station will be flooded so it will have to be evacuated. When no further need for patrolling is indicated, boats will return to station. Coast Guard personnel, with all appropriate available mobile equipment, will proceed to pre-assigned locations selected for maximum availability for rescue operations during and after the hurricane. Communications equipment will be placed in operation.

6.2.16 National Guard: Will assist policing units as indicated under Police. Assisted by the Red Cross, they will care and feed the evacuees using the Armory as a shelter. Their two ambulances will take part in evacuating incapacitated persons to the emergency hospital.

6.2.17 Civil Air Patrol: Will activate its prearranged warning patrol schedule to look for isolated groups which do not appear to be taking shelter. Will notify either Sheriff's Office or Coast Guard depending on whether it is a land or sea situation. As plane transmitters broadcast only on FAA standard airways communications frequency, contacts will be made through FAA Airways Communication Station at Homeport Airport.

6.2.18 Planes will leave for bases outside threatened area as soon as there appears to be no further need for patrolling or until winds become strong or ceiling or visibility begins to lower.

6.2.19 Public Utilities: Main gas lines to evacuation areas will be shut off. Every attempt will be made to maintain electric service in the central section of the city in which most of the shelters are located. Here the power lines are underground and electrical hazards have been greatly reduced. In other sections of the city, power will be shut off when gusts begin to exceed 60 mph.

7. PLAN B -- EXPECTED TIDE 9-12 FT. M.S.L.
(See Charts 1 and 4)

7.1.1 Same as Plan A plus the following:

Areas to be Evacuated and Time Required	Shelters	Approaches
B (3 hrs.)	Court House	W on 25th St.
C (2 hrs.)	City Hall	W on 24th St.
D (1 hr.)	Adams Hotel	N on H St.
E (2 hrs.)	Christ Church	S on I St.
F (1 hr.)	Gem Theatre	W on 5th St.
G (3 hrs.)	Primary School	W on 10th St.
H (3 hrs.)	Burr High School	W on 18th St., N on Denver St.

7.1.2 Areas are all in the city and there is no specified evacuation route. However, the police will see to it that the approaches to the shelters are one-way in the direction indicated above and on the maps.

7.1.3 Buildings west of G Street need not be evacuated above street floor. Tenants of upper floors are requested to provide refuge for occupants of street-level floors and basements.

7.1.4 The settlements of Sardine Springs, Four Corners, and Sandville lying in the area bounded by Routes 17, 19, 18, and 24 will have to be evacuated, but they have taken this responsibility upon themselves. They do depend on Homeport for warnings, however, and they are on all warning lists. The Sheriff will ascertain that evacuation notices reach these towns when advised by the Emergency Control Center and will assist in their evacuation if requested.

Emergency Duty Assignments for Evacuation

7.2.1 Communications: Power plant will be flooded so Station WXYZ may be forced to suspend sometime before the worst part of the storm. Meteorological warnings and other pertinent instructions will be transmitted via State Police radio and/or teletypewriter to Station WMET, which will then carry on the full emergency schedule intended for Station WXYZ.

7.2.2 Weather Bureau: The airport will be flooded by the tides within the expected range of heights. Furthermore, the operations would be greatly hampered by the eventual power failure. The staff should therefore evacuate to the Emergency Control Center and try to carry on their duties at the emergency meteorological post there.

7.2.3 FAA Airways Communications Station: This office would be in the same predicament as the Weather Bureau. Hence, the staff will also evacuate to the Emergency Control Center and help with the communications activities there.

7.2.4 Civil Defense: Same as for Plan A (Par. 6.2.3) except for additional areas to be evacuated.

7.2.5 Red Cross: Same as for Plan A (Par. 6.2.4) except staffing additional shelters.

7.2.6 Transportation: Same as for Plan A (Par. 6.2.6) except for additional bus service by Homeport Transit Company as required by Emergency Transit Schedule for Plan B. The Company's bus equipment will be supplemented by 10 county school busses and 10 National Guard trucks equipped to carry personnel. This supplementary equipment will operate under instructions of the Company's Chief Dispatcher who will assign enough vehicles to operate the schedules listed in Emergency Transit Schedules for Plan B.

7.2.7 Police: City Police will extend the duties listed in Plan A (Pars. 6.2.7 and 6.2.8) to cover the additional evacuation areas and evacuation routes as shown in Emergency Transit Schedules for Plan B.

7.2.8 State Police will perform same duties listed under Plan A (Par. 6.2.9) and will assign 15 troopers to the Homeport Police to assist in directing traffic and maintaining order.

7.2.9 The Sheriff will operate as under Plan A (Par. 6.2.10) and will ascertain that Sardine Springs, Four Corners, and Sandville receive evacuation warnings and provide assistance for their evacuation if they request it.

7.2.10 Fire Department: In addition to operations stipulated in Plan A (Pars. 6.2.11 and 6.2.12) the equipment at Station 2 will be moved to the Burr High School Athletic Field when wind reaches 40 mph. Personnel will take shelter in the Field House taking radio with them.

7.2.11 Coast Guard: Same as for Plan A (Pars. 2.3.13-6.2.15). In addition, utilize mobile communications equipment previously set up and take over when other units cease to function and to maintain contact with other Coast Guard units. To the extent permitted by weather conditions, other personnel carry out rescue operations.

7.2.12 National Guard: Same as for Plan A (Par. 6.2.16). In addition, will place 10 trucks with drivers at disposal of Homeport Transit Company for evacuation purposes.

7.2.13 Civil Air Patrol: Same as for Plan A (Pars. 6.2.17 and 6.2.18).

7.2.14 Public Utilities: The electric power and gas plant will have to be abandoned. As soon as it is suspected that Plan B will have to be put in effect, notice of the impending plant shutdown will be released by the Emergency Control Center for broadcast to the public. The plant management will phone supervisors of all buildings equipped with standby power plants (lists of persons to be called are already available at the plant, at its city office, and the Emergency Control Center) to notify them of the expected service interruption and to check standby equipment and fuel supplies.

7.2.15 When occupation of the plant is no longer considered safe, valves, switches, and engines will be shut off. Plant personnel will then seek shelter at City High School.

8. PLAN C - EXPECTED TIDE 13-16 FT. M.S.L.
(See Charts 2 and 5)

Areas to be Evacuated and Time Required	Shelters	Routes or Approaches
Turtle, King, Barracuda, and Shark Keys (3 hrs.)	Mound City High School	Boats to Marina, busses via Marina Rd. and N on Route 17, W on Route 18.
All settlements east of Route 17 from Northville to Homeport (5 hrs.)	Mound City High and Elementary School	N on Route 17, W on Route 18.
All settlements east of Route 17 from Southville to Homeport (5 hrs.)	Crossville Grammar School	S on Route 17, W on Route 24, N on Route 19.
Homeport Beach (4 hrs.)	Fairhaven High and Jr. High School	Causeway; N on A St., W on 5th St. and Route 22, S on Route 21.
Area A (3 hrs.)	Triangle Bldg.	W on 15th Street
B (3 hrs.)	Apex Bldg.	W on 13th Street
C (2 hrs.)	Court House	W on 25th Street
D (3 hrs.)	City Hall	W on 24th Street
E (2 hrs.)	Acme Bldg.	W on 20th Street
F (2 hrs.)	Adams Hotel	W on 17th Street
G (2 hrs.)	King Hotel	S on H Street
H (3 hrs.)	City High	W on 7th Street and E on 8th.
I (2 hrs.)	Masonic Hall	S on N Street
J (3 hrs.)	City Auditorium	W on 15th Street
K (3 hrs.)	Burr High	W on 12th Street
L (3 hrs.)	Primary School	W on 10th Street

8.1.1 Buildings west of railroad tracks in Homeport proper need not be evacuated above street floor. This also applies to designated hurricane-safe masonry buildings between G Street and railroad tracks. Tenants of upper floors are requested to provide refuge for occupants of street-level floors and basements.

8.1.2 Sardine Springs, Four Corners, and Sandville will also have to be evacuated, and Homeport's only responsibility is to insure that they are

warned. The Sheriff will ascertain that the warnings reach these settlements and that evacuation is effected.

Emergency Duty Assignments for Evacuation

8.2.1 Communications: Same as Plan B (Par. 7.2.1).

8.2.2 Weather Bureau: Same as Plan B (Par. 7.2.2).

8.2.3 FAA Airways Communications Station: Same as Plan B (Par. 7.2.3).

8.2.4 Civil Defense: Same as Plan A (Par. 6.2.3) except for additional areas to be evacuated.

8.2.5 Red Cross: Same as Plan A (Par. 6.2.4) except for additional shelters to be manned requiring more trained personnel to be brought in.

8.2.6 Transportation: Will place Emergency Transit Schedule for Plan C in operation when notified by Emergency Control Center. Equipment will be supplemented by 10 county school busses and 10 National Guard trucks.

8.2.7 Police: City Police will extend duties to cover additional evacuation areas and routes shown in Emergency Transit Schedules for Plan C.

8.2.8 State Police: Same as Plan B (Par. 7.2.8).

8.2.9 Sheriff: Same as Plan B (Par. 7.2.9).

8.2.10 Fire Department: Same as Plan B (Par. 7.2.10)

8.2.11 Coast Guard: Same as Plan B (Par. 7.1.11).

8.2.12 National Guard: Same as Plan B (Par. 7.2.12) plus evacuating their own Armory.

8.2.13 Civil Air Patrol: Same as Plan A (Pars. 6.2.17 and 6.2.18).

8.2.14 Public Utilities: Same as Plan B (Pars. 7.2.14 and 7.2.15).

9. POST-HURRICANE MEASURES

9.1.1 After passage of the hurricane the public will be advised to take the following safety measures:

1. Remain in shelters until informed by those in charge that you may return to your homes.

2. Seek medical care at Red Cross disaster stations or hospitals for persons injured during the storm.

3. Don't touch loose or dangling wires. Report such damage to the light and power company, or nearest police officer.

4. Report broken sewer or water mains to the water department.

5. Guard against spoiled food in refrigerators if power has been off any appreciable length of time.

6. Unless you are qualified to render valuable emergency assistance, stay away from disaster areas where you may hamper first aid or rescue work. Doctors and nurses will be issued special passes.

7. Drive automobiles cautiously. Debris-filled streets are dangerous, so keep your eyes on the road. Along the coast soil may be washed from beneath the pavement, which may collapse under the weight of vehicles.

8. Be alert to prevent fires. Lowered water pressure makes fire-fighting difficult after storms.

9. Take down shutters and save the lumber. Store in a handy place for future use.

9.1.2 Coast Guard vessels, aircraft, and shore units will carry out patrols as soon as possible after the hurricane passes, prepared to give assistance to vessels or persons in distress. Survivors should be ready to signal these units as they approach.

9.1.3 Information as to assistance available for storm victims will be provided by press, radio, and other means. For family disaster-caused problems involving need for food, clothing, repair or rebuilding of homes, and medical and nursing care free counselling service and grants of financial assistance on an individual family basis based on the family's ability to help itself is available at Red Cross disaster headquarters upon each family's application. Red Cross through its welfare inquiry service and in cooperation with the Post Office Department will have available Safety Notification Cards and Change of Address cards by which affected families may notify relatives of their post-hurricane status and re-establish their promptly receiving their mail.

EVACUATION PLANS A AND B

FOR EXPECTED STORM TIDES OF 4-8 AND 9-12 Ft. MSL
HOMEPORT HURRICANE PREPAREDNESS DISTRICT

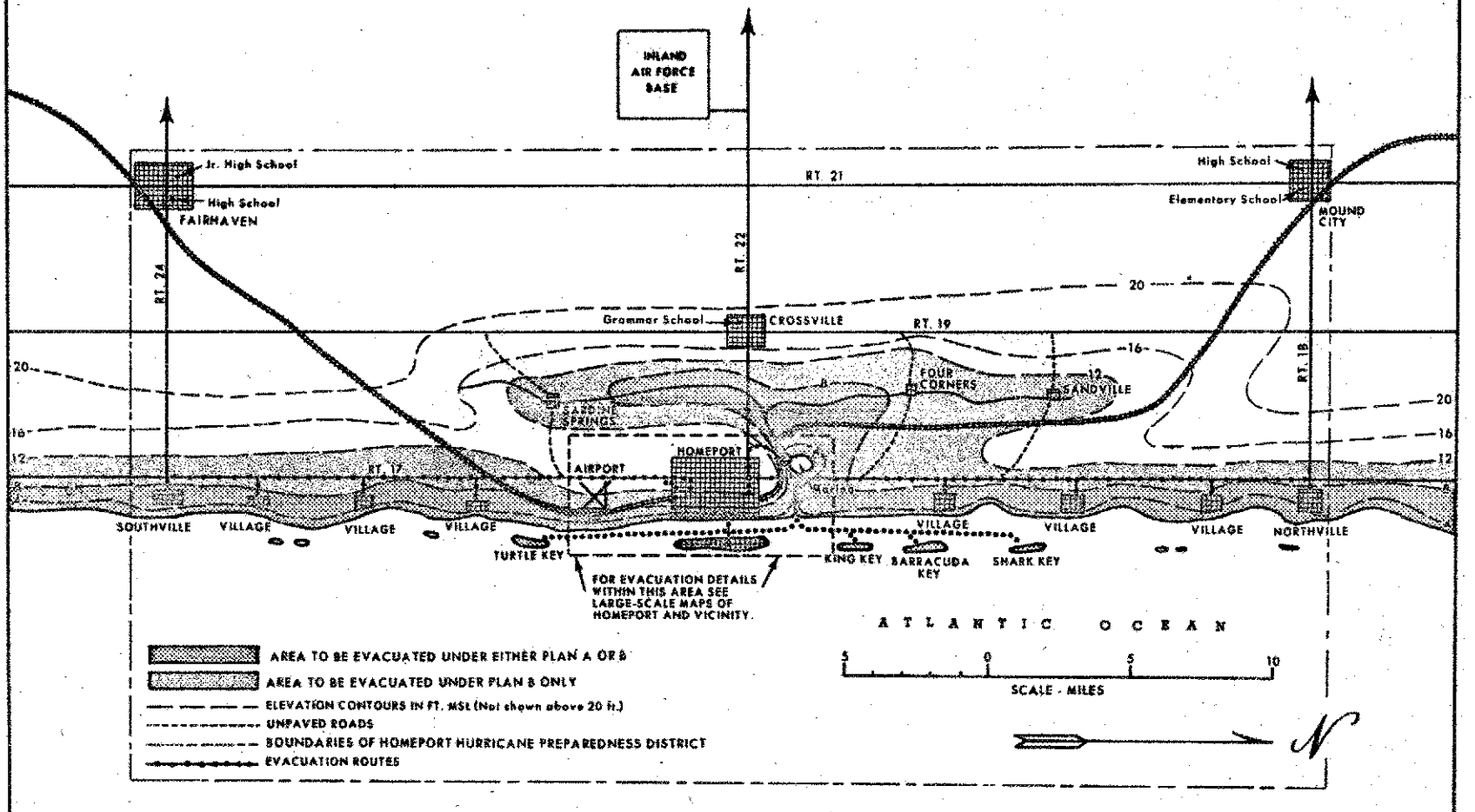

CHART 1

EVACUATION PLAN C

FOR EXPECTED STORM TIDES OF 13 - 16 Ft. MSL

HOMEPORT HURRICANE PREPAREDNESS DISTRICT

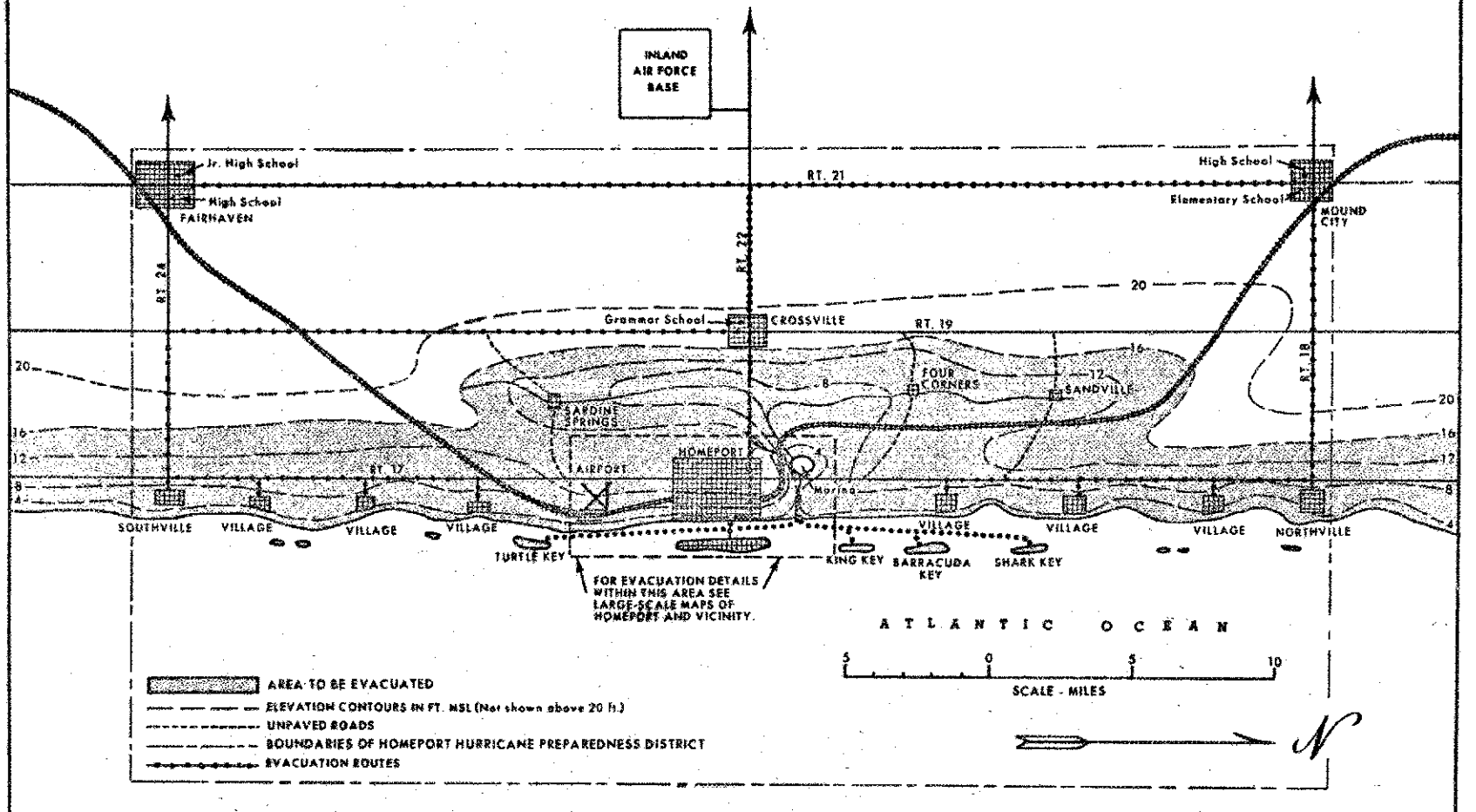

CHART 2

EVACUATION PLAN A

FOR EXPECTED STORM TIDES OF 4 - 8 Ft. MSL

HOMEPORT AND VICINITY

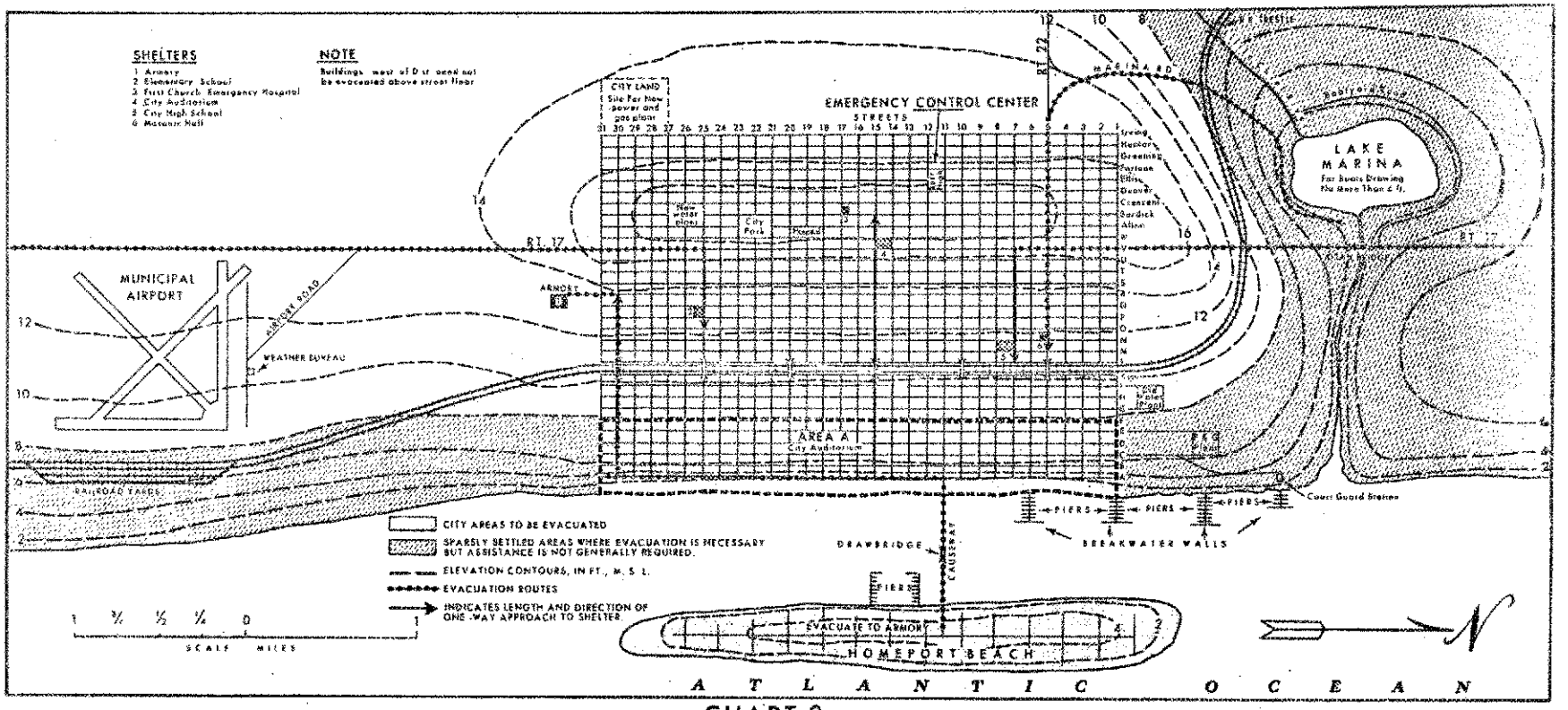

CHART 3

EVACUATION PLAN B

FOR EXPECTED STORM TIDE OF 9 - 12 Ft., MSL

HOMEPORT AND VICINITY

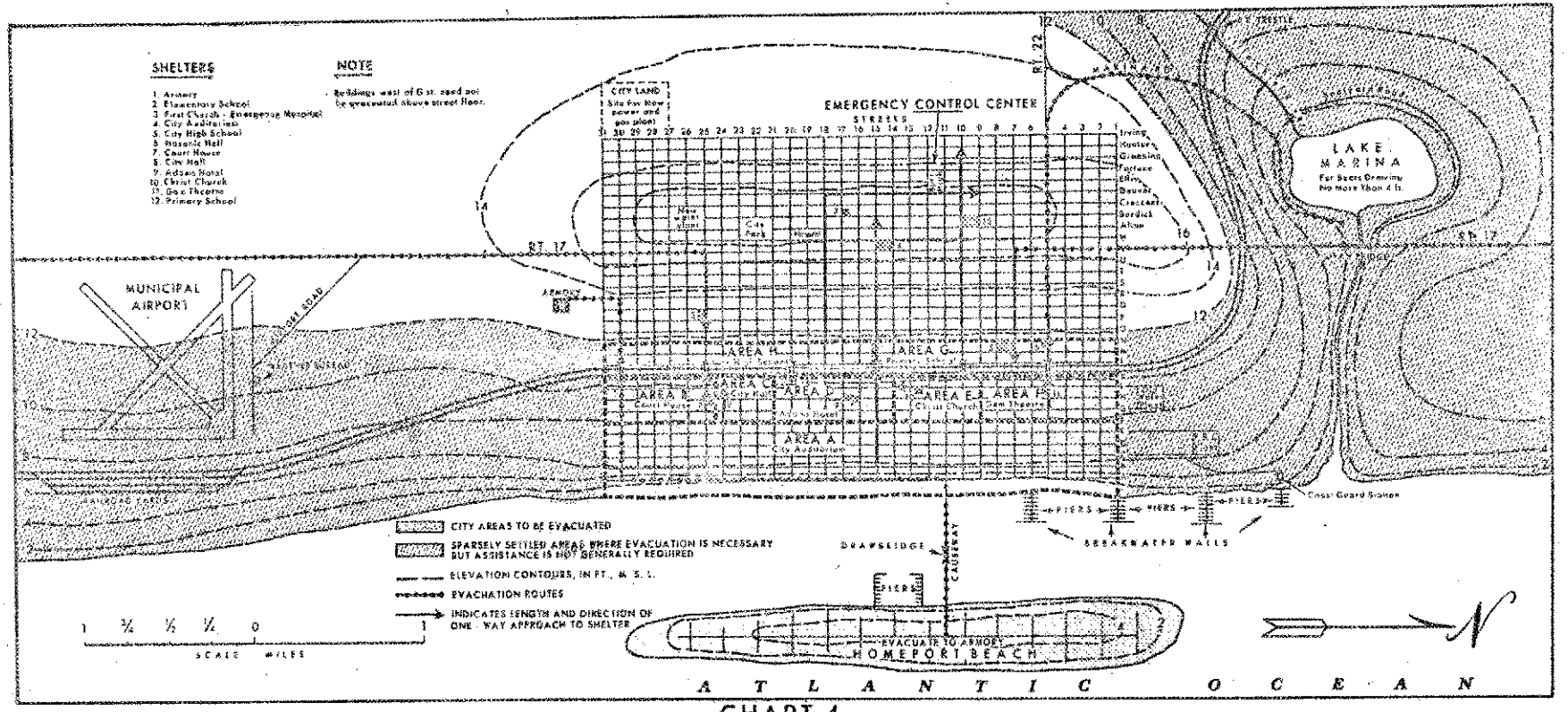

CHART 4

EVACUATION PLAN C
FOR EXPECTED STORM TIDE OF 13-16 FT. MSL
HOMEPORT AND VICINITY

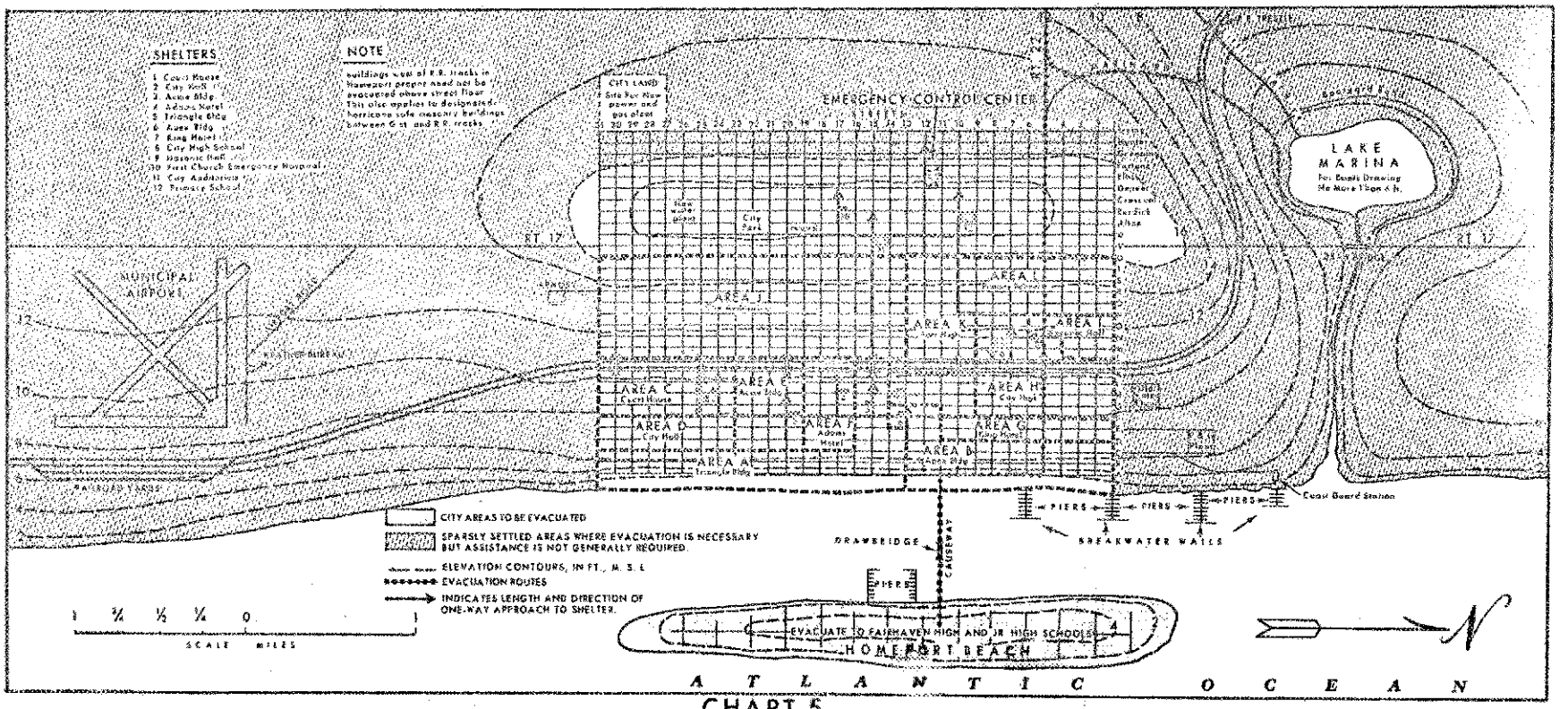

CHART 5

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX D

DIGEST OF PUBLIC HEARINGS AND STATEMENTS FROM OTHER AGENCIES

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX D - DIGEST OF PUBLIC HEARINGS AND STATEMENTS FROM OTHER AGENCIES

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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX D - DIGEST OF PUBLIC HEARINGS AND STATEMENTS FROM OTHER AGENCIES

D1. INTRODUCTION. This appendix presents a digest of the minutes of three public hearings held by the District Engineer, New York District, at Babylon, Westhampton Beach, and Riverhead, New York, on 19 December 1955, 20 December 1955, and 22 April 1958 respectively. Also included is a summary of communications received in connection with the hearings and statements from other agencies in connection with the review of this report.

D2. The Babylon and Westhampton Beach hearings were held for a dual purpose: (1) to obtain information for use in the cooperative beach erosion control study and (2) to ascertain the desires of local interests in connection with the Hurricane Survey of the south shore of Long Island from Jones Inlet to Montauk Point including the Inner Bays, pursuant to Public Law 71, 84th Congress, approved 15 June 1955. At the start of the hearings, a representative of the Beach Erosion Board gave an illustrative talk on the history and effect of shore processes. Because of the dual nature of the hearings, the speakers and the briefs submitted gave information concerning both the beach erosion and hurricane problems. In addition to the data included herein, a number of speakers stressed the inadequacy of the hurricane warning system and requested improvement of this vital service, and submitted statements referring to the Inner Bays along the south shore of Long Island.

D3. The Riverhead hearing was held to acquaint local interests with the plan of beach erosion control and hurricane protection which forms the basis of the authorized beach erosion-hurricane protection project described in paragraphs 78 to 82 of the main report, and to obtain their views thereon.

D4. A summary of the number of persons who registered at the hearings, the total number who spoke, and the total number of communications submitted, follows:

	Babylon Hearing	Westhampton Beach Hearing	Riverhead Hearing
Number of persons registered	88	95	285
Number of speakers	21	29	41
Number of communications submitted	29	35	95

Table D-1 - Digest of minutes of public hearing before District Engineer, New York District, held at Babylon, New York on 19 December 1955

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Hon. Frank J. Becker, Congressman	Third New York District	Remedial measures to save the shores along the south shore of Long Island.	To eliminate loss of valuable property and consequent loss of taxes.	Urged that the studies be completed without delay and assured his full support in Congress towards authorization of the remedial work.
Hon. Stuyvesant Wainwright, Congressman	First New York District	Supports comprehensive erosion control program for south shore of Long Island including consideration of the inlets.	-	Made reference to new legislation under consideration by Congress which provides for Federal participation in the cost of protection of private property similar to the existing law which provides for such participation in connection with public property only. Discussed hurricane warning service.
Henry TenHagen, Deputy Chief Engineer	Department of Public Works, State of New York	-	State of New York is party to joint cooperative study.	Desires completion of the beach erosion study as soon as possible so that local projects may fit into overall plan.
Frank Champ, Assistant Superintendent at Jones Beach	Robert Moses, President Long Island State Park Commission	-	-	Read letter signed by Mr. Moses (see table D-2, page D-4).
Harrison Weber, Suffolk County Canals and Waterways Engineer	Albert Case, Suffolk County Superintendent of Highways	Improvement by methods to be developed by the Beach Erosion Board.	-	Submitted brief giving factual data (see table D-2, page D-4).
Charles F. Pfeifle	Town of Babylon	-	-	Read letter from Town Supervisor (see table D-2, page D-4).
Thomas D. Harris, Member, Islip Town Board	Town of Islip	Construction to be initiated on public lands which will most benefit private lands.	-	Desires that work of improvement proceed regardless of the outcome of pending legislation with respect to Federal participation in the cost of protection of private property.
Howard Ledluse, President	Association of Davis Park	Urges quick action to stop erosion of beach.	Fire Island outer beach is eroding at a rate of 25 feet a year.	-
J. Wright Taussig, Vice Chairman	Fire Island Beach Erosion Control Committee	Endorses recommendations of 1946 Beach Erosion Board report. Desires placing of groins along Fire Island, and nourishing of beaches by feeder beaches. Also desires filling in breaks in the offshore bar by dumping sand and rock from bottom-dump scows.	Approximately 75 feet of ocean front has been lost along the entire length of Fire Island since 1938. The level of the water in the ocean has risen approximately six inches in the last 25 years.	Gave storm and damage data and discussed methods of shore protection. Indicated that the Fire Island Beach Erosion Control Committee represents 15 communities with about 2500 homes, a total ocean front of over 30,000 feet, a real valuation of over 20 million dollars, and a normal summer population of 15,000 which is increased two or three times during weekends and holidays.
Francis W. Goggins, Attorney	Village of Saltaire	-	-	Requested permission to submit at a later date maps and photographs showing changes in shore conditions at Saltaire since 1938. Referred to this community as the chief victim of the 1938 hurricane.
Mrs. Elise Burke, Secretary	Fire Island Beach Erosion Control Committee	-	-	Showed photographs depicting shore erosion along Fire Island and offered to submit them at a later date.
Henry Saia, Chairman, Erosion Committee	Property Owners Association of the Village of Ocean Beach	-	-	Requested permission to submit a statement at a later date.

Table D-1 - Digest of minutes of public hearing before District Engineer, New York District, held at Babylon, New York on 19 December 1955

(Continued)

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Laurence F. Rumey, Chairman, Inlet Committee	Babylon Tuna Club	-	-	Supports any erosion control program provided that a safe inlet is maintained into Great South Bay.
Herman F. Heine	Babylon Tuna Club	-	-	Concurs with views of Mr. Rumey.
Harry J. Thompson, Assistant to Division Engineer	The Asphalt Institute	-	-	Suggested use of asphalt groins and cited their successful use by the State of Maryland.
Mary Salsam, Chairman, Local Dune Committee	Ocean Bay Park	Protection of the Fire Island barrier beach, both publicly and privately owned.	The barrier beach protects the public water in Great South Bay and the mainland of Long Island with all its public works.	-

Table D-2 - Statements received by District Engineer prior and subsequent to public hearing held at babylon, New York on 19 December 1955

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
16 Dec 1955	L	Hewlett R. Bishop, Atlantic Coast Director, U. S. Maritime Administration	Summer resident of Water Island	Prohibition against motor vehicles cutting through the dunes except at certain designated points.	The motor vehicle traffic over the dunes breaks up the vegetation and results in consequent loss of sand by wind action.	Describes damages during past storms and cites 75-foot recession of the ocean dune during the past six years.
19 Dec 1955	M	Sherwood T. Allen	Property owner at Fair Harbor	-	-	Opposes public highway on Fire Island.
19 Dec 1955	N	Martin Cechener	Property owner at Lonelyville	Jetties to hold Fire Island beaches.	-	Opposes public highway on Fire Island.
19 Dec 1955	O	Robert Moses, President	Long Island State Park Commission	Utilization of hydraulic fill for protection of the outer beach. Use of jetties where absolutely unavoidable. Moving houses back where they are too close to ocean front.	-	As an incident to hydraulic filling, dredging of a continuous boat channel on the bay side is suggested. Suggestion is also made that public parks be developed in preference to private development of the barrier beach. With respect to stabilization of Moriches and Shinnecock Inlets, the latter is favored in the event that the cost of required work for the two inlets is excessive.
16 Dec 1955	P	Harrison Weber, Canals and Waterways Engineer	Superintendent of Highways, Suffolk County	Any method of beach stabilization which is practical and economical.	-	Gives statistics on storm damage and local expenditures on repair of storm damage and on ocean front State aid beach projects.
-	Q	Donald E. Muncy, Supervisor	Town of Babylon	Preservation of the barrier beach.	Mainland will be flooded if barrier is not protected.	Also urged speed in the initiation of the project recommended in the cooperative beach erosion control study of Fire Island Inlet westerly to Jones Inlet completed in 1955.
19 Dec 1955	R	J. Wright Taussig, Vice-Chairman	Fire Island Erosion Control Committee	Endorses recommendations of 1946 Beach Erosion Board report. Desires construction of long jetties extending to points beyond the 6-foot contour and preferably to the 12-foot contour. Suggests periodic pumping of hydraulic fill from the bay side for the establishment of a broader and higher dune line.	Loss of barrier beach would damage mainland villages.	Describes the development on the barrier beach and the extent of beach loss as a result of storms. Cites an average recession of the shore line of 75 feet during the past 25 years, 35 feet of which was in the last seven years. Indicates that level of water has risen 6 inches in the past 25 years.
19 Dec 1955	U	-	Long Island Lighting Company	Favors erosion control program to stop loss of valuable land.	Erosion is not only a threat to the economic well being of the area but also directly affects the Company requiring it to relocate facilities and to take other steps to avoid inundation.	Describes activities of the Company damages due to past storms.
20 Dec 1955	Z	J. Wright Taussig, Vice-Chairman	Fire Island Erosion Control Committee	Hydraulic fill from the bay to be placed on the beach and dunes, supplemented for complete protection by substantial groins and rebuilding of the offshore bars.	In spite of efforts to rebuild the dunes by bulldozing sand from the beach, the crest of the dunes has retreated 50 feet since 1938 and houses are now actually overhanging them.	In addition to the general data given in exhibit R, damage data, expenditures for repair of damage, and suggested improvements are submitted with specific reference to Point O'Woods.

Table D-2 - Statements received by District Engineer prior and subsequent to public hearing held at Babylon, New York o. 19 December 1955

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed by	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
-	BB_1	-	Water Island	-	-	Describes damage to dunes and property during past storms and work done to build up the dunes by snow fence and brush, bulldozing sand from the beach, and planting of beach grass.
7 Dec 1955	BB_2	John N. Thorpe	Fire Island Pines Association	-	-	Describes erosion of dunes, damage to property and the artificial building up of dunes with the aid of snow fences.
-	BB_3	-	Fair Harbor	-	-	Gives damage data for the 1938 hurricane and states that Fair Harbor like its neighboring community Saltaire was almost completely destroyed during this hurricane. Also gives data on dune losses during subsequent storms.
-	BB_4	-	Ocean Bay Park	Jetties for long range protection. Hydraulic fill to be placed on dunes or on the beach to provide stock piles of sand for natural replenishment of the beach.	Because of the recession and loss of dunes, the communities on Fire Island are in a critical situation and immediate remedial measures are required.	Describes dune damage during past storms and the work done by the County to repair the damage consisting of hydraulic fill, planting of dune grass and placement of snow fences.
14 Aug 1953	BB_5	Acting Director	U.S. Coast and Geodetic Survey	-	-	Gives data on dune and shore lines at Fair Harbor and Saltaire.
-	BB_6	Francis V. Goggins, Village Attorney	Village of Saltaire	Immediate pumping of hydraulics fill from bay to ocean front, supplemented by construction of groins or jetties at strategic locations along the beach for long range protection.	The shore line has receded in places more than 375 feet since 1936 in spite of substantial local expenditures for erosion protection projects. Immediate short term protected measures and a long term program are required for the preservation of the beach.	Describes shore line changes, the disasterous results of the 1938 hurricane including loss of life and estimated damages, the rehabilitation work, and damages of subsequent storms. Photographs showing the effects of the storms are included.
17 Jan 1955	CC	Carol F. Austin Secretary, Beach and Dune Committee	Cherry Grove Property-Owners Association	-	-	Although the dunes and beach suffered comparatively little damage in the past few years, the community is well aware of the debacle of the 1938 hurricane and protective measures have been taken in building up and protecting the dunes by means of snow fencing and planting of beach grass.

Table D-3 - Digest of minutes of public hearing before District Engineer, New York District, held at Westhampton Beach, New York on 20 December 1955

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Hon. Stuyvesant Wainwright, Congressman	First New York District	Allow Federal Government to participate up to one-third of cost for protection of public or private property. Use of hydraulic fill on beaches and construction of jetties.	The cost of adequate shore protection is beyond the means of the local communities and consequently Federal participation in the protection of private property as well as public property is essential.	Referred to his remarks made at the Babylon hearing the preceding day (see table D-1, page D-2). Objected to ocean highway along dunes of barrier beach. Against closing of Moriches Inlet. Stressed the need for changing existing law in order to provide for Federal participation in the cost of protection of private property.
Henry TenHagen, Deputy Chief Engineer	Department of Public Works, State of New York	-	-	Anxious to see study completed.
George Miller Fox, Branch Manager	Suffolk County Water Authority	-	-	Presented information on damages sustained by the Water Authority due to storms.
Judge Henry F. Ostermann	Philipp Hattemer, Supervisor, Town of Brookhaven	Restoration of dunes.	To assure protection of property on Fire Island as well as the mainland.	because of the magnitude of the work and cost, erosion control and inlet maintenance should be taken over by the Federal Government. Stressed the importance of stabilization and maintenance of Moriches Inlet.
Wilmot B. Halsey, Mayor	Village of Westhampton Beach	-	-	Gave damage data for past storms.
Capt. E. T. Osborn	Moriches Inlet Stabilization Committee and Waterways Committee of Long Island Association	-	-	In favor of retaining both Moriches and Shinnecock Inlets. Submitted brief on the importance of Moriches Inlet (see table D-4, page D-8).
Charles E. Corrigan	Shinnecock Inlet Stabilization Committee of Hampton Bays	Pump sand from inner bays to build up dunes on barrier beach.	Protection of barrier beach is essential.	Submitted brief on the need of protection of ocean shore front and the importance of Shinnecock Inlet (see table D-4, page D-9).
Nicholas W. Griek, Secretary	Long Island Fishermen's Association	-	-	Inlets and erosion of barrier beach are inter-related problems. Stressed the importance of Shinnecock and Moriches Inlets and the need for their improvement and stabilization Read letter from Town of Brookhaven Baymen's Association (see table D-4, page D-9).
Hon. Edward R. Lupton	State Assemblyman	-	-	Desires study of the entire area rather than a piecemeal solution and Federal participation in solving the problem. Described State participation in shore protection projects.
Stephen S. Meschutt, Supervisor	Town of Southampton	-	-	Desires Federal participation in financing improvements and maintenance, since the cost is beyond the means of the local communities.
H. S. Topping Supervisor	Town of East Hampton	-	-	Town of East Hampton is in a safer position than the western towns, since it is not on a barrier beach and consequently not subject to break throughs.

Table D-3 - Digest of minutes of public hearing before District Engineer, New York District, held at Westhampton Beach, New York on 20 December 1955

(Continued)

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Mrs. Louise P. Pell	The Westhampton Association	-	-	Submitted statement from the Westhampton Association (see table D-4, page D-9).
Vincent R. Reilly, President	Westhampton Chamber of Commerce	Stabilization of offshore sand bars where a break through has occurred by using rock filled barges to act as seals. Hydraulic fill from inner bays to be pumped on beach.	Would protect the mainland as much as the barrier beach.	Favors Federal financial participation in cost of protection of private property. Submitted storm damage data from residents of Westhampton Beach and Quogue.
Frank T. Moss, Director	Montauk Chamber of Commerce	Stabilization of existing dunes along the beach west of Hither Hills State Park and in the Montauk Village area.	To stop break through during storms.	Described inundation of highway and wash out of railroad track during the hurricane of August 1954 which resulted in the isolation of the village of Montauk. Submitted brief on storm damage (see table D-4, page D-9).
Herman A. Ehmann	Moriches Chamber of Commerce	Desires speedy action to stop erosion.	-	Gave data on rate of shore erosion.
Vincent Ferrante	Mastic Beach Republican Club and Mastic Beach Property Owners Association	-	-	Desires Federal maintenance of Moriches Inlet. Referred to erosion of property at Mastic Beach.
Erving A. Larsen, Vice President	Mastic Beach Property Owners Association	-	-	Stressed the potential loss of life during storms.
Thomas H. Eyton-Jones	Mastic Republican Club and Mastic Taxpayers	Creosoted wooden groins angled slightly to the east.	Groins would accrete and the accretion would replenish the dunes naturally.	Questioned feasibility of getting hydraulic fill from inner bays because deepening of bays may allow vibrations, caused by pounding of the waves, to weaken the dunes on the barrier beach. Favors Federal financial participation in cost of constructing protective devices in front of public and/or private property. Desires rapid completion of the study and maintenance of all inlets.
Ronald W. Chapman	East Moriches Civic Association	Rebuilding dunes on barrier beach in East Moriches vicinity.	Protection of homes and commercial investments.	Against closing Moriches Inlet. Desires Federal aid in rebuilding dunes on barrier beach.
Ralph A. Sturges, Jr.	-	-	-	Discussed winds, tides and waves.
Ernest J. Christie, Meteorologist in charge of New York City Office	U. S. Weather Bureau	-	-	Described the function of his office and made suggestions on how to utilize to best advantage weather information. Spoke of the possibility of a terrific storm washing over Fire Island and reaching the mainland.
. North, esident	Northampton Construction Co.	Construction of stone groins, 600 feet long, 700 or 800 feet apart along entire south shore of Long Island.	To protect and stabilize entire south shore of the island.	Suggested comprehensive study of the entire south shore of Long Island.
Allie J. Warfield, Trustee	Village of Westhampton Beach	-	-	Desires Federal financial aid for improvements, since the cost of beach erosion control is beyond the means of the local communities.

Table D-4 - Statements received by District Engineer prior and subsequent to public hearing held at Westhampton beach, New York on 20 December 1955

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
6 Dec 1955	B and B_1	Edmund A. Prentis	Resident of Westhampton Beach	Annual dredging of 50,000 cubic yards of sand from sand flats in bays opposite mouths of Moriches and Shinnecock Inlets and placement of this material close to the barrier beach west of the inlets.	To provide feeder material for natural distribution along barrier beach to prevent further erosion.	Survey shows that the crest of the dunes approximately 2,500 feet west of Swordfish Club have retreated northward 45 feet since spring of 1945.
				Endorses recommendations made in 1946 Beach Erosion Board Report and desires a final report to be made by this agency.	Report to be used as basis for measures to be taken to protect the barrier beach.	
14 Dec 1955	C and C_1	O.L. Carlson	Commandant, Headquarters Third Naval District	Jetties and/or permanent beach line bulkhead fronting property.	To protect the U. S. Navy Radio Station at Amagansett.	Gives data on storm damages, cost of repair of storm damages, tidal heights, and evacuation of navy personnel for 1954 and 1955 storms.
13 Dec 1955	D	Harold S. Meinhardt	Property owner at Center Moriches	Moriches Inlet should be closed or allowed to close naturally.	To protect against further damage caused by storms.	Gives statistics on storm damages to residence.
20 Dec 1955	E	John Rosato, President	Mastic Tax Payers Association, Inc.	Supports beach erosion program.	To prevent damages to barrier beaches and development thereon.	-
7 Dec 1955	F	Arthur Wilcox, Commodore	Moriches Yacht Club	Proper protection of Fire Island against storm waves overtopping dunes and washing sand into Moriches Bay.	To prevent shoaling of navigable inland waterways in Moriches Bay.	-
16 Dec 1955	G	Robert W. Martin, Jr.	Property owner fronting Moriches Bay	-	-	Gives estimate of damage caused by erosion and desires Federal relief.
20 Dec 1955	H	August Stout, Jr., Secretary	Chamber of Commerce of the Moriches	Rebuilding dunes on barrier beach off Center Moriches.	Barrier beach protects mainland bay front areas.	Neglect has caused deterioration of barrier beach so that the mainland is now imperiled.
19 Dec 1955	I	Edward H. Rogers, President	Heelbarp Corp., property owner at Westhampton Beach	-	-	Gives data on storm damages. States that shore of barrier beach has eroded 100 feet from 1938 to 1954. Shoaling has been caused in the bay by storm waters washing over the barrier beach. A storm as severe as the 1938 storm would destroy the barrier beach and much of the village on the mainland.
20 Dec 1955	J	William M. Burcher	Col. Keith L. Morgan of Swordfish Club, Inc. and Yardarm Hotel at Westhampton Beach	Restore and maintain 18-foot high dunes of sufficient breadth by deepening Intracoastal Waterway and using dredged material as fill.	To stop damage caused by wave action.	Gives data on damages caused by storms. Against use of jetties and bulkheads.
30 Nov 1955	K	Capt. E. T. Osborn, President	Moriches Inlet Stabilization Committee	Stabilization of Moriches Inlet by jetty extension and maintenance.	To improve tidal conditions in Moriches Bay and to strengthen the barrier beach.	Discusses the necessity of maintaining an inlet to Moriches Bay.

Table D-4 - Statements received by District Engineer prior and subsequent to public hearing held at Westhampton Beach, New York on 20 December 1955

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
19 Dec 1955	N	Charles S. Corrigan, Chairman	Shinnecock Inlet Stabilization Committee	Stabilization of Shinnecock Inlet by jetty extension and repair.	To cause build up of barrier beach to east of inlet and, therefore, make the barrier beach safe.	Discusses importance to eastern Long Island of keeping the inlet open. Indicated that entire Atlantic Ocean shore front from Jones Beach to Montauk Point needs attention.
20 Dec 1955	P	Egbert H. Howell, Secretary	Town of Brookhaven Bayman's Association	Requests Federal participation in improvement and stabilization of Moriches Inlet.	To rehabilitate shellfish producing areas. To serve as safety valve and prevent breaks through carrier beach.	Construction of the Moriches and Shinnecock jetties has resulted in beach building in the immediate vicinity.
20 Dec 1955	Q	Mrs. Louise Fell, Secretary and others	The Westhampton Association	Favors plan to stop dune erosion.	To protect property on barrier beach and mainland.	Discusses value of property which is in danger and efforts of individuals to protect their property. Gives statistical data on damages caused by storms.
18 Dec	S and S_1 to S_6	Capt. Frank T. Moss	Montauk Chamber of Commerce	Rebuild dunes by using snow fencing and then plant beach grass. Make mandatory, by legal means, the retention of dune height during seaside building operations and require owners of such structures to install bulkheads. Make provision for immediate dune rebuilding after breaching by storms to prevent further enlarging of breaches by subsequent storms.	Prevent washout of highway and railroad, and isolation of the community, paralysis of local sport and commercial fishing industries which bring an annual income of over $1,000,000, isolation of Camp Hero, and depreciation of real estate values.	Includes photographs showing extent of flooding and damage during 31 August 1954 hurricane, and data on damages and erosion for various storms in the area east of Napeague Harbor.
20 Dec 1955	V	-	Quantuck Beach Club, Inc.	-	-	Gives storm damage data.
20 Dec 1955	W	Mrs. Tillie W. Reynolds	Property owner at Westhampton Beach	-	-	Gives storm damage data.
Undated	X	Mr. and Mrs. Robert F. Mangel, Jr.	Resident at Hampton Beach	-	-	Dune Road was impassible during storms of 31 August 1954, 15 October 1954 and October 1955. Loss of use of facilities for four days after storms of 1954. Gives erosion and damage data.
19 Dec 1955	Z	Edmund A. Prentis	Resident at Westhampton Beach	-	-	Gives data on storm damage.

Table D-4 - Statements received by District Engineer prior and subsequent to public hearing held at Westhampton Beach, New York on 20 December 1955

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
undated	AA	Clarence C. Hulse	Resident at East Moriches	Stabilization of Atlantic Ocean shore front to withstand any storm. Also construction of jetties to stop sand entering inlets. Suggests high and low section jetties, slanted southwesterly, to build wider beaches, and snow fences and dune grass to aid the building of dunes.	- To decrease impact of waves on the dunes.	Discusses conservation measures which would allow natural drainage into bays and increase property values along bay front.
undated	BB_1	Maurice Brower, President	Joint Pollution Committee	Stabilization of Moriches Inlet.	To eliminate pollution of Moriches Bay which depresses property values and eliminates fish breeding. To allow Moriches Bay to be used by the Coast Guard and auxiliary boats during war time.	-
20 Dec 1955	CC_1	A. R. Allen, Jr.	Resident at Westhampton Beach	Federal Government should develop plans for restoring 18-foot high dunes and for inlet stabilization along entire south shore of Long Island. Legislation by State of New York to grant easements. Village or town should maintain improvements under Federal inspection.	To stabilize entire south shore of Long Island.	Discusses former measures taken and states that they have been insufficient. Believes that Federal, State, and county cooperation is necessary in developing a shore protection program.
5 Jan 1956	DD and DD_1	Percy B. Raynor, Town Clerk	Town of Brookhaven	Retention and stabilization of Moriches Inlet.	To prevent contamination of Moriches Bay and resulting lower property values, and to prevent the elimination of shellfish.	Discusses money already spent for inlet maintenance. Favors improvements to Fire Island Inlet, but opposes inlet improvement project which does not include Moriches Inlet.
16 Jan 1956	EE to EE_3	Charles E. Anderson	Property owner at Mastic	Retention of Moriches Inlet.	Moriches Inlet acts as safety valve for waters in the bay.	-
20 Jan 1955	FF	Harold DuFrane, Mayor	Village of Southampton	-	-	Submits statistical data on expenses resulting from storms of 1954.
21 Sept 1954	GG_1	Harold DuFrane, Mayor	Village of Southampton	-	-	Submits damage data for storms of 1954.
24 Jan 1954	HH	Marian S. Berri	Resident of Amagansett	-	-	Submits storm damage data.
30 Jan 1956	II	Mrs. Clara C. Heaney	Resident of Amagansett	-	-	Submits damage data. Discusses destruction of dines by Coast Guard at Amagansett and consequent inundation of property.

Table D-5 - Digest of minutes of public hearing before District Engineer, New York District, held at Riverhead, New York on 22 April 1958

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Hon. Stuyvesant Wainwright, Congressman	First New York District	-	-	Read his statement (see table D-6, page D-20).
John E. Harney, Wildlife Research Biologist	U. S. Fish and Wildlife Service, Boston, Mass.	-	-	Pointed to the importance of the fish and wildlife resources on Long Island and submitted letter from D.R. Gascoyne, Regional Director, Boston, Mass. (see table D-6, page D-20).
G. W. Haines, Chief Engineer, Coastal Engineering	Department of Public Works, State of New York	-	-	Read letter and report from M.E. Goul, District Engineer, Babylon, N. Y. (see table D-6, page D-20). Thanked Colonel Rogers and the others attending the hearing.
Alan Robinson, Administrative Assistant	New York State Flood Control Commission	-	-	Read his statement (see table D-6, page D-21).
Percy B. Raynor, Supervisor	Town of Brookhaven	-	-	Summarized his written statement and submitted photographs showing storm damage (see table D-6, page D-21).
Harvey E. Cooley, Mayor	Village of Quogue	-	-	Indicated that the reports heard at the hearing may be used to bring the subject study to a conclusion.
John A. Ludlow, Mayor	Village of Saltaire	-	-	Read his written statement (see table D-6, page D-21).
Arthur H. Silsdorf, Mayor	Village of Ocean Beach	-	-	Introduced Mr. Gilbert Serber, Chairman of the Fire Island Erosion Control Committee to present the official position of the village of Ocean Beach.
Gilbert M. Serber, Chairman	Fire Island Erosion Control Committee	-	-	Read statement on behalf of the Fire Island Erosion Control Committee (see table D-6, page D-21) and introduced Mr. J.W. Taussig, Vice-Chairman of the Committee.
J. W. Taussig, Vice-Chairman	Fire Island Erosion Control Committee	-	-	Confirmed statement made by Mr. Serber. Stated that fill placed on the beach at Point O'Woods and Ocean Beach was rapidly eroded and that efforts have been made to build the dunes by brush and bulldozers.
Cyrus P. Smith, Trustee	Village of Westhampton Beach	Favors plan presented by the U. S. Army District Engineer.	-	Stated that groins would not be of much value because they create erosion. Reported that the village has tried to correct the erosion problem on its barrier beach which has an assessed value of about one-fourth of the entire village, and that assistance from the State, County and Town in protecting the area is needed as soon as possible.
Richard Greenawyer, President of Board of Trustees	Union Free School District No. 14, Ocean Beach, Fire Island	-	-	Stated that there was a moral obligation to protect Fire Island.
Alan Hathway, Vice President	Kismet Beach and Lighthouse Shores, Inc.	-	-	Submitted photographs showing storm damage (see table D-6, page D-21).
Mrs. Elise F. Burke, Secretary	Fire Island Erosion Control Committee	-	-	Submitted photographs showing erosion of barrier beach (see table D-6, page D-21). Endorsed Mr. Serber's remarks.

Table D-5 - Digest of minutes of public hearing before District Engineer, New York District, held at Riverhead, New York on 22 April 1958

(Continued)

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Albert I. Drosin, Chairman, Maintenance Committee	Ocean Bay Park Property Owners Association	-	-	Concurs with the program of the Fire Island Erosion Control Committee.
Barney Goldwater	Ocean Bay Park Property Owners Association	Construction of rock jetties.	Jetties are the only permanent solution.	Inquired as to what action will be taken as a result of views expressed.
Alfred C. Hall, President	Fair Harbor Property Owners Association	-	-	Submitted written statement (see table D-6, page D-22).
				Relayed comments of the President, Bay Shore Chamber of Commerce, expressing concern about the barrier beach and asking for aid as soon as possible.
Richard D. Noel, President	Cherry Grove Property Owners Association	-	-	Endorsed Mr. Serber's recommendations.
LeRoy Pearsall	Inlet Committee, National Party Boat Owners Alliance	Construction of jetties.	Jetties are advised by experts.	-
Vincent R. Reilly, Vice President	South Fork Civic Conference	-	-	Read statement from South Fork Civic Conference (see table D-6, page D-22).
Wilson F. Reynolds	Westhampton Chamber of Commerce, Inc.	-	-	Read statement from Westhampton Chamber of Commerce (see table D-6, page D-22).
Lawrence F. Runey, Chairman	Fire Island Inlet Committee	-	-	Went on record as following the views of the Fire Island Erosion Control Committee on inlets and jetties.
Pierrepont E. Twitchell, Treasurer	Suffolk County Taxpayers Association	Jetties.	-	Stated that primarily dangerous sites should be taken care of first.
				Urged care in spending money on improvements, since experts are in disagreement.
C. N. Wade, President	Water Island Association	-	-	Concurred with report of Mr. Serber.
				Described damage in 1954 and 1958 storms and cited danger to mainland.
Millicent Selsam, Chairman	Ocean Bay Park Dune Committee	-	-	Expressed agreement with report of Fire Island Erosion Control Committee.
				Stated that fill placed in summer of 1957 has been eroded and a more permanent measure is needed.
Joseph B. Glancy, President	Shellfish, Incorporated	-	-	Indicated that inlets must be considered in any comprehensive plan of beach erosion control.
				Suggested that material currently being dredged from bays should be deposited on beach for nourishment.
James Obert Collins	Resident of Seaview	-	-	Concurred with plan presented by Mr. Serber.
Clifford C. Edwards	John M. Olin, property owner east of Georgica Pond	-	-	Urged careful study of eastern portion of study area.

Table D-5 - Digest of minutes of public hearing before District Engineer, New York District, held at Riverhead, New York on 22 April 1958

(Continued)

Speaker	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
Richard G. Hendrickson, Farmer and U.S. Weather Observer	-	Jetties and other improvements to hold the sand.	Jetties will fill up and overflow.	Described the nature and form of the beach sand.
William D. Lauersan	Resident of Huntington Station, N. Y.	-	-	Spoke of use of asphalt in jetty construction.
Wallace F. Pickard	Property owner on Fire Island	-	-	Read portions of his written statement (see table D-6, page D-22).
Harry Safron	Property owner at Ocean Bay Park	-	-	Endorsed Mr. Serber's recommendations.
Henry Such Smith, Transportation Specialists	Resident of New York, N. Y.	-	-	Made statement which is covered in his press release (see table D-6, page D-22).
Voice	-	-	-	Inquired about the public ownership requirement for Federal participation in the project.
Voice	-	-	-	Inquired as to how soon the project would start if approved.
Joseph W. Cermak, Coordinator	Suffolk County	-	-	Asked if project could start within two years. Thanked Colonel Rogers for holding hearing on behalf of Suffolk County Board of Supervisors.
E. L. North	-	Hydraulic fill and rock jetties.	Jetties will anchor the fill.	Related experience in jetty building (see also table D-6, page D-16).
Joseph M. Lubart, M.D.	Property owner at Ocean Beach	-	-	Inquired about effect of proposed fill on houses along dunes.
Voice	-	Hydraulic fill.	-	Stated that jetties would rob the beach to the west.
Voice	-	-	-	Indicated that jetties do not rob the beach sand.
Voice	-	-	-	Inquired about cost of jetties.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
17 Apr 1958	1	Hon. Frank J. Becker, Congressman	Third New York District	-	-	Urges immediate action in submitting recommendations to Congress for steps to be taken to halt erosion and further damage along the south shore of Long Island.
1 Apr 1958	2	Howlett E. Bishop, Atlantic Coast Director, U. S. Maritime Administration	Summer resident of Water Island	Long-range dune restoration program and construction of ramps over dunes together with an educational program and posters advising the public of the need to prevent damaging of the dunes by vehicles crossing thereon.	To prevent breaks through the dunes and property damage during storms.	Gives data on dune erosion and damages during the November 1953 and March 1958 storms. Incloses copy of his letter dated 1 April 1958 to the Suffolk County Board of Supervisors.
18 Apr 1958	3	Paul F. Royster, Assistant to the Federal Highway Administrator	U. S. Bureau of Public Roads.	A policy that would permit construction of fixed highway bridges.	Fixed bridges with reasonable navigation clearances would aid in evacuating persons from threatened areas in anticipation of and during hurricanes and would permit vessels to reach harbors of refuge. Evacuees and vessels would be endangered if low-level movable spans were damaged and failed to operate.	-
18 Apr 1958	4	Robert Moses, President	Long Island State Park Commission	Favors the solution proposed by the Army Engineers of hydraulic fill pumped in from the bay. Favors adoption of method which would not involve moving or demolishing houses in developed areas. Long-range planned program for the preservation of the seashore on Long Island.	This is the only sensible course to pursue. Makeshift brush and wire jetties and similar expedients as tried after the 1938 hurricane are ineffective.	Notes that Federal, state and county officials are cooperating in solutions for stabilization of Fire Island, Moriches and Shinnecock Inlets at a combined cost of $15,000,000. Favors public ownership of long stretches of shorefront on both sides of these inlets. Suggests assessment on local owners to pay portion of cost of proposed Fire Island Inlet to Montauk Point improvement. Incloses map and copy of letter dated 25 February 1958 indicating areas where work and studies are under way and where studies are proposed.
2 Apr 1958	5	Raymond R. MacLean, Clerk	Board of Supervisors, Suffolk County	Requests Federal and State agencies to take immediate action to provide both temporary and permanent measures to protect Fire Island Beach and the south shore from erosion.	The March 1958 storm has created an emergency situation along Fire Island Beach and the south shore of Suffolk County by reason of beach destruction, which poses a threat to life and property.	Submits resolution adopted by the Board of Supervisors on 31 March 1958.
15 Apr 1958	6	Albert B. Bauer	Property owner at Ocean Bay Park	Emergency dredging, fencing and long-range protection in the form of jetties for the protection of the shore line at Fire Island.	The ravages of last season's storms have destroyed the dunes to a degree where the inundation and destruction of property may prove fatal to persons and installations.	-
11 Apr 1958	7	Richard Greenmayer, President	Board of Trustees, Fire Island School, Union Free School District No. 14, Ocean Beach, N. Y.	Immediate and long-range restoration of dunes.	Delayed action may result in loss of life.	Draws attention to the economic and moral justification of the undertaking.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
9 Apr 1958	8	Elise Burke, Secretary	Fire Island Erosion Control Committee	-	-	Indicates the committee chairman will address the hearing.
11 Apr 1958	9	Edward Feinberg, Treasurer	Seaview Association of Fire Island	Urges acceptance of the views of the Chairman of Fire Island Erosion Control Committee regarding improvements and State and Federal aid.	-	Notes the damage of seven storms in the winter of 1957 to property which exceeded $1,000,000.
20 Apr 1958	10	A. V. Taylor, President	Ocean Bay Park Property Owners Association	Supports plan of the Fire Island Erosion Control Committee for building of jetties and temporary relief by dredging sand fill from Great South Bay.	-	States that Federal action is required.
16 Apr 1958	11	George W. Arnold, Secretary	Babylon Rotary Club	-	-	Furnishes copy of letter to Babylon Town Board indicating the importance of attending the hearing to indicate the urgency of the situation.
10 Apr 1958	12	I. Jerome Riker, President	Bath and Tennis Club of Westhampton Beach	Permanent measures to be taken by the government to protect the beaches.	To stop erosion which is a threat to a hotel and club representing an investment of over $1,500,000.	Spent over $50,000 to build dunes and fill land and expends funds annually to maintain the dunes.
15 Apr 1958	13	Maurice Barbash, President	South Beach Development Corporation, Babylon, N. Y.	A system of jetties for beach erosion control in preference to sand dunes.	Jetties would trap sand.	Points to effectiveness of Fire Island Inlet jetty in trapping sand and feels that sand dunes would be subject to erosion requiring periodic replenishment. Notes that the corporation is building a colony of summer homes east of Fair Harbor.
17 Apr 1958	14	L. E. Gooding	Owner, Sea Crest Motel, Amagansett, N. Y.	Hopes that something will be done by State and Federal Governments to alleviate property damage and erosion.	-	Discusses damage to property and erosion resulting from storms and emphasizes danger from breaks through dunes at Napeague Beach which prohibit traffic on Montauk Highway.
10 Apr 1958	15	Albert J. Gowan, Vice President	The Franklin National Bank, Bay Shore, N. Y.	Construction of long jetties at appropriate intervals.	If erosion is not controlled on Fire Island, the ocean might overflow into the bay, damaging the mainland of Long Island.	-
11 Apr 1958	16	Frederick H. Dechant	Harris-Dechant Associates, Consulting Engineers, Philadelphia, Pa.	-	-	Will appear at hearing.
Undated	17	Mrs. Alf Olsen	Home owner at Amagansett	-	-	Requests help in dealing with the problem of beach erosion on Gardiners Bay shore.
10 Apr 1958	18	Thomas L. Walsh	Home owner at Westhampton Beach	Construction of jetties.	Prevention of damage.	Cites the loss of several thousand dollars due to beach erosion and hurricane damage.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
15 Apr 1958	19	Vladimir De Gravenhoff	Home owner at Ocean Bay Park	Construction of jetties.	Prevention of erosion would promote extensive development and increase tax revenues.	-
Undated	20	Mrs. Jeanne Gravenhoff	Resident at Ocean Bay Park	Emergency dredging and snow fencing to repair the beach and dunes, and jetties as a permanent improvement.	-	-
15 Apr 1958	21	Herman Kapolkin, New York, N. Y.	-	Suggests that seawalls incorporate his invention called a Waves Power Plant.	-	Explains his invention for converting energy from sea waves into compressed air to produce power.
16 Apr 1958	22	Martin Michel	Home owner on Fire Island	Emergency dredging and long-range protection by jetty construction.	-	-
11 Apr 1958	23	George S. King, M.D.	Property owner at Lonelyville	Construction of stone jetties.	To reclaim and hold the shorefront.	Indicates that replenishment of sand eroded by hurricanes is useless and that dunes do not protect the beach. Notes that some people advocate sinking old ships along the beach for shore protection and states this would be expensive and destroy the beauty of the oceanfront.
16 Apr 1958	24	Catherine and Edward Vaughan, Ocean Bay Park	-	Construction of long jetties at necessary intervals.	-	-
17 Apr 1958	25	Lester Roxdell, New York, N. Y.	-	Dredging and fencing as a temporary measure and jetties for permanent relief at Ocean Bay Park.	Last year's dredging and fencing prevented serious damage.	-
17 Apr 1958	26	Edward L. North, Engineering Counselor, Westhampton Beach	-	Construction of stone jetties and hydraulic fill for the whole length of the south shore of Long Island.	To protect the south shore of Long Island.	Desires that Federal participation in beach erosion control should be the same as in flood control, inland surface erosion, irrigation and reforestation. Discusses items of importance in studying the beach erosion problem and rendering a recommendation to the Secretary of the Army. Encloses sketch showing a typical cross-section of jetties with estimates of quantities and cost. Reviews his experience as jetty construction contractor and raises several questions regarding the Jones Inlet jetty. Points to the size and rapid growth of population on Long Island.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
17 Apr 1958	27	Wolf Elkan, M.D.	Home owner at Ocean Bay Park	Effective measures for erosion control on Fire Island.	To prevent destruction of Fire Island beach and damage to the mainland of Long Island.	A project would reduce unemployment and create permanently increased values to the country.
18 Apr 1958	28	Charles Simon	Home owner at Seaview	Action to protect the beaches and dunes.	To prevent damage on oceanfront and mainland of Long Island and to preserve Fire Island for future generations.	-
18 Apr 1958	29	L. B. Kinghan	Property owner at Seaview	Measures to prevent erosion of Fire Island.	-	-
18 Apr 1958	30	James E. Stroock	Property owner at Seaview	Preservation of the beach front on Fire Island.	Continued erosion will endanger lives and property. Fire Island serves as a bulwark protecting the Long Island mainland against ocean inundation.	-
18 Apr 1958	31	Joseph Miller, New York, N. Y.	-	Preservation of beaches on Fire Island.	Urgently needed to conserve the beaches which have suffered great erosion.	-
18 Apr 1958	32	Herbert Michael Lowe, New York, N. Y.	-	Long jetties at necessary intervals, from Fire Island Inlet to Montauk Point.	-	-
Undated	33	Mr. & Mrs. Thos. A. Jennings	Property owners at Quiogue	-	-	Discusses damage to property due to erosion at Quantuck Bay.
18 Apr 1958	34	Rose Feinstone	Home owner at Seaview	Long jetties at necessary intervals from Fire Island Inlet to Montauk Point.	-	-
19 Apr 1958	35	Walter W. Weissmann	Property owner at Seaview	Requests immediate government assistance to protect Fire Island.	Further delay would be unfortunate.	-
19 Apr 1958	36	George Escott, New Rochelle, N.Y.	-	Long jetties at necessary intervals from Fire Island Inlet to Montauk Point.	-	-
17 Apr 1958	37	Marian Wolfson, Bayside, N. Y.	-	Emergency dredging and fencing and jetties for long-range protection.	To avoid a catastrophe.	-
19 Apr 1958	38	Mrs. Ann Feuerstein, Bay Shore, N. Y.	-	Long jetties at necessary intervals from Fire Island Inlet to Montauk Point.	To protect financial investments.	-
19 Apr 1958	39	Mrs. Josephine W. Quigg	Property owner at Seaview	Urges support of recommendation of Chairman, Fire Island Erosion Control Committee for construction of long jetties at proper intervals.	To provide permanent solution to the erosion problem.	-
18 Apr 1958	40	Frank A. Sieverman, Jr.	Resident of Ocean Beach	Favors construction of jetties by Federal Government as permanent solution.	Indicates that temporary protective measures which have been undertaken in the area are wasteful and that permanent measures are needed to reduce erosion and and property damage. Points to the effectiveness of the Fire Island Inlet jetty.	-

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
20 Apr 1958	41	Theodore H. Lindsey, Vice President	Ocean Bay Park Property Owners Association, Inc.	Emergency dredging of sand and the installation of snow fence as temporary measure and construction of jetties as a permanent measure.	To protect Fire Island against erosion.	-
20 Apr 1958	42	Teviah Sachs and Harry Kolberg	Home owners at Seaview	Preservation of Fire Island as recommended by Chairman, Fire Island Erosion Control Committee.	-	-
21 Apr 1958	43	Louis Vannoni, White Plains, N.Y.	-	Dredging, fencing or protection in the form of jetties.	Recent storms have destroyed a great deal of the dune along Fire Island beach.	-
21 Apr 1958	44	M. M. Melicow, M.D.	Home owner at Seaview	Construction of long jetties at necessary intervals from Fire Island Inlet to Montauk Point.	To save Fire Island and safeguard the south shore of Long Island.	-
21 Apr 1958	45	Mordecai Gorelik	Home owner at Seaview	Favors plan proposed by Chairman, Fire Island Erosion Control Committee.	-	The problem of beach erosion increases in seriousness from year to year.
22 Apr 1958	46	Mrs. H. J. Berkson, Seaview, N. Y.	-	Construction of long jetties at necessary intervals from Fire Island to Montauk Point.	-	-
Undated	47	Gloria Mathews	Property owner at Saltaire	Requests immediate action to protect Fire Island.	To prevent further erosion, possible loss of life and property damage.	Beach erosion inflicted considerable damage to her house and surrounding land. Since 1950 more than 3,500 sq. ft. of land vanished because of erosion.
-						Leaves choice of specific protective measures to discretion of engineers.
Undated	48	Mrs. Harold Brower and eight neighbors	Home owners at Bellmore Harbor	-	-	Furnishes information on flood damages to residences.
19 Apr 1958	49	M. L. Harrison, President	Oak Island Beach Association, Inc.	Dredging of Fire Island Inlet with the sand to be placed at Oak Beach instead of being dumped at sea.	To relieve erosion from tidal currents in the inlet and to provide a safe navigation channel.	Indicates that despite substantial sums spent for bulkheading and jetties, erosion at Oak Beach has reduced habitable land to a strip less than 500 feet wide in most places; that 54 houses representing an investment of about a half million dollars are threatened; and that some homes have been moved away from the waterfront.
21 Apr 1958	50	Mrs. Hi Carr	Property owner at Seaview	Construction of jetties.	-	States that the condition of the dunes and beach deteriorates with each winter's storm and that residents have tried to build up the dunes with snow fence and brush.
22 Apr 1958	51	Mrs. Joseph Kaufman	Home owner at Ocean Bay Park	Restoration of beach as an emergency measure and permanent protection in the form of jetties.	To save Fire Island and Long Island.	-
22 Apr 1958	52	George Marek, New York, N. Y.	-	Construction of long jetties from Fire Island to Montauk Point.	-	-

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958
(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
21 Apr 1958	53	Theodore J. Vogel	Property owner in Seaview and Ocean Beach area	Immediate assistance in control of erosion and construction of jetties.	To hold and build up the beach which has been eroding rapidly in recent years.	Points to the effectiveness of the Fire Island Inlet jetty in trapping sand and notes that much of the hydraulic fill placed at Ocean Beach in 1952 was eroded in October of the same year.
22 Apr 1958	54	Mrs. Dorothy Quick Mayer, East Hampton, N. Y.	-	-	-	States that the best method of dune repair involves use of snow fence and tree boughs with sand.
21 Apr 1958	55	Edwin A. Arnzen, Secretary	Chamber of Commerce of the Moriches, Center Moriches, N. Y.	Rebuilding of the dunes on Fire Island.	The barrier beach is the only means of protection to the mainland.	Favors any and all measures which would provide shore protection on the barrier beaches. Notes that Suffolk County and the Town of Brookhaven can supply official records of damage caused by erosion and storms.
22 Apr 1958	56	August Stout, Jr., Temporary Chairman	Moriches Inlet Stabilization Committee, Center Moriches, N. Y.	Rebuilding of the dunes on Fire Island.	-	Urges review of brief filed by the committee at the 1955 hearing in Westhampton Beach and completion of the cooperative study as soon as possible.
21 Apr 1958	57	Mrs. Charles L. Woody, Jr.	Property owner at East Hampton	Urges Government to include the Town of East Hampton in a project for protection against storms.	To prevent erosion and property damage.	Gives details on erosion of land and dunes and states that bulldozing work, snow fencing and grass planting which cost her about $7,000 was washed away this past winter. Indicates that her house, valued at least $150,000, is threatened by destruction.
21 Apr 1958	58	Mrs. Lawrence Flinn	Property owner at East Hampton	Urges Government to include the Town of East Hampton in a project for protection against storms.	To prevent erosion and property damage.	Gives details on erosion of dunes and states that snow fences built last summer have been destroyed by storms. Indicates that her house, valued at over $200,000, is menaced by the ocean.
21 Apr 1958	59	Mrs. Jane Erdman Sobotka	Property owner at East Hampton	Requests Government to include the Town of East Hampton in a project for protection against storms.	To prevent erosion and property damage.	Gives details on erosion of land and dunes and states that a large amount of money has been spent on bulkheads, snow fences, beach grass and brush to protect her property.
22 Apr 1958	60	Raymond A. Smith, Jr. Attorney	Neapeague Co., Inc., property owner at Napeague	Restoration of the ocean beach. Restoration of dunes on publicly-owned property.	To prevent erosion and property damage and loss of tax revenue.	States that property including five cottages and a motel represents an investment of about $150,000 and that $2,500 has been spent to build snow fences and plant beach grass. Notes severe erosion caused by storms in 1958 has necessitated moving a cottage away from the oceanfront, and the possibility that two other cottages will have to be moved. Discloses that dunes on adjacent property have been damaged by persons crossing thereon, and that this results in flooding by the ocean during storms. Encloses photographs showing condition of property in November 1955 and damage following March 1958 storm.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
22 Apr 1958	61	W. Eugene Johnson, Jr., Secretary	Moriches Yacht Club, Center Moriches, N.Y.	Repair of damage on Fire Island Beach and preservation of the shoreline.	To prevent destruction of the coastal barrier which would result in loss of millions of dollars in property, and to the fishing and boating industries.	-
22 Apr 1958	62	Edward H. Rogers	Property owner at Westhampton Beach	Hydraulic fill to build up the dunes in areas where material may be obtained from the inner bays. Construction of a series of jetties where a supply of hydraulic fill is not available.	To provide protection against storm damage on the oceanfront and the mainland along the inner bays and to improve navigation where fill is obtained from the inner bays.	Gives details on erosion of dunes and notes the depreciation in value and salability of property subject to storm damage. States there are 515 dwellings in the Westhampton Beach and Quogue Beach areas where the land and improvements have a current value of over 12 million dollars.
22 Apr 1958	63	Hon. Stuyvesant Wainwright, Congressman	First New York District	Positive action to protect Long Island shores in accordance with the recommendations of U. S. Army District Engineer.	-	Points out that public interest in the need for protection was aroused following the devastation resulting from Hurricane Carol. Discusses his efforts in pressing for legislation to permit Federal participation in the cost of protecting private shores and outlines his efforts leading to initiation of the subject cooperative beach erosion study. Indicates that he will introduce legislation to carry out the project following approval by the Corps of Engineers.
28 Mar 1958	64	D. H. Gascoyne, Regional Director	U.S. Fish and Wildlife Service, Boston, Mass.	-	-	Outlines interest in the shellfish, finfish and wildlife resources in the inner bays and indicates that the Fish and Wildlife Service is prepared to undertake an investigation to determine areas where dredging to obtain fill can be accomplished with the least detrimental effect. Copy of this exhibit and letters of 28 May 1958 and 9 June 1958 are contained in appendix J of the subject report. These subsequent letters from the Wildlife Service state that it would not oppose any project designed to maintain or improve the barrier beaches and that its investigation would aim at providing suggested modifications that would protect fish and wildlife resources and still remain within the framework of the primary project purpose.
21 Apr 1958	65	M. E. Goul, District Engineer	New York State Dept. of Public Works, Babylon, N. Y.	Favors plan proposed by the Army Engineers for hydraulic fill with natural slopes in undeveloped areas. Suggests that fill placed on the foreshore along developed areas be confined by groins where necessary, and that the cost of such groins should be considered part of the initial cost to be shared by Federal and local interests.	-	Encloses copy of report prepared in response to a resolution adopted by the Suffolk County Board of Supervisors describing damage done by recent storms with approximate cost of emergency restoration. The report classifies areas requiring dune restoration in order of priority and points out that 5¼ miles of shorefront are in immediate need of restoration at an estimated cost of $480,000. It suggests construction of three groins in the Westhampton Beach area for future consideration. It also suggests that local interests request reimbursement for money spent on remedial measures which may be in agreement with the plan of the Corps of Engineers.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
22 Apr 1958	66	Alan Robinson, Administrative Assistant	New York State Flood Control Commission, Albany, N.Y.	-	-	Indicates that the New York State Flood Control Commission has a vital interest in the possible authorization and prosecution of any hurricane-flood control project in this area.
22 Apr 1958	67	Percy B. Raynor, Supervisor	Town of Brookhaven	Maintenance and protection of beaches along the north and south shores of Long Island and stabilization and improvement of inlets.	Destruction of the barrier beach or closing of inlets would result in a loss of millions of dollars to the shellfish and fishing industries and recreational activities, and a loss of assessed valuations on real estate.	Presents data indicating the economic importance of Long Island to the United States. Requests greater Federal assistance in the cost of constructing protective works and indicates that local governments are unable to finance the high cost of such projects. Incloses photographs showing damage from recent storms on Fire Island.
22 Apr 1958	68	John A. Ludlow, Mayor	Village of Saltaire	Endorses recommendation of Chairman, Fire Island Erosion Control Committee for construction of long rock jetties to secure permanent protection. Hydraulic fill from Great South Bay pending construction of the jetties.	To prevent property damage and loss of tax revenues.	Emphasizes the constantly increasing development of vacation land on Fire Island and the possible devastation of the area by the sea in the absence of protective measures.
22 Apr 1958	69	G. K. Sorter, Chairman	Fire Island Erosion Control Committee	Construction in stages of rock jetties extending offshore beyond the 12-foot depth contour with the westernmost jetty to be located in the vicinity of Fire Island Lighthouse and succeeding jetties at intervals of about 3 miles for a distance of 15 miles to the east. Some beach feeding by hydraulic fill. Model studies of Fire Island, Moriches and Shinnecock Inlets.	To trap sand in order to create a wide beach and to build up the dunes by the action of the wind on the accreted sand. This would preserve the barrier beach and would protect the mainland along the inner bays. Also, trapping of sand by the proposed jetties would reduce shoaling of the inlets. To provide initial fill east of each jetty and to replace possible erosion on the westerly side. To point the way to their stabilization or possible relocation where desirable.	Indicates that the Committee represents 16 communities and the Sunken Forest Preserve on Fire Island. Describes in detail the conditions which are causing storm damage on Fire Island and states that the shoreline has receded 80 to 100 feet in the past 40 years of which 30 to 40 feet have eroded in the past 10 years. Points to the effectiveness of the Fire Island Inlet jetty in trapping littoral drift and points to the lack of success in providing protection by means of hydraulic fill, bulldozing and constructing short jetties, bulkheads and revetments.
22 Apr 1958	70	Submitted by Alan Hathway, Vice President	Kismet Beach and Lighthouse Shores, Inc.	-	-	This exhibit consists of photographs taken in 1958 showing breaks through the dunes at Fire Island State Park east of the lighthouse and photographs and maps depicting erosion from 1926 to 1958 at Kismet.
22 Apr 1958	71	Submitted by Mrs. Elise F. Burke, Secretary	Fire Island Erosion Control Committee	-	-	This exhibit consists of photographs of Fire Island Inlet jetty taken in 1941, 1946 and 1958 showing accumulation of sand at Democrat Point, and photographs showing dune erosion at Saltaire, Ocean Beach, Ocean Bay Park and Point O'Woods during various periods from the early 1930's to 1958.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958
(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
15 Apr 1958	72	Alfred C. Hall, President	Fair Harbor Property Owners Association	Construction of jetties as suggested by Chairman, Fire Island Erosion Control Committee.	To provide permanent protection to eliminate the possibility of loss of life and damage to property on Fire Island and on the mainland along the inner bays.	The communities along the south shore of Long Island cannot afford to entertain consideration of temporary protective measures as a solution.
22 Apr 1958	73	John H. Thorpe, Fire Island Pines	-	Hydraulic fill as an interim measure and construction of jettise similar to the Fire Island Inlet jetty for permanent protection.	-	Notes that about 25 feet of dune has eroded in a period of over 25 years and indicates that over 5,000 feet of snow fence has been constructed at Fire Island Pines to trap wind-blown sand.
22 Apr 1958	74	-	Ocean Bay Park	Supports recommendation of Chairman, Fire Island Erosion Control Committee for construction of rock jetties as a permanent solution.	Experience has shown that beach fill is only a temporary solution.	States that building of snow fences, placing brush and planting beach grass have been effective in holding and slowly building up the dunes which are quickly eroded during storms.
22 Apr 1958	75	James N. Dunlop, President	Sunken Forest Preserve Inc., New York, N. Y.	Construction of a series of rock jetties extending beyond the 12-foot depth contour and starting at a point 3 miles east of the Fire Island Inlet jetty with successive jetties 3 miles apart to the east for as great a distance as may prove necessary; with such temporary feeding of the beach by hydraulic fill as may be needed.	To protect and improve the barrier beach on Fire Island which faces the threat of destruction.	States that the corporation owns 73 acres of land on Fire Island east of Point O'Woods which is a primeval forest providing a habitat for wildlife. Indicates experience has shown that hydraulic fill, bulldozing sand from the beaches and bulkheads are ineffective in protecting Fire Island, and points to the effectiveness of the Fire Island Inlet jetty in trapping sand.
22 Apr 1958	76	Carlos Videla, President	South Fork Civic Conference, Towns of Southampton and East Hampton	Immediate action to protect the oceanfront from Fire Island to Montauk.	To save the beaches and the intracoastal navigation channels.	This organization represents 22 local civic groups with a membership of over 5,000 persons.
22 Apr 1958	77	William R. Robinson, President	Westhampton Chamber of Commerce	Immediate strengthening of the dunes at Westhampton Beach.	Hundreds of houses are in danger of being cut off by new inlets cutting through the dunes. This condition would wipe out private property and undermine the economic structure of the village.	-
22 Apr 1958	78	Wallace F. Pickard	Property owner on Fire Island	Construction of long jetties as recommended by Chairman, Fire Island Erosion Control Committee.	Experience with the Fire Island Inlet jetty in trapping sand indicates that jetties are effective in stabilizing the shore. All other measures including hydraulic fill, short timber and concrete jetties and snow fencing have failed. Construction of long jetties would also solve the inlet shoaling problem by trapping littoral drift before it enters the inlet.	Notes that erosion on the south shore of Long Island has been going on for centuries, but its dangers have been recognized only since the 1938 hurricane. Stresses that there are two distinct problems: one is the need for immediate temporary measures to prevent further damage to critical areas and the other is the need for a long-term permanent solution.
23 Apr 1958	79	Submitted by Henry Such Smith, Transportation Specialist, New York, N.Y.	-	Beach replenishment in strategic areas to meet storm erosion problems by dredging sand from the ocean where the depths are greater than 30 feet.	-	This exhibit is a press release of his statement presenting geological background data on shore processes and pointing out that construction of jetties and bulkheads would not provide a lasting benefit in erosion control. The exhibit also contains a copy of his letter dated 6 March 1946 to the Borough Clerk of Bay Head, New Jersey, giving suggestions for improvement of the shore in that area by hydraulic fill to be dredged from the ocean.

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958

(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
22 Apr 1958	80	J. O. Straus	Property owner at Ocean Beach	Construction of groins extending to the 12-foot depth contour.	To protect the barrier beach and the mainland along the inner bays.	Does not favor hydraulic fill and condemning beach front property.
22 Apr 1958	81	Joseph R. Wright and John A. Neikles	Residents of Ocean Bay Park	Supports the recommendations of the Fire Island Erosion Control Committee.	-	-
22 Apr 1958	82	Max Gordon	Resident of Seaview	Measures to protect Long Island as quickly as possible.	-	-
21 Apr 1958	83	Ralph H. Levey	Summer resident of Fire Island	Construction of jetties at intervals of 3 miles as recommended by Chairman, Fire Island Erosion Control Committee.	To prevent loss of life.	States that 60 to 130 feet of dunes have eroded in a period of over 30 years.
Undated	84	Josephine Squier	Property owner at Seaview	Construction of long jetties at necessary intervals from Fire Island to Montauk Point, and repairing the dunes on Fire Island.	To protect life and property on Fire Island and on the mainland along the inner bays.	-
Undated	85	Louis Alter	Resident of Seaview	Construction of jetties on Fire Island.	To eliminate threat of destruction from storms.	-
22 Apr 1958	86	Alice Zanerra	Property owner at Amagansett	Building of breakwaters.	To protect the beach and eliminate dangerous condition to life and property.	Indicates lack of warning of oncoming hurricanes and consequent danger to loss of life. Reports considerable damage and erosion of the beach and dunes.
22 Apr 1958	87	Henry Greenfield, Forest Hills, N.Y.	-	Construction of jetties similar to the one at Fire Island Inlet.	All other erosion control measures are ineffective.	-
21 Apr 1958	88	Max J. Green, Manager	Chicopee Manufacturing Corporation, Cornelia, Georgia	-	-	Proposes use of their manufactured screen cloth in erecting fences to trap wind-blown sand.
17 Apr 1958	89	Mrs. Beverley Elkan	Home owner at Ocean Bay Park	Supports every action for control of erosion of Fire Island.	To prevent the destruction of Fire Island which protects the mainland along the inner bays.	Construction of protective works would alleviate unemployment in the area and create permanently-increased values to the country.
23 Apr 1958	90	J. Stanford Setchell	Sequasse Property Owners Association, Inc., West Islip, N.Y.	Erosion control program to preserve the Fire Island barrier beach.	-	Cautions that excessive widening and deepening of inlets for navigation would result in higher water level in the bay which would inundate developed areas on the mainland.
Undated	91	Ella & Arthur Coons	Summer residents of Fire Island	Construction of long jetties at necessary intervals from Fire Island to Montauk Point.	-	-
22 Apr 1958	92	Gertrude Parker, Recording Secretary	The Mastic Beach Property Owners Association, Inc.	Any plan of improvement to protect property in the Mastic Beach area.	-	States that the Mastic Beach area has an assessed valuation of over $6,000,000.
24 Apr 1958	93	Mrs. Germaine M. Ristoff	Home owner on Fire Island	Stabilization of the Fire Island shore.	-	-

Table D-6 - Statements received by District Engineer prior and subsequent to public hearing held at Riverhead, New York on 22 April 1958
(Continued)

Date	Exhibit in Minutes of Public Hearing	Signed By	Interest Represented	Improvement Desired	Reasons Advanced	Remarks
25 Apr 1958	94	Ralph H. Axtholm	Property owner at Westhampton Beach	Some immediate action.	-	Notes that the ocean broke through the dunes near his house during the 21-22 March 1958 storm following erosion of the beach by early winter storms which uncovered a series of old jetties. Indicates these jetties accelerated erosion of the dunes.
29 Apr 1958	95	Nicholas Montemarano	Gurney's Inn, Montauk, N. Y.	Construction of rock jetties recommended by Chairman, Fire Island Erosion Control Committee as a permanent plan, and hydraulic fill as a stop-gap measure until jetties are constructed.	To safeguard the south shore of Long Island which has the finest beaches in the country.	-

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

JOHN W. JOHNSON
SUPERINTENDENT

M. E. GOUL, DISTRICT ENGINEER
MONTAUK HIGHWAY, AT LITTLE EAST NECK ROAD

COUNTIES IN 10TH DISTRICT
NASSAU
SUFFOLK
GREATER NEW YORK

BABYLON, L. I., N. Y.,

December 9, 1958

Hurricane Barriers

Col. T. DeF. Rogers, Dist. Engr.
Corps of Engineers, U. S. Army
111 East 16th Street
New York 3, N. Y.

Dear Sir:

At your request, we have reviewed the hurricane barrier placements at Mastic Beach and find that we cannot concur in their use. The small 50 foot opening would be a hazard to boat traffic, especially at night, and would seriously affect the inter-change of waters between Bellport Bay and Moriches Bay, which, in turn, could worsen an already serious pollution problem. Furthermore, should any heavy flooding condition occur to the east or west of these barriers, there is no doubt that the local residents would blame this flooding on the barriers. These same local residents would also resent the obstruction to their bay privileges.

Although you have requested our opinion in this matter, it is to be pointed out that our existing Erosion Control Laws do not permit State participation in hurricane protection, and, therefore, the entire local share for the construction and maintenance of these barriers would have to be borne by Suffolk County.

We have conferred with the Suffolk County authorities concerning the construction of these barriers, and they are in agreement with the above noted objections.

Very truly yours,

M E Goul

M. E. GOUL
District Engineer

GWH:IF

Cc: H. Ten Hagen
H. Evans
A. Cass
J. Cermak

COUNTY OF SUFFOLK

H. LEE DENNISON
COUNTY EXECUTIVE

August 30, 1965

U. S. Army Engineer District
111 East 16th Street
New York, N.Y. 10003

Dear Sir:

Returning herewith the draft copy of the Interim Hurricane Study by the U. S. Army Corps of Engineers which was forwarded to Suffolk County for comment.

The Suffolk Board of Supervisors and the County Executive concur entirely with the findings of the Corps that floodwalls and levees would not be feasible or useful as protection against tidal flooding of the areas along the inner bays of the County.

The County Executive also feels that protection in the area from Fire Island Inlet westward to the County line is being adequately provided for by the Long Island State Park Commission.

A copy of the final Corps report would be appreciated by the County Executive.

Very truly yours,

H. Lee Dennison
S.K

H. Lee Dennison
County Executive

HLD:sk

COUNTY CENTER • RIVERHEAD, LONG ISLAND, N. Y. 11901 • PARK 7-4700

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

July 14, 1965

District Engineer
New York District
U. S. Army Corps of Engineers
111 East 16th Street
New York, New York

Dear Sir:

In regard to your interim report on hurricane studies of the Inner Bays of the Atlantic Coast of Long Island, New York, since no construction features are recommended, fish and wildlife resources are not significantly involved and we do not plan to prepare a report unless your report is modified to include construction recommendations.

Sincerely yours,

Thomas A. Schrader

Thomas A. Schrader, Chief
Division of Technical Services

J. BURCH McMORRAN
SUPERINTENDENT

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

1220 WASHINGTON AVENUE
STATE CAMPUS

ALBANY 26, NEW YORK

September 7, 1965

Colonel R. T. Batson, District Engineer
U. S. Army Engineer District, New York
Corps of Engineers
111 East 16th Street
New York, N. Y. 10003

Re: Interim Report on Hurricane Study - Inner Bays from Fire Island Inlet to Montauk Point and Fire Island Inlet to Jones Beach

Dear Colonel:

The subject combined report has been reviewed by the New York State Department of Public Works which has solicited comments from Suffolk County officials and the Long Island State Park Commission.

Suffolk County officials, after analysis of the study, report that construction of hurricane levees between the barrier beach and the mainland would not be feasible. They feel the protection afforded would be more than offset by the difficulties caused to navigation interests and the possibility of increasing pollution in the bays. They also feel that protection in the area from Fire Island Inlet westward to the county line is adequately provided by the Long Island State Park Commission.

The Park Commission, after review of the study affecting their interests, report that dunes above elevation +12.0 south of the Boardwalk at Jones Beach would not be acceptable. While they offer no objections to dunes constructed to elevation +18 from the east end of the Boardwalk to Oak Beach they feel that the existing highway affords the area the necessary protection from hurricanes. They also feel that some additional beach nourishment should be provided in the Gilgo Beach area where erosion is occurring at a rapid rate and will soon endanger both the Gilgo pavilion and Ocean Parkway.

New York State concurs in the views expressed by Suffolk County and the Long Island State Park Commission.

Sincerely,

J. Burch McMorran

J. BURCH McMORRAN
Superintendent of Public Works

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX E

POLLUTION AND FISH AND WILDLIFE

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX E - POLLUTION AND FISH AND WILDLIFE

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INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX E - POLLUTION AND FISH AND WILDLIFE

I. POLLUTION

E1. GENERAL. There is no known pollution on the ocean side of the barrier beaches. However, the Inner Bay waters of the study area are abnormally enriched by nutrients having their principal origin in organic wastes produced by human activities. These wastes come largely from sewage effluents reaching the ground water which is discharged to the bays. Where the soil is porous and subsurface disposal systems are operating adequately, the wastes are easily leached into the ground water. Where the soil is not conducive to the use of subsurface systems, overflows occur which find their way into the surface streams. Organic nitrogen, coliform organisms, and synthetic detergents all indicate that human wastes are entering the watercourses. Contamination of the bay waters by the sewage effluents provides ample nutrients to support the large plankton population. Algae of all kinds will continue to flourish and to produce occasional excessive blooms so long as the present enrichment of bay waters continues. As population density increases the situation may be expected to become worse.

E2. GREAT SOUTH BAY. In a summary report prepared and released by the New York State Health Department in June 1962 it was concluded that the waters in Great South Bay, with the exception of the area at the Ocean Beach sewage treatment plant outfall, are not polluted from a bacteriological standpoint and are open to shellfishing. The tributary creeks and canals are polluted to a varying degree. Although they receive no appreciable amounts of raw sewage, they are subject to infiltration from subsurface sewage disposal systems. A small tidal range and the absence of currents prevent adequate dilution and disposal of the wastes.

E3. In a joint summary report of 6 June 1962 prepared by the New York State Department of Health, the United States Public Health Service and State conservation and park agencies, it was concluded that large numbers of plankton, including algae, are in all portions of the bay. Considerable amounts of phosphates and nitrates enter the bay, their source primarily being domestic sewage, industrial wastes, duck farms and leachings from agricultural fertilizer. There is an abnormally low nitrate-phosphate ratio and is attributed to the utilization by plankton of most of the nitrates, leaving an excess of phosphates. As nitrate contribution increases with population growth and continued disposal of sewage effluents to the ground water aquifier, the algae population and troubles associated therewith may be expected to increase.

E4. MORICHES BAY. The problem of pollution has been particularly acute in Moriches Bay. Duck farms situated in waters tributary to this bay, mainly in areas near Forge River and Seatuck Cove, contribute additional wastes along with sewage effluents previously described in paragraph E1. Algae growth, locally known as "small form", thrives from nutrients resulting from these effluents having a deleterious effect on the propogation of shellfish in this area. The pollutants also cause odor and discoloration of the water. The Woods Hole Oceanographic Institution made studies in 1950-1957, sponsored by the towns of Islip and Brookhaven, to determine the cause of the virtual disappearance of the seed oysters since about 1938 and the market oysters since about 1947. In these studies, Moriches Bay was recognized as the most seriously polluted area, and that the unsatisfactory conditions of Great South Bay for the production of oysters was excessive pollution by organic matter, partly originating in Moriches Bay.

E5. SHINNECOCK BAY. In its report of 1953, the New York State Department of Health, Water Pollution Control Board reported that there is some pollution in Shinnecock Bay resulting from the presence of duck farms in the area and indiscriminate sewage discharges from boats and surface runoff from the highly populated areas.

E6. POLLUTION ABATEMENT. A Federal pollution study is underway for the Hudson, Champlain and Metropolitan New York Areas by the Water Projects Section, Technical Service Branch, Division of Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare. Great South Bay, Moriches Bay, and Shinnecock Bay will be included in this study.

E7. The Moriches and Shinnecock Inlets navigation project as listed on table 2 of the main report, will provide for assured uninterrupted opening of the inlets to the maximum extent consistent with navigational requirements. Greater tidal exchange through the inlets will result in better dilution of the pollutants by admitting more saline water into the bays and in greater flushing of the bay waters.

E8. Article 6 of the New York State Health Law, enacted in 1949 and subsequently amended by Article 12, declares it to be the policy to maintain reasonable standards of purity of the waters consistent with public health, recreation and protection of fish and wildlife by preventing new pollution and abating any existing pollution. The article makes it unlawful to discharge matter causing conditions in contravention of the standards adopted by the New York State Water Pollution Control Board, which was created to implement and enforce the law. It expressly prohibits discharge of wastes which are injurious to edible fish and shellfish or the propagation thereof. The Water Pollution Control Board has made surveys of the bays in the study area and has determined for each portion of the bays and tributaries the desirable classification of standard of purity and best usage. In areas where duck farms exist, the farm owners have been required to treat the wastes at the source prior to discharge into the bays. The present method of treatment consists of discharging the wastes through lagoons, or settling basins. The lagoons are

cleaned periodically. This method results in removal of about 90 percent of the settleable solid wastes. However, the soluble wastes which include the nutrients responsible for the support of algae blooms, are discharged into the bay. A survey of Moriches Bay and Great South Bay during the summer of 1956 by the Woods Hole Oceanographic Institution indicated that the pollution had not abated, although the great majority of the farms had instituted the lagoon system.

E9. The construction of sewerage systems and sewage treatment plants to collect and remove the domestic and industrial wastes in the study area is required. While the sewerage system of the western part of Nassau County is near completion, plans are now under study for a sewage treatment system to cover the eastern part of the county adjacent to Great South Bay. Suffolk County is currently engaged in a planning study to develop a comprehensive sewerage system to serve its portion of the study area.

II. FISH AND WILDLIFE

E10. GENERAL. Fish and Wildlife resources of significance are found within the study area. The south shore tidal waters are extremely valuable commercial and sport fishery and wildlife resources.

E11. FISH. Ocean front. Sport and commercial fishing is found in the waters of the ocean front. The major sport fishery resource associated with the ocean front area is the striped bass. The early spring northward migrants, the summer resident bass, and the southward migrants of late fall maintain their movements in close relationships with the shorefront area. Major seasonal concentrations of striped bass can be found in the areas of the inlets and particularly east of Moriches Inlet. Lesser numbers of fish species such as bluefish, mackeral, weakfish, and fluke also utilize the ocean habitat along the shorefront area.

E12. Surf casting and bottom fishing from the beach along the shorefront area, as well as trolling in outboard and smaller inboard boats make up the specialized methods of angling for these sport fishes. Surf casters concentrate their activity in that area from Moriches Inlet eastward, which are easily accessible by foot or beach buggy. The very nature of the highly specialized type of fishing and the extensive travel involved to get to the ocean waters creates an above average investment by these salt water anglers.

E13. Commercial fishery of the shorefront area involves the same fish species described above. Of particular importance is the beach haul seine operation for commercial taking of striped bass. The shorefront area in general where most seining operations take place is east of Moriches Inlet.

E14. Inner Bay areas. Important sport and commercial fisheries are dependent upon many species of finfish that live in these tidal areas. The marsh and associated habitat areas are used as spawning, nursery, or feeding grounds. More than 60 species of fish use the bay habitat areas for at least a part of each year. Of these, the summer flounder, winter flounder, striped bass, bluefish, black sea bass, tautog, northern puffer, American eel, northern kingfish, and scup are sought by sport fishermen. The average annual harvest of commercial finfish for the ten-year period 1947-1957 was 790,000 pounds which brought $113,710 at the landings; the fish being principally flounder, eel, fluke and blowfish. The commercial fish catch for the bay areas during the years 1954 to 1961 are listed on table E1. Sport fishing also utilizes the bay fisheries to a large extent. A 1956 summary of fluke fishermen alone, covering the period June through August 1956, showed that 194,200 fishermen were carried in 41,680 boat sailings. The fluke fishermen harvested well over one and one-half million fish.

TABLE E1 - FISH CATCH IN BAY AREAS (THOUSANDS OF POUNDS)

Area	1954	1955	1956	1957	1958	1959	1960	1961
GREAT SOUTH BAY								
Fish	697	505	312	99	98	106	72	114
Shellfish	11	16	22	120	2,141	1,732	1,830	1,763
Total	708	521	334	219	2,239	1,838	1,902	1,877
MORICHES AND SHINNECOCK BAYS								
Fish	294	374	536	511	430	196	186	240
Shellfish	-	9	3	12	428	512	398	422
Total	294	383	539	523	858	708	584	662

Source: Bureau of Commercial Fisheries, Office of Statistical Services, Bayport, Long Island.

E15. SHELLFISH. Shellfish are extremely important throughout parts of the bays. The broad expanse of shallow bay waters and mud flats provide productive habitat for shellfish. Blue crabs, bank mussels, blue mussels, hard shelled clams, oysters, razor clams, scallops, and soft clams are the principal shellfish. The average annual landings of commercial shellfish for the ten-year period 1947-1957 amounted to 21,050,000 pounds which sold at the landings for an average annual value of $1,298,675. In some areas pollution prohibits utilization of the shellfish resource. This

shellfish resource, although located in "non certified" areas, represents a resource potential. Shellfish would be available for use following an adequate pollution program or for transplanting purposes to certified areas from which they could be harvested for ultimate utilization by the consumers. The commercial shellfish catch for the bay areas during the years 1954 to 1961 are listed on table E1.

E16. WILDLIFE. The bays with their complex of marshes, mud flats and tidal shallows are used by many species of migrating waterfowl in Spring and Fall, but more important they serve as a wintering terminus for huge segments of waterfowl population which migrate chiefly from the Maritime Provinces of Canada, Newfoundland and Labrador because of the natural feeding and resting facilities the habitat provides. The bay bottoms produce an unusually abundant supply of animal and vegetable foods suitable and readily available for the diving ducks, while the mud flats and shoal areas produce an abundance of food for the dabbling ducks. The bay areas are part of the extremely important south shore waterfowl habitat unit existing along the North Atlantic Coast. The United States shares under treaty with Canada and Mexico responsibility for perpetuating our continental waterfowl population. These bays together with other Long Island waters and wetlands, are important areas contributing to achieving this objective.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX F

FLOOD PLAIN ZONING

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX F - FLOOD PLAIN ZONING

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LIST OF EXHIBITS

Exhibit	Description
F1	Resume of Flood Plain Information Studies Under Section 206

INTERIM HURRICANE STUDY
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APPENDIX F - FLOOD PLAIN ZONING

F1. GENERAL. The adoption of effective regulatory measures to prohibit development in hazardous flood areas, whether residential and/or commercial centers, will result in the saving of lives and property in the area while diminishing future demands on the Federal, State, and local governments for flood relief and flood control expenditures. A careful study must be made before zoning a flood plain to serve the needs of the community in the best manner possible, with a minimum of danger from hurricane damage, and with proper allowance for the future growth of the community. In the preparation of an appropriate zoning ordinance, two important factors must be considered; namely, (a) the height of the flood stage in the area to be zoned below which construction will not be permitted, and (b) land use or development which will be permitted in the zoned area.

F2. DETERMINATION OF FLOOD STAGE. The maximum tide of record would normally have considerable influence on the establishment of the level or elevation below which the local governments should not permit improvements that could be damaged by high tides. However, with raising of the dunes under the authorized project, as described in paragraph 79 of the main report, bay levels will be considerably lowered with consequent lowering of flood heights for use as future zoning criteria of the various communities in the study area.

F3. For expensive installations of structures where there would be a potential hazard to human life during severe storms, the various bay stages, estimated frequency of bay stages, wind set-up, and wave run-up as described in paragraphs 65 to 67 of the main report will be helpful in establishing the flood stage for the communities within the study area; a lesser flood level may be considered for other improvements, depending on the type of improvement or structure. Some communities within the study area have already established some zoning control within the flood plain area as shown in table F1.

F4. LAND USE AND DEVELOPMENT. Within the flood plain area it may be desirable to provide more than one zone, with a different type of improvement permitted in each zone. Planning for each type of improvement to be permitted in a zoned area would depend on local requirements and economics. It is believed that full emphasis should be placed on such open-type uses as parking lots, parks, playgrounds, golf courses, and agriculture for those areas which are extremely low and therefore subject to periodic flooding. Certain manufacturing and storage buildings compatible with the hazards involved could be permitted, such as industries primarily connected with concrete and clay products, where damage would be minimal.

F5. As an aid to local flood plain planning, State and local governmental agencies may obtain, upon request, additional information through flood plain studies conducted by the Corps of Engineers under Section 206 of the Flood Control Act of 1960 as described in Exhibit F1. The work usually done by the Corps under this authority involves surveying and mapping of flood plain areas, together with other studies necessary to establish the flood damage potential, flood heights, and the extent of inundation of the areas involved. Study requests in New York State are coordinated with the Executive Director for Flood Control, New York State Department of Public Works, Albany, New York.

TABLE F1 - ZONING REGULATIONS CONTROLLING DEVELOPMENT ON TIDAL LANDS WITHIN STUDY AREA AND ON THE BARRIER BEACH

Areas investigated(a)	Minimum elevation of building required	Buildings prohibited in specific areas	Remarks
Town of Southampton	No	No	None
Village of Quogue	No	Yes	No private garage, stable, guesthouse, children's playhouse, or private boathouse may be situated less than 25 feet from any waters upon which a plot of land abuts. Ordinance No. 26 of the village of Quogue which became effective on 23 October 1945 prohibits the building of any main dwelling within a distance of 50 feet from the southerly edge of the top of the dunes; however, it permits the construction of a private bathhouse on the dunes provided it be build without any damage to the dunes. The cutting into and excavating of dunes is prohibited.
Village of Southampton	No	No	None
Village of Westhampton Beach	No	Yes	Amended Ordinance No. 21 prohibits the building of structures on the dunes and requires property owners to construct access walkways at least 2 feet above the crest of the dune. Buildings south of Dune Road require the bottom floor girder to be a minimum number of feet above mean sea level; this required elevation varies from zero to 22 feet above mean sea level for distances from the crest of the dune of 230 and zero feet respectively.
Town of Islip	No	No	None
Village of Brightwaters	No	No	None

TABLE F1 - ZONING REGULATIONS CONTROLLING DEVELOPMENT ON TIDAL LANDS WITHIN STUDY AREA AND ON THE BARRIER BEACH (Cont'd)

Areas investigated(a)	Minimum elevation of building required	Buildings prohibited in specific areas	Remarks
Town of Brookhaven	Yes	Yes	The Board of Health for the town of Brookhaven specifies a minimum first floor elevation at approximately 5 to 6 feet above mean sea level. Article 85-226 of the Zoning Ordinance for the town of Brookhaven states that where the lot line of any lot abuts tidal or non-tidal waters, or the shore, strand or beach along said tidal or non-tidal waters, no building or structure shall be erected or altered within fifty (50) feet of such lot line.
Village of Bellport	No	No	None
Village of Patchogue	No	No	None
Town of Babylon	No	Yes	Article XX, Section 7 of the "Building Zone Ordinance of the town of Babylon" states that no structure shall be erected on unzoned tidal lands without the approval of the Town Board.
Village of Babylon	No	No	None
Village of Lindenhurst	No	No	None
Village of Amityville	No	No	None
Town of Oyster Bay	Yes	Yes	Based on Article XI, Sections 1 and 3 of the "Amendments to the Building Code of the town of Oyster Bay", no building may be erected without a first floor elevation as specified by the Town Engineer, where "first floor" does not include any garage floor basement or cellar. No structure shall be erected on "tidal lands" without the approval of the Town Board.
Village of Massapequa Park	No	No	None

(a) The villages listed are incorporated communities. The unincorporated communities in the study area are not listed since they are governed by the zoning regulations and ordinances of the town in which they are located.

EXHIBIT F1

RESUME OF FLOOD PLAIN INFORMATION STUDIES

UNDER SECTION 206

RESUME OF FLOOD PLAIN INFORMATION STUDIES UNDER SECTION 206, PUBLIC LAW 86-645 (Flood Control Act of 1960)

1. Authority. The general authority for flood plain information studies by the Corps of Engineers is Section 206, Public Law 86-645 (Approved 14 July 1960) which reads:

"SEC. 206(a) That, in recognition of the increasing use and development of the flood plains of the rivers of the United States and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use by States and municipalities, the Secretary of the Army, through the Chief of Engineers, Department of the Army, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies, and general criteria for guidance in the use of flood plain areas; and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard: Provided, That the necessary surveys and studies will be made and such information and advice will be provided for specific localities only upon the request of a State or a responsible local governmental agency and upon approval by the Chief of Engineers.

"(b) The Secretary of the Army is hereby authorized to allot, from any appropriations hereafter made for flood control, sums not to exceed $1,000,000 in any one fiscal year for the compilation and dissemination of such information."

2. Objectives. The major objectives of these studies and technical advice are:

a. To compile in a useful form and disseminate to State and local governmental agencies, information on floods and potential flood hazards, including identification of areas subject to inundation by floods of various magnitudes and frequencies;

b. To encourage optimum and prudent use of the Nation's river valleys by providing to State and local governmental agencies a factual basis for:

(1) Reducing future flood damages and hazards through carefully considered and well-planned local regulations and use of the flood plains;

(2) Planning such advance protection as may be economically justified for prospective land uses that could not be undertaken without protection;

(3) Preserving adequate floodway and channel rights-of-way and channel clearances.

c. To provide publicly available information for the guidance of private citizens and interests on use of the flood plains;

d. To reduce future expenditures for Federal projects to protect developments which, in the absence of the program, would have taken place, or for alleviation of flood problems arising from improper flood plain development."

3. Relation of information studies to other measures. These flood plain information studies are proposed as a medium of public education for use either in conjunction with or in lieu of other means of reducing flood damages. They will provide a useful means of explaining the flood hazard to the public, and in securing effective public understanding of and cooperation with flood warning services and evacuation measures where these are used. Information studies, in addition to use for official zoning and other regulatory action, will enable individuals and organizations to gage the need for flood proofing measures to reduce their losses in flood-prone areas, including areas where protective works cannot be justified. However, Section 206 does not extend any Federal authority over zoning or other regulation of flood plain use, which come within the sovereighty and police power of the individual States. Flood plain information studies are intended to furnish advice, and to encourage those affected to help themselves. This legislation and this manual do not provide for the Corps of Engineers to undertake flood plain zoning work, or community planning for States and municipalities, such as that normally done by their employees or by private planning or other consultants.

4. Letter of application. The application of the State or local governmental agency should be a letter to the District Engineer, prepared with his assistance if necessary, signed by an authorized officer of the sponsoring local agency, and containing the following and any other relevant information, either in the letter or in inclosures. It is desirable that applications from local governmental agencies be submitted through a State agency.

a. Authority of local governmental agency. The authority, law, charter, or resolution clearly establishing the local agency by the State or subdivision thereof, its interests and jurisdiction in flood plain regulation and planning, and its relation to other local agencies having responsibility therefor, should be cited or attached.

(1) Necessity for a responsible local governmental agency. The existence or possible establishment of responsible local agencies to request or sponsor flood plain information studies is considered of great importance. Such agencies should have authority to cooperate with the Corps of Engineers on this matter and to disseminate and explain the information compiled and provided in flood plain information reports.

(2) State coordinating agency and coordinator. The Governor of New York has designated the Water Resources Commission as the agency having an overall interest in all water resource activities in the State. The Commission has delegated the coordination of local requests for flood plain studies to the Division of Flood Control, New York State Department of Public Works. The State Coordinator is the Executive Director for Flood Control, New York State Department of Public Works, Albany, New York.

b. Desired objectives of study. In addition to the general objectives given in preceding paragraph 2, the local applicant should state specifically

the local objectives which prompt the application for a Federal study under Section 206.

c. Scope and limits of study. The geographic area to be studied should be described, together with the nature of present use and any contemplated community or other plans for flood plain development. The time available before local planning decisions must be made should be stated. The type and extent of local data, mapping, planning, etc., that are available and that will be furnished to supplement the studies by the Corps of Engineers, without cost to the United States, should be described. Any local cooperation in gathering data, mapping, or other services that can be provided should be stated.

d. Assurances of local cooperation. The letter of application should give assurances that:

(1) The applicant will publicize the information report in the community and area concerned, and make copies available for use or inspection by responsible interested parties and individuals.

(2) Zoning and other regulatory, development and planning agencies, and public information media, will be provided with the flood plain information for their guidance and appropriate action.

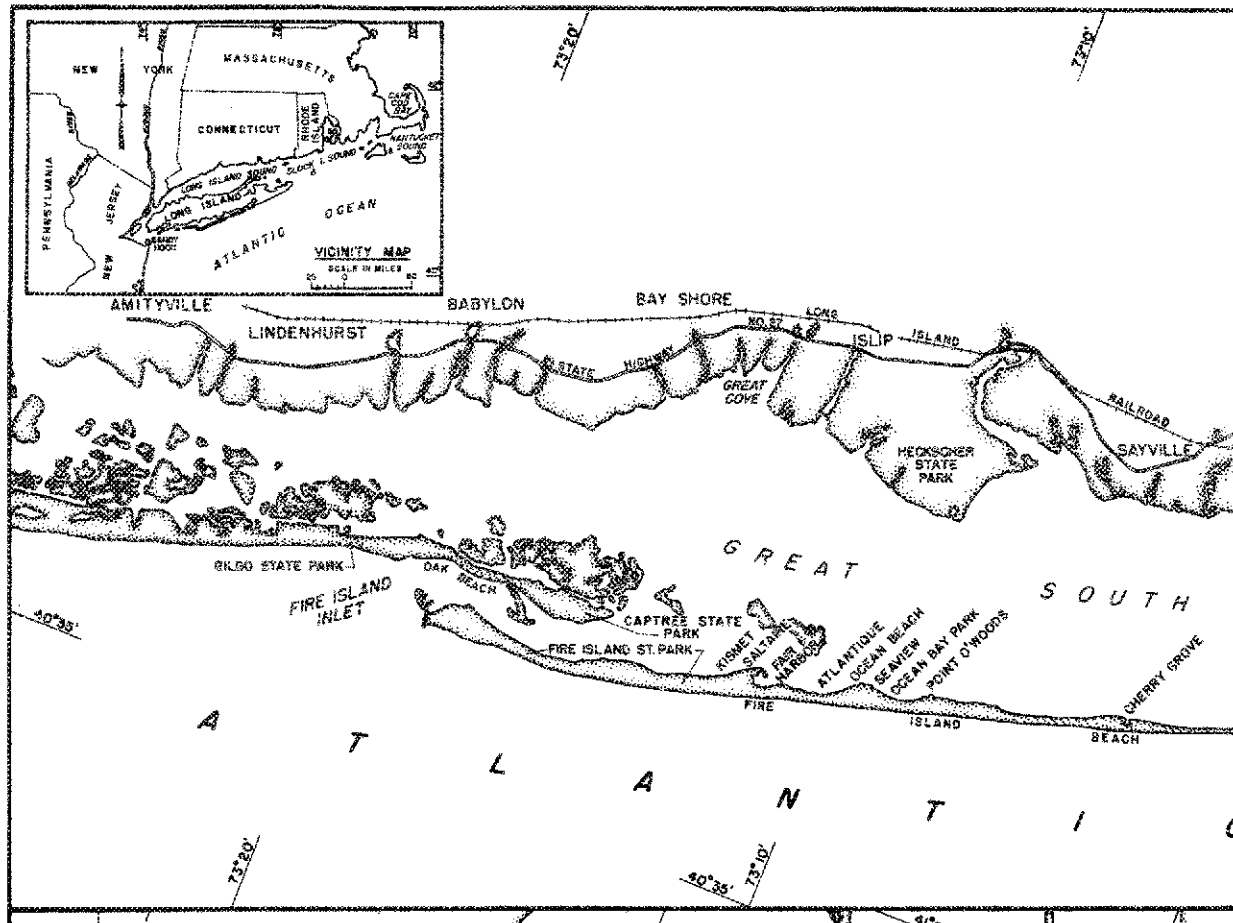
(3) Survey markers, monuments, etc., established in any Federal surveys undertaken for Sec. 206 studies, or in regular surveys in the area concerned, will be preserved and safeguarded.

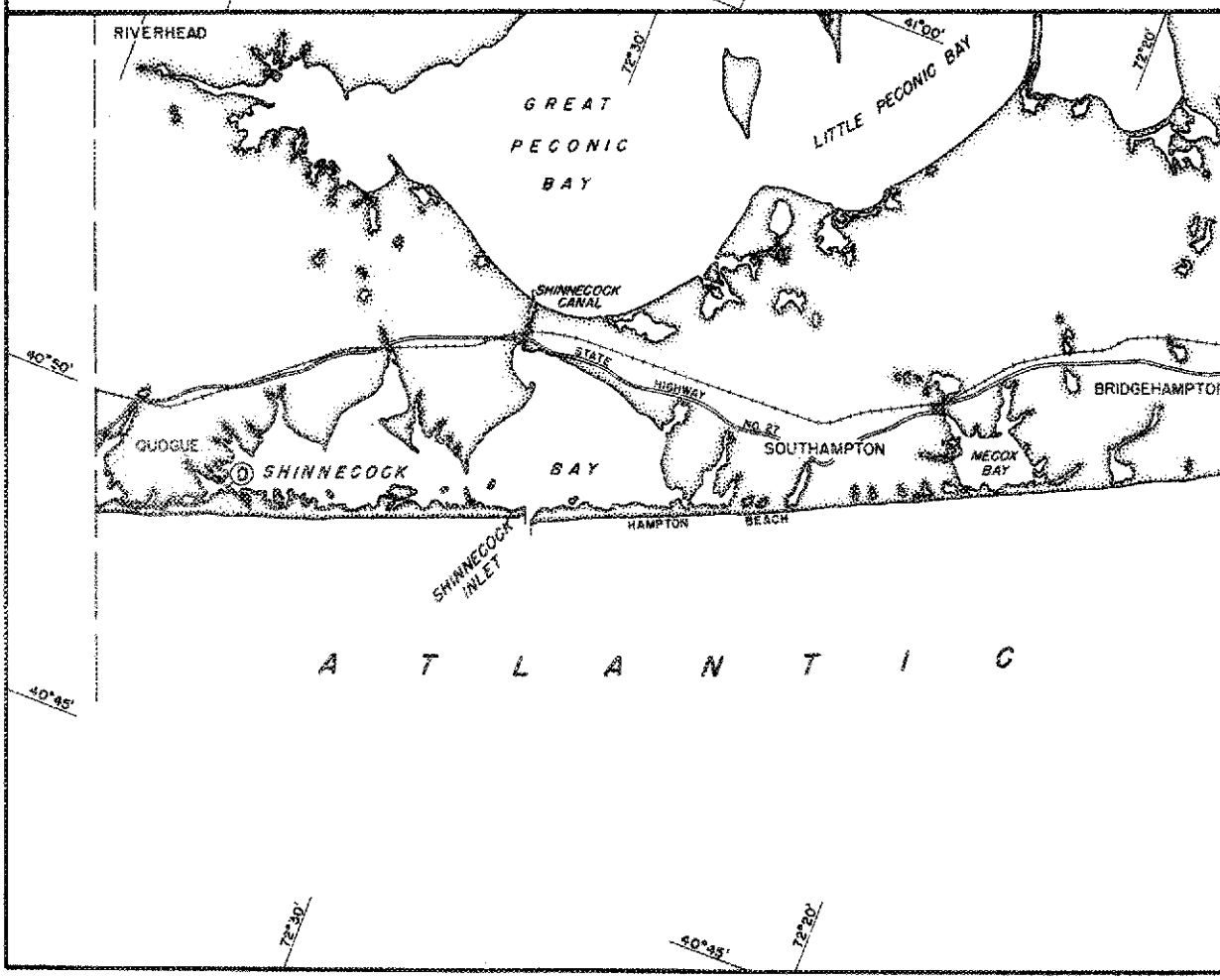
5. Processing of applications. Letters of application received from the State or Coordinator will be reviewed by the District Engineer; if satisfactory, then will be processed through the Division Engineer to the Chief of Engineers for approval, and for allotment of funds, when available, to initiate the study.

INTERIM HURRICANE STUDY
ATLANTIC COAST OF LONG ISLAND, NEW YORK
JONES INLET TO MONTAUK POINT (REMAINING AREAS)

APPENDIX G

A MODEL HURRICANE PLAN FOR A COASTAL COMMUNITY


NEW YORK
MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
PENNSYLVANIA
NEW JERSEY
LONG ISLAND SOUND
LONG ISLAND
ATLANTIC OCEAN
VICINITY MAP
AMITYVILLE
BABYLON
BAY SHORE
LINDENHURST
ISLIP
LONG ISLAND
STATE HIGHWAY NO. 27
GREAT COVE
RAILROAD
HECKSCHER STATE PARK
SAYVILLE
GILGO STATE PARK
OAK BEACH
FIRE ISLAND INLET
CAPTREE STATE PARK
FIRE ISLAND ST. PARK
KISMET
SAILORS HARBOR
ATLANTIQUE
OCEAN BEACH
SEAVIEW
OCEAN BAY PARK
POINT O'WOODS
CHERRY GROVE
FIRE ISLAND BEACH
GREAT SOUTH
ATLANTIC
73°20'
72°30'
40°35'


RIVERHEAD
GREAT PECONIC BAY
LITTLE PECONIC BAY
SHINNECOCK CANAL
STATE HIGHWAY NO. 27
BRIDGEHAMPTON
QUOGUE
SHINNECOCK BAY
SOUTHAMPTON
MECOX BAY
HAMPTON BEACH
SHINNECOCK INLET
ATLANTIC
72°30'
72°20'
41°00'
40°50'
40°45'
40°35'