BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 10

THAMES RIVER TO NIANTIC BAY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION. BOSTON. MASS.

MARCH 29, 1957

Beach Erosion Control Report on Cooperative Study of Connecticut

Area 10

New London Harbor to Niantic Bay

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OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
150 CAUSEWAY STREET
BOSTON 14, MASS.

NEDGW March 29, 1957

SUBJECT: Beach Erosion Control Report on Cooperative Study of Connecticut, Area 10, Thames River to Niantic Bay

TO: Chief of Engineers, Department of the Army, Washington 25, D. C.

SYLLABUS

This report, the tenth and last of a series to cover the entire coast of Connecticut includes study of the shore line of the city of New London and the town of Waterford lying between the Thames River and Niantic Bay. The purpose of the study is to determine the most suitable methods of stabilizing and improving the shore line.

The Division Engineer finds that most of the shore is comparatively stable or adequately protected by shore structures, that erosion is resulting in the loss of some sandy beaches and that damages have resulted to developed areas from flooding and wave attack during hurricanes and exceptional storms accompanied by extreme high tides. The Division Engineer also finds that closure of an inlet by drifting sand creates a problem due to lack of drainage and tidal flushing.

Practicable plans have been developed by the Division Engineer for (1) reduction of drifting and loss of a beach on the west shore of New London Harbor by construction of an impermeable groin, (2) restoration of beach losses and protection of shore development at Ocean Beach and Neptune Park by direct placement of sand fill and (3) maintenance of flow in and out of Goshen Cove by inclosure of the inlet in a culvert or by construction of jetties.

The Division Engineer recommends that no project be adopted by the United States and that protective measures which may be undertaken by local interests, based upon their determination of economic justification, be accomplished in accordance with plans prepared and methods suggested in this report.

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Area 10

New London Harbor to Niantic Bay

I - GENERAL

1. Authority. - This report was prepared by the Corps of Engineers, United States Army, in cooperation with the Connecticut State Flood Control and Water Policy Commission under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The basic agreement for the entire Connecticut shore line was approved by the Chief of Engineers on August 28, 1947 and the detailed program for this area on May 1, 1950.

2. Purpose. - The purpose of the study is to determine (1) the most suitable methods of stabilizing and improving the shore line between New London Harbor and Niantic Bay, (2) which sections of the shore are desirable locations for beach improvements, and (3) the economic justification of protective and improvement measures.

3. Prior Reports. - There have been no prior reports on beach erosion control or shore protection by the United States in this area. A report on Ocean Beach was prepared during 1938 by a private engineering concern entitled "Restoration, Expansion and Development of Ocean Beach". This report followed the severe damage which occurred to private property at Ocean Beach during the hurricane of September 1938. It recommended widening and raising the elevation of the beach by hydraulic pumping of sand, filling in marsh for a parking field, construction of a bathhouse, boardwalk, swimming pool, game areas and other buildings all with a view to public recreational use of the area, generally as has since been done.

4. A geological report pertinent to the study area was published in 1929 as Bulletin No. 46 of the State Geological and Natural History Survey of Connecticut. This paper by Henry Staats Sharp, A.M., entitled "The Physical History of the Connecticut Shore Line" described the geological history of Connecticut and the various topographical features of the shore line. Appendix B of this report is based largely upon this paper.

5. Location. - The study area is located on the north shore of Long Island Sound at and adjacent to New London. Its shore line is about 8½ miles in length of which 2¼ miles is in the city of New London along the west shore of New London Harbor north of the Alewife Cove inlet and 6¼ miles in the town of Waterford between the Alewife Cove inlet and Bay Point in Niantic Bay. Publicly owned shores consist of Ocean Beach in New London, owned by the city, having a shore frontage of 2,000 feet and Harkness

Memorial State Park and Seaside Sanatorium in Waterford, both owned by the State of Connecticut having shore frontages of 3400 and 1500 feet, respectively. The New York, New Haven and Hartford Railroad runs generally parallel to the coast within a distance not exceeding 2½ miles. United States Highway Route 1 also runs parallel to the coast about 5 miles inland and it connects with United States Route 1A, state highways and city and town roads and streets to provide access to the shore. The study area is shown on United States Coast and Geodetic Survey Charts 214, 293, 359 and 1211, Army Map Service topographic quadrangles, New London and Niantic and on Plates 1, 8 and 9.

6. Population. - The populations of New London and Waterford according to the 1950 census are 30,551 and 9,100 respectively. Seasonal changes in population are negligible.

7. Description. - The shore line of the study area is one of submergence. The study area consists of two headlands. The easterly headland between New London Harbor and Jordan Cove is broad and blunt and it terminates at Goshen Point. The westerly headland between Jordan Cove and Niantic Bay is narrow and smaller terminating at Millstone Point. The shore line of the Goshen Point headland is comparatively smooth and regular with slight projections formed by bedrock or boulders. A number of gently curving crescent shaped sandy beaches extend between these projections. The Millstone Point headland is less regular in shape, its shore line being largely composed of bedrock, quarry waste and riprap but here also sandy pocket beaches exist in indentations. The New London shore borders a built-up residential area. Ocean Beach Park at the south limit of New London is a city owned public bathing beach and amusement park while other sandy beaches to the north are privately owned and restricted to private use. Harkness Memorial State Park at Goshen Point in Waterford has a public bathing beach for the physically handicapped, and Seaside Sanatorium, a tuberculosis sanatorium for children immediately east of Seaside Point, is state owned. There are a few residences and cottages adjacent to the east end of Seaside Sanatorium, a residential development in the Pleasure Beach area and a small new cottage development is being built at the Millstone Point headland just west of the Jordan Cove entrance. Except for a few widely spaced residences, the remainder of the Waterford shore is undeveloped. Detailed descriptions of shore segments are included in Part III, Plans of Improvement, Paragraphs 15-31 and in Appendix A. The geology of the area is described in Appendix B. Information concerning the classification of shore waters obtained from a sanitary study is included in Appendix J. According to this classification only that shore area in New London Harbor between Long Rock and the east limit of the study is in a questionable category from the standpoint of bathing water safety.

8. Statement of the Problem. - Problems exist at a number of locations. A sandy cuspate beach at the west side of New London

Harbor at the east limit of the study area opposite Mitchell Junior College has been subject to northward migration resulting in loss of beach along its south side. Damages have occurred to bathhouses at Osprey Beach as a result of wave action and high tides during exceptional storms and hurricanes. Flooding of the road and residential areas along the shore of New London Harbor has also occurred during these periods of exceptionally high tides. There has been erosion and loss of sand beach fronting the sea wall along the southern portion of Neptune Park, a residential development, and also along the adjacent north end of Ocean Beach. In the town of Waterford, near the west limit of Harkness Memorial State Park, drifting sand has resulted in repeated closure of Goshen Cove inlet. This has caused flooding due to lack of drainage or an offensive condition due to lack of flushing, a problem which has been of concern to the State of Connecticut and to property owners bordering Goshen Cove. The sandy shore between Goshen Cove inlet and Seaside Sanatorium has been subject to erosion and retreat, resulting in loss of land. The eroded bluff in this area is now quite close to a small cottage development. Localized erosion of the sand beach fronting the sea wall at Seaside Sanatorium has necessitated the placement of riprap revetment at a number of places to protect the wall from undermining. Existing groins fronting the sanatorium sea wall have not been maintained and have consequently deteriorated.

II - FACTORS PERTINENT TO THE PROBLEM

9. Littoral Materials. - a. Characteristics. The character of littoral material as indicated by mechanical analysis of beach samples taken at midtide elevation and by probings in offshore areas is shown in tabular form on Plates 8 and 9.

b. Sources. The principal natural sources of supply of beach building materials were the sands and gravels deposited by glaciers. The upland of the Goshen Point headland located between the Thames River estuary and Jordan Cove is composed of stratified sand and gravel apparently deposited as a glacial outwash plain. The erosion of this headland has furnished an abundant supply of fine material for the formation of sandy beaches. The minor streams emptying into Long Island Sound in the area contribute little or no beach material. The absence of any serious shoaling problem in the navigation channels at New London Harbor indicates that little material is contributed to the study area by the Thames River.

10. Littoral Forces. - a. Waves. No wave measurements or statistical wave data are available. Waves approach the shore only from southerly directions, i. e. from the east clockwise around to the west. The fetches of waves generated by local winds are limited as follows: 11 miles across Fishers Island Sound to the east, 5 to 6 miles to Fishers Island and 22 miles to Long

Island to the southeast, 22 and 32 miles to Long Island to the south and southwest, respectively, and about 90 miles across Long Island Sound to the west-southwest. Swells from the Atlantic Ocean approach the shore from the southeast through an opening between Fishers Island and Long Island. The maximum height of waves breaking inside the low water line at exposed locations with tides 3 feet in excess of the mean height of high water is approximately 5 feet but during infrequent higher tides, larger waves can reach the shore.

b. Currents. Tidal currents in Long Island Sound set to the west during flood and to the east during ebb tides. Maximum currents occur on the ebb. At strength of current, the average velocity in Long Island Sound opposite the study area is 1.3 knots and the spring velocity is 1.6 knots. In the Thames River, the flood current is usually weak, and the ebb current averages about one-half knot. During freshets, the ebb current attains considerable velocity.

c. Winds. Wind data are available from United States Weather Bureau observations at Block Island, Rhode Island and New Haven, Connecticut. Winds at Block Island are believed to be more representative of winds which occur in the study area. The prevailing wind direction at Block Island is southwest. Winds at Block Island from the southwest quadrant occur about 39 percent of the time while winds from the southeast quadrant, the only other onshore direction, occur about 16 percent of the time. Wind roses compiled from records of observations at Block Island and New Haven are shown on Plates 3 and 4.

d. Storms. Winds equal to or greater than 32 miles per hour at Block Island blow most frequently from the northwest direction or offshore with respect to the study area. Onshore winds of this magnitude blow about 11 times a year from the southwest quadrant and 9 times a year from the southeast quadrant. At New Haven, the only location within Long Island Sound for which records are available, winds equal to or greater than 32 miles per hour blow from the prevailing northwest direction about once a year and from the onshore southerly quadrants between 2 and 3 times per year. Storm frequency at New Haven may be more representative of conditions in the sheltered Long Island Sound area than that at Block Island. Detailed information concerning hurricanes, storm damages and exposure of the shore is contained in Appendix D.

e. Tides. Tides are semi-diurnal. The mean range at the State Pier, New London is 2.6 feet and at Millstone Point is 2.7 feet. The spring ranges at the same locations are 3.1 and 3.2 feet, respectively. The maximum tide of record at New London was 11.1 feet above the plane of mean low water during a hurricane on September 21, 1938. Tides in excess of the mean height of high water occur on an average approximately as follows: 3 feet in excess about once a year, 2 feet in excess about 5 times a year and 1 foot in excess about 98 times a year. More detailed information concerning tides is contained in Appendix C.

11. Shore History. - a. Shore Line and Offshore Depth Changes. Significant changes in the position of the shore line have occurred as follows:

Location	Period	Shore Line Change
850 feet of shore north of and adjacent to Profile 1	1838-1846 1916-1955	Recessions of 100 to 150 feet Accretion of 50 to 100 feet
1200 feet of shore south of and adjacent to Profile 1	1838-1883 1883-1955	Recession of up to 250 feet Little change
South end of Osprey Beach	1846-1883 1883-1955	Recession of up to 100 feet Little change
North End of Ocean Beach and the adjacent shore to the north	1846-1883 1883-1955	Accretion of 100 to 125 feet Recession of about 25 feet
Shore between Ocean Beach and Harkness Memorial State Park	1839-1883 1883-1955	Accretion of 100 to 200 feet Recession of up to 100 feet
2000 feet of shore west of and adjacent to tip of Goshen Point	1839-1955	Accretion of up to 150 feet
2500 feet of shore, 2000 to 4500 feet west of the tip of Goshen Point	1846-1955	Recession of up to 150 feet
Seaside Point to Magonk Point	1883-1955	Irregular recession less than 100 feet
White Point to Pleasure Beach	1846-1955	Accretion varying up to 200 feet
Sandy shore of Pleasure Beach	1846-1883 1883-1955	Accretion up to 150 feet Recession of 50 to 75 feet
East shore north of Pleasure Beach to Jordan Cove entrance	1883-1955	Irregular changes, principally recession along the south half and accretion by artificial filling of a large triangular area around 1931 along the north half of the area.

Location	Period	Shore Line Change
West of Jordan Cove entrance along east and south sides of Millstone Point	1883-1955	Recession varying irregularly up to about 150 feet
North half of west shore of Millstone Point	1838-1955	Accretion of up to 400 feet

Offshore depth changes during the period between 1839 and 1882-83 as indicated by comparative positions of the 6- 12- and 18-foot depth contours generally consisted of deepening east of the Goshen Cove inlet and shoaling to the west. Profiles run during 1955 indicate that since 1883 there has been shoaling in the offshore area opposite Ocean Beach (Profiles 3 and 4) and at Harkness Memorial State Park west of the tip of Goshen Point (Profiles 7 and 8). During the same period offshore deepening is indicated at Profile 1 near the east limit of the study area, at Profile 11 just east of Seaside Sanatorium, at White Point (Profile 13), at Profile 15 east of the Jordan Cove entrance, at the east side of Millstone Point (Profile 18) and between Millstone and Bay Points (Profiles 19 and 20). Changes indicated by other profiles were generally minor. More detailed descriptions of shore line and offshore depth changes are contained in Appendix E. Comparative changes are shown on Plates 5, 6 and 7. Descriptions of the more significant changes are also included in Part III, Plans of Improvement, Paragraphs 15-31.

b. Existing Protective Structures. Protective structures consisting of sea walls, bulkheads, groins, revetment and breakwaters exist throughout the study area. Structures have generally been built to protect the immediate shores which they front. In most cases they have had little or no effect on adjacent shores. In New London, structures consist principally of sea walls, revetment and a few short groins protecting residences, the shore road and low land areas north of Ocean Beach. In Waterford the principal structures consist of sea walls, bulkheads and groins at Seaside Sanatorium, and along the small residential developments north and south of Pleasure Beach and west of and adjacent to the Jordan Cove entrance. Most structures were constructed privately and historical information concerning them is therefore not readily available. Information about sea walls and groins at Seaside Sanatorium, a timber bulkhead at the Jordan Cove entrance and a sea wall and groins at the west side of the Jordan Cove entrance is contained in Appendix G. General descriptions of structures throughout the study area are included in Appendix A. Discussions and descriptions of structures pertinent to beach erosion and protection problems are included in Part III, Plans of Improvement, Paragraphs 15-31.

c. Profiles. Beach profiles were run during 1954 and 1955 at selected locations. They are shown on Plates 7, 8 and 9. Profiles ranged in length from 800 to 2000 feet and extended seaward from the berms of beaches or from the tops of sea walls to depths of 10 to 48 feet below mean low water. Beach slopes from the landward to the seaward ends of the profiles are included in the following tabulation. The slopes are designated as fractions thus: 1/11 (to be read as 1 vertical to 11 horizontal). Figures in parentheses following the fractions represent elevations above or below mean low water depending upon the sign (+ above, - below) and they designate the zone of the beach to which the slope is applicable. Slopes of 1/100 or flatter are designated as level.

Slopes of Beach Profiles

Profile No.	Slopes
1	1/11 (above +2.0), 1/35 (+2.0 to -3.0), 1/4 (-3.0 to -10.0), 1/20 (-10.0 to -15.0), then level
2	1/10 (above 0.0), 1/32 (0.0 to -13.0), 1/70 (-13.0 to -24.0)
3	1/38 (above +6.0), 1/22 (+6.0 to -25.0), then level
4	1/57 (above +5.0), 1/33 (+5.0 to -29.0, irregular), then level
5	1/12 (above -3.0), 1/50 (-3.0 to -11.0), then level
6	1/18 (above +5.0), 1/7 (+5.0 to -2.0), 1/39 (-2.0 to -9.0), then level
7	1/14 (above 0.0) 1/34 (0.0 to -17.0 irregular), then level
8	1/70 (above +6.0), 1/14 (+6.0 to -4.0, irregular), 1/28 (-4.0 to -14.0), then level
9	1/13 (above -9.0, irregular), 1/40 (-9.0 to -14.0), then level
10	1/18 (above +6.0), 1/9 (+6.0 to -4.0), 1/21 (-4.0 to -8.0), 1/80 (-8.0 to -15.0), then level
11	1/11 (above -2.0), 1/33 (-2.0 to -8.0), then level
12	1/10 (above +1.0), 1/40 (+1.0 to -18.0 irregular) irregular (-18.0 to -34.0)
13	1/10 (above 0.0), 1/35 (0.0 to -23.0 irregular), 1/12 (-23.0 to -38.0), then almost vertical to -48.0
14	1/11 (above -2.0), 1/27 (-2.0 to -13.0), then level and irregular
15	1/7 (above +2.0), level (+2.0 to 0.0), 1/48 (0.0 to -10.0)
16	1/7 (above +1.0), level (+1.0 to -2.0)
17	1/10 (above +2.0), level (+2.0 to 0.0), 1/70 (0.0 to -11.0)
18	1/8 (above 0.0), level (0.0 to -1.0, irregular), 1/56 (-1.0 to -10.0)
19	1/9 (above 0.0), 1/21 (0.0 to -10.0), 1/42 (-10.0 to -21.0)
20	Bedrock shore, irregular, 1/30 (-6.0 to -18.0), 1/23 (-18.0 to-28.0) then level

12. Analysis of the Problem. - The loss of beach material is caused by wave action. The general features of the problem are essentially the same but detailed features vary throughout the area. Waves and swells cause littoral drift. Offshore loss of beach material is caused by ordinary short storm waves. Material is probably returned in part to the beaches by swells during calm periods. The prevailing direction of ordinary onshore winds is southwest. Storm winds blow most frequently from the northwest or offshore. There is only a slight predominance of onshore storm winds from the southwest over those from the southeast quadrant. Except for an opening between Fishers Island and Long Island through which waves and swells approach from across the Atlantic Ocean, the greatest fetches exist across Long Island Sound from westerly directions. The direction of movement of littoral drift is governed principally by the configuration of the shore. This movement is generally north along shores which are oriented in a north-south direction. Elsewhere it is generally away from projecting points. The natural source of supply of beach building materials has been largely eliminated by erosion of unconsolidated material down to the underlying bedrock or it has been cut off by the construction of sea walls, revetments and other protective works. The amount of littoral drift is therefore small. Streams do not contribute any appreciable amount of material to the beaches. A tabulation of the direction and evidence of littoral drift at various locations is included in Appendix F.

13. In general, the rate of supply of beach material cannot be increased except by artificially placing material directly on the beach or in stockpiles to be distributed by wave action. Groins are useful in reducing losses of existing or artificially placed beach material. Loss of land has been prevented by armoring the shore against wave attack with sea walls and revetment in those areas where the supply of material has been inadequate to maintain a protective beach. Other methods of protection, such as offshore breakwaters are not considered applicable in this area.

14. Design Criteria. - Proposed protective measures are designed to provide protection against ordinary conditions of comparatively frequent occurrence. They are not intended to provide protection in the event of hurricanes or exceptional storms of infrequent occurrence although even under these conditions some protection will be afforded. Specific design criteria used for proposed protective works are described in the following subparagraphs and detailed design data are included in Appendix K.

a. Design Tide. The design tide is the maximum elevation of tides which occurs at least once a year. Tide records at New London indicate that this elevation is 3 feet above the plane of mean high water.

b. Groins. The horizontal shore section should ordinarily have a top elevation not lower than the general height of existing

berms of beaches and a length equal to that of the berm of the anticipated beach. In this study area, the top elevation should be approximately 5 feet above the plane of mean high water. Barrier groins which are intended to completely block passage of littoral drift or to reduce it considerably should be higher than the anticipated beach berm. The intermediate sloped section should not be steeper than the slope of the existing bottom. The top elevation of the outer section should not be lower than 1 foot above the plane of mean low water. For riprap construction, the minimum height of groins should be 3 feet. Groins should be sand tight and firmly anchored at their shore ends to prevent flanking. Groin lengths are generally determined by the toe of the anticipated beach or sand fill. Stone sizes and slopes for groins are computed using the Iribarren method as described in Technical Report No. 4 of the Beach Erosion Board entitled "Shore Protection Planning and Design". The design wave used is the maximum wave that can break in the depth of water at the groin if the fetch is not a limiting factor. With the fetches available, such maximum waves can generally be generated. Blankets of spalls or crushed stone are used under riprap groins or jetties to minimize settlement due to scour.

c. Sand Fills. Berm elevations of proposed fills are based on those of existing beach berms. The minimum width of fills is based on widths found to afford protection in the area. Computed volumes of fills are based on slopes similar to existing slopes but fills can be placed initially to a steeper slope and permitted to take a natural slope under wave action. Based on these criteria berm elevations are approximately 5 feet above mean high water and beach widths above mean high water are approximately 125 feet with fill slopes of 1 on 20 to 1 on 30. Suitable sand for beach fills would have size and gradation characteristics similar to those of the sand components of the existing materials on the beaches. For the purpose of detailed design of beach fills, the investigations of materials on the beaches and in proposed borrow areas given in this report must be supplemented when plans and specifications are being prepared.

III - PLANS OF IMPROVEMENT

15. West Shore of New London Harbor (North End), Plates 8 and 13. - The easterly portion of the study area extending about 900 feet north and 300 feet south of Profile 1 at the west side of New London Harbor is a sandy cuspate beach. The shore is privately owned. Development in the vicinity is residential with Mitchell Junior College located on the landward side of the shore road. Use of the shore is limited to area residents. The shore is composed of medium to fine sand fronting grass covered dunes. There is a layer of boulders at the apex of the beach, probably placed as revetment and a series of short boulder groins south of the apex. Shore line changes north of Profile 1 consisted of landward

movement from 1838 to 1846, irregular landward and seaward movement from 1846 to 1883, a small seaward movement from 1883 to 1913 and an additional larger seaward movement up to 1955. South of Profile 1, the shore line moved continuously landward from 1838 to 1955, the only large movement occurring from 1846 to 1883. Due to lack of development close to the shore, there is no serious erosion problem in the area. The cuspate beach has tended to migrate northward by erosion south and accretion north of the apex. Construction of an impermeable groin at the apex of the beach would reduce northward drifting and loss of material from the south end of the beach. A suitable type of groin is shown on Plate 10.

16. West Shore of New London Harbor (South End), Plates 8 and 13. - The shore along the west side of New London Harbor from the sandy cuspate beach at the east limit of the study area to and including the shore projection at New London Harbor Light is privately owned. Development on the seaward side of the shore road consists of a small group of residences at the north end of the area and a few individual residences at projecting rocky areas to the south. Development landward of the shore is residential. Use of the shore is limited to residents. The shore line along the northerly half of the area is at or near sea walls and it is largely composed of coarse material ranging from gravel to boulders except at the south side of groins and shore projections which impound sandy material. The south half of the area is characterized by rock outcrops and intervening sandy pockets of fine to medium sand. Shore structures consisting of stone or concrete walls, riprap revetment and short boulder, riprap or rubble masonry groins exist throughout the area. The only appreciable shore line changes of record consisted of a landward movement of up to 200 feet from 1846 to 1883 along the northerly 900 feet of shore and a seaward movement of about the same magnitude between 1846 and 1955 along the shore of the small indentation located immediately north of New London Harbor Light. Shore line changes along the remainder of the area during the period 1838 - 1955 were generally small and irregular. No problems have been reported. Maintenance of existing sea walls and riprap revetment and additional construction of similar works as needed should provide suitable shore protection. Groins have not impounded any appreciable amount of beach material. Their principal value consists of reduction of erosion of shore areas which are composed of unconsolidated material. Development of a comprehensive plan of protection is not necessary. It is practicable for property owners to provide necessary shore protection by armoring segments of the shore with sea walls and revetment wherever needed.

17. Osprey Beach, Plates 8 and 14. - Osprey Beach is a sandy pocket between projecting rocky headlands. Most of the beach above high water is composed of fine sand. Its south end is covered with boulders and other coarse stony materials. There are a few outcrops of bedrock along the beach, both on and offshore. The shore is privately owned and it is used as a private bathing beach.

Facilities consist of a small bathhouse and fireplaces near the north end and a larger bathhouse near the south end. A shore road borders the landward edge of the beach. The area landward of the road is residential in development. There is a rubble masonry wall behind most of the beach. At its south end, the shore and the road are protected by various types of masonry walls, riprap revetment and concrete and riprap groins. The only appreciable shore line changes of record occurred between 1846 and 1883 and they consisted of seaward movement of up to 125 feet along the northerly 500 feet of beach and landward movement, generally less than 100 feet, along the rest of the shore. Between 1883 and 1955 a smaller additional seaward movement of the shore of the north end of the beach occurred while changes along the south end were small and irregular. The south end of the beach which has been subject to erosion and recession is now naturally protected by the coarse material left as a residue of past erosion. Damages have occurred to bathhouses and other structures on the beach from wave attack during hurricanes and exceptional storms accompanied by extreme high tides. It is not considered economically feasible to provide complete protection against damages of such infrequent occurrence. Reduction of damages can probably be effected most economically by providing for the probability of occurrence of wave attack by increasing the structural strength of buildings or by constructing them out of reach of waves. Existing protective structures, if maintained, should provide adequate protection against additional shore recession.

18. Neptune Park, Plates 8 and 15. - The shore of Neptune Park, a residential development between Osprey and Ocean Beaches is convex and irregular in shape. It is composed of outcrops of bedrock with fine sandy pocket beaches held between the outcrops. The shore is privately owned and its use is limited to residents of the area. Concrete and rubble masonry walls protect lawns in front of the residences. Shore line changes from 1883 to 1955 were generally small and irregular consisting principally of seaward movement except adjacent to Ocean Beach. In this latter area the shore line has receded in recent years, reportedly since about 1954. The consequent lowering of beach level has necessitated construction of toe walls along the base of existing structures to protect against undermining. If maintained, existing walls should provide adequate protection for the residential development bordering the shore except during hurricanes and exceptional storms accompanied by extreme high tides. Residents are concerned over loss of the fronting sand beach and damages which occur when water overtops the walls. Restoration of beach losses and some protection against overtopping of walls by wave action can be provided by direct placement of sand fill to form a wider protective beach. A practicable plan for this type of protection and restoration has been developed and it is shown on Plate 10.

19. Ocean Beach Park, Plates 8 and 15. - Ocean Beach is a wide, concave sandy beach located north of and adjacent to Alewife

Cove. It is owned by the City of New London which has developed it as a modern public park and bathing beach. It is provided with a bathhouse, parking area, boardwalk, swimming pool, game areas, restaurant, refreshment stands and various other facilities. Fill for widening and raising the elevation of the beach and reclamation of marsh for the parking field was obtained by hydraulic dredging in Alewife Cove during the spring and summer of 1940. The beach is composed of fine to medium sand with small outcrops of rock at its north end and offshore opposite Alewife Cove. There are no protective structures along the shore. A row of stones along the south side of the Alewife Cove inlet probably represents the remains of a jetty. Between 1839 and 1883 the shore line generally moved seaward 50 to 100 feet with the greater movement along the north end. From 1883 to 1955 changes were smaller, the shore line generally moving landward about 25 to 50 feet. The bathing beach has a width varying from about 100 feet at the north end, 200 to 300 feet along most of the shore and 120 feet at the south end. Due to this width, the development in the backshore is out of reach of wave attack and has not been subject to damages. It was observed during November 1955 that erosion at the northern boundary of the park had lowered the beach level several feet at a steel fence exposing its foundation, undermining it and causing its seaward end to collapse. The erosion area is continuous with and adjacent to the erosion area at Neptune Park described in the preceding paragraph. Over the period of record losses of beach material have been moderate. It therefore appears that a desirable and practicable method of maintaining the beach consists of periodic nourishment by direct placement of sand fill. Probings in the offshore area indicate that sand for beach nourishment exists within a practicable distance for hydraulic dredging and pumping to shore. A practicable plan for restoring beach losses at the north end of Ocean Beach and the adjacent Neptune Park shore is shown on Plate 10.

20. Between Ocean Beach and Harkness Memorial State Park, Plates 8 and 16. - The shore bounded by Alewife Cove at Ocean Beach and Harkness Memorial State Park at Goshen Point is a sandy tombolo fronting marsh. It is tied to a bedrock shore at Goshen Point and a small rocky island at its east end. The shore is privately owned and used to a limited extent for bathing. The only structure in the area consists of a small private bathhouse near Goshen Point. The shore line has been subject to landward movement since 1883 averaging about one foot per year. Due to lack of development, this recession has not created any problem. The shore is suitable in its present state for recreational use. Due to its low elevation and its history of recession, it is not advisable to develop the tombolo by construction of permanent buildings thereon. No protective works are needed and none have been considered.

21. Harkness Memorial State Park, Plates 8 and 16. - Harkness Memorial State Park, located at the tip of Goshen Point, was formerly a large private estate. It was left to the State of

Connecticut which now uses it as a public park. Public facilities consist of a museum, picnic area, bathhouse and bathing beach, the latter for the physically handicapped. The shore composition varies from exposed bedrock at the east end of the park, a fine to medium sand pocket beach west of and adjacent to the rock and a shore which becomes progressively coarser to the tip of Goshen Point which is boulder strewn both on and offshore. West of the tip of the point the shore becomes progressively finer. At the west limit of the park near the mouth of Goshen Cove, it consists of medium sand. There is riprap revetment protecting the tip of Goshen Point, the adjacent backshore to the east and the sand dunes at the sandy pocket beach near the east limit. There is riprap, the remains of a jetty, near the west limit at the Goshen Cove entrance. The only buildings near the shore are small wooden bathhouses at the bathing beach in the sandy pocket near the east limit of the park. Comparative maps indicate that the shore has been subject to accretion from 1838 to 1883. Between 1883 and 1955 the accretion continued west of the tip of Goshen Point but a small amount of erosion and shore recession appears to have occurred east of the point. There is no known beach erosion problem in the area. Closure of the Goshen Cove inlet by drifting sand creates a drainage problem in Goshen Cove reportedly resulting in flooding due to lack of drainage or drying out with a resultant offensive condition due to lack of tidal flushing. Drifting of sand results in minor migration of the inlet. Due to lack of development and limited use of the beach, this migration has not created any problem. The inlet can be kept open by (1) excavation, (2) inclosing it in a culvert with its outfall located offshore or (3) construction of jetties of sufficient height to prevent overtopping by drifting sand. The first method, excavation, has been used by the former private owner and more recently by the State of Connecticut. Due to the rapid formation of a sand bar across the inlet and the shoaling of the inlet channel by erosion of the loose sand forming its banks, excavation has been required at frequent intervals. This method has therefore not been considered to be entirely satisfactory and the State of Connecticut has requested advice concerning the problem. In view of this interest, even though the problem is not strictly one of beach erosion control, plans have been considered for inclosure of the inlet in a culvert or construction of jetties in order to prevent formation of a bar at the entrance and construction of revetment to stabilize the banks of the channel. These plans are shown on Plate 10.

22. Between Harkness Memorial State Park and Seaside Sanatorium, Plates 8, 9 and 17. - The shore extending westward from the Goshen Cove inlet to Seaside Sanatorium is privately owned with development limited to a small concentration of cottages and residences at the west end of the area. The shore consists of a fine to medium sandy barrier bar largely covered with sand dunes. The beach is used to a limited extent for bathing by residents. Most of the shore is unprotected. Protection is afforded to short extents of the low sandy bluff fronting residences by a stone wall

and riprap revetment. Comparative maps indicate that between 1846 and 1955, there was accretion and seaward movement of up to one foot a year along the easterly one-fourth of the shore and erosion and landward movement of up to one and one-half feet per year along the rest of the shore. The erosion has moved the shore line at its west end landward of the adjacent Seaside Sanatorium property which is protected by a seawall. Due to the limited development of the area, past erosion has not created any serious problem. A practicable method of providing protection for existing and future development, if needed, consists of armoring the bluff behind the sand beach with a sea wall or riprap revetment or both, generally as has been done at the adjoining Seaside Sanatorium shore. Construction of groins perpendicular to the shore might be helpful in reducing losses of the sand beach but maintenance by direct placement of sand fill would probably still be required.

23. Seaside Sanatorium, Plates 9 and 17. - Seaside Sanatorium, a children's tuberculosis hospital owned by the State of Connecticut, is located east of and adjacent to Seaside Point. Hospital buildings are set more than 100 feet behind a stone masonry sea wall which protects a wide lawn bordering the shore. The shore consists of five pockets formed by six riprap groins which project seaward from the sea wall at varying angles. The beach material is sandy with the material finer in the easterly pockets. The pocket beaches are finer and wider at their east ends at the west side of the groins. Changes in the position of the shore line indicated by comparative shore line maps consisted of seaward movement between 1838 and 1883 and a small irregular landward movement from 1883 to 1955. The sea wall and groins which were constructed around 1932 and 1938 have provided adequate protection for the hospital grounds. The existing small sandy pockets have sufficient area to provide for the present and foreseeable future recreational use of the shore. Erosion has necessitated the placement of riprap revetment along the toe of portions of the wall to protect it against undermining. The groins have not been maintained and they have deteriorated but they are still effective in retaining the sandy pocket beaches. For continued protection of the area, the sea wall should be maintained by periodic repairs and by placement of additional riprap revetment along its toe as needed to prevent undermining. The groins should also be maintained sufficiently to prevent loss of the existing beach. No detailed plan of protection is necessary and none has been developed.

24. Seaside Point to Magonk Point, Plates 9 and 18. - The shore west of Seaside Sanatorium to the tip of Seaside Point and thence to Magonk Point is privately owned with a few residences well behind the shore line at both ends. Bedrock is exposed at both points. The rest of the shore is gravelly and bouldery except for small sandy pockets. Dry stone and rubble masonry walls protect the shore in the vicinity of residences. There are two riprap groins at and east of the tip of Seaside Point and another between the two points. The use of the shore for recreational use

is limited to residents. Shore line changes have been irregular over the period of record consisting of accretion between 1846 and 1883 and recession from 1883 to 1955, the shore line movements varying between 50 and 100 feet. Due to the lack of development near the shore, erosion has not created any serious problem. Existing structures and the coarse nature of the shore provide adequate protection for the area.

25. Magonk Point to White Point, Plates 9 and 18. - This privately owned shore area consists of two bedrock points and an intervening pocket. The bedrock shore extends several hundred feet westward from Magonk Point, merges into a gravel, cobble and boulder shore and thence a sandy dune covered beach, the latter adjacent to White Point. There are no buildings near the shore. The development in the inland area is residential. Use of the shore is probably limited to residents. The only protective structure is a dry stone wall fronting the bluff behind the bedrock shore along the west side of Magonk Point. Comparative shore line maps indicate that the only change from 1883 to 1955 was a landward morement of 50 to 75 feet along the central and western portion of the area. Due to lack of development, this shore recession has not created any serious problem. There is no known need or desire for protection of the area.

26. White Point to Pleasure Beach, Plates 9 and 18. - The shore from White Point northward to Pleasure Beach is privately owned and partially developed for residential use. There is one residence at White Point and a few others along the north end of the area. Recreational use of the shore is limited to residents. There is bedrock at the tip of White Point, a coarse bouldery shore adjacent to and north of White Point and a sandy dune covered beach to the north. The sandy beach narrows at its north end in front of rubble masonry and concrete walls and a steel sheet pile bulkhead which protect the residential development located near the shore. There are three riprap breakwaters offshore opposite White Point. Comparative maps indicate that accretion moved the shore line seaward between 1846 and 1883 and that between 1883 and 1955 an additional seaward movement of up to about 150 feet occurred along the southerly two-thirds of the area while the northerly one-third moved irregularly landward for a distance not exceeding about 50 feet. No erosion problem has been reported. The north end of the area which has been subject to shore recession appears to be adequately protected by existing structures. In the event that erosion in this area lowers the beach level or exposes the structures, necessary protection can be provided by placement of riprap revetment along the toe of the structures to prevent undermining and to dissipate the energy of wave attack.

27. Pleasure Beach, Plates 9 and 19. - Pleasure Beach, a sand bar topped by a low grass covered dune fronts marsh and a pond. The bar extends southward from a bedrock island which is connected to the mainland by a causeway. There are no buildings on the bar

or island. Heavy stone blocks and riprap, apparently the remains of a wharf protect the northwest corner of the island. The causeway is protected by low stone walls and it in turn, with a northward projecting wall or breakwater, provides shelter for small boats. Comparative shore line maps indicate that between 1846 and 1883 there was accretion and a seaward movement of about 150 feet along the shore of the sand bar while from 1883 to 1955, the sand bar retreated about 50 to 75 feet. Shore line changes along the island and causeway have been irregular during the above periods, consisting principally of seaward movement, probably the result of construction of walls and filling. There is no known erosion problem of concern. The sandy beach is of satisfactory composition and it is used for bathing by area residents and by townspeople. There has been some interest in acquiring the area for use as a town bathing beach. The beach is satisfactory for this purpose without any improvement. The beach can be maintained in its present position if desired by periodic placement of small quantities of sand. No plan of protection is needed and none has been developed.

28. Shore East of Jordan Cove Entrance, Plates 9 and 19. - The shore of the mainland north of the causeway leading to Pleasure Beach consists of riprap revetment and walls of rubble masonry, brick and cut stone, all at or close to the waters edge in front of a residential development. At its north end the shore is narrow and sandy along a triangular partly-filled undeveloped land area which projects westward across Jordan Cove. This filled area was apparently once a westward trailing sandspit. It was artificially built up and inclosed within a wooden bulkhead with a few short timber groins along its seaward face. The bulkhead along the landward sides is still intact but along the seaward face little remains of the original structures. Comparative shore line maps indicate that between 1846 and 1883 there was little change in the position of the southerly 300 feet of shore while the remainder of the shore moved seaward. The principal shore line change from 1883 to 1955 consisted of a seaward movement along the triangular land area resulting from artificial filling around 1931. Maintenance of the existing protective structures fronting the residential development should generally provide adequate protection against erosion. Due to lack of development and use, construction of additional protective works along the triangular land area in Jordan Cove is not warranted at this time. This land is low in elevation and in its present condition is considered to be unsuitable for development.

29. Shore West of Jordan Cove Entrance, Plates 9 and 20. - The shore extending westward from the Jordan Cove entrance to the first prominent shore projection at the east side of Millstone Point is privately owned. Except for the shore of the above projection which is coarse in composition, boulder strewn and protected by heavy riprap, the shore is sandy in composition. The sand beach varies in width from 30 to 50 feet in front of a stone masonry sea

wall along the easterly portion which has been recently developed for residential use. Along the rest of the sandy shore to the west which is undeveloped the beach has a width of 75 to 120 feet. Riprap groins have been built, one at each end of the wall and riprap revetment has been placed along a short length of shore east of and adjacent to the easterly groin. Another short riprap groin exists west of the development. Use of the shore is limited to residents. Comparative maps indicate that the shore line of the easterly half of this area moved seaward between 1838 and 1883 and movements along the rest of the shore during this period were irregularly landward and seaward. Between 1883 and 1955, the shore line receded generally throughout for distances of about 50 to 150 feet, the small recession occurring in the vicinity of the shore projection at the west limit of the area. There is no known serious erosion problem in the area. The existing structures, if maintained, should provide adequate protection.

30. Millstone Point, Plates 9 and 20. - Millstone Point is the site of a stone quarry. Most of its shore is composed of stone quarry waste. There are a number of outcrops of bedrock at both sides of the point and small extents of sandy beach in pockets along the east side. There are no buildings or structures near the shore. Comparative maps indicate that the east shore was eroded and moved landward about 50 to 200 feet between 1838 and 1955, that the south shore moved up to 200 feet seaward from 1838 to 1883 and generally less than 100 feet seaward from 1883 to 1955. The west shore line moved predominantly seaward from 1838 to 1955 with the largest movement about 400 feet. The seaward shore line movements described are believed to have been effected artificially by the the disposal of stone quarry waste. There is no known erosion problem within the area and no plan of protection has been considered.

31. Millstone Point to Bay Point, Plates 9 and 20. - The shore extending between bedrock outcrops at the northwest limit of Millstone Point and at Bay Point is a sandy pocket beach. The area is privately owned and undeveloped. The only known use of the shore is for Red Cross swimming classes conducted with the owners' permission. Comparative maps indicate that between 1838 and 1883 there was erosion and landward shore line movement along the east half of the beach and accretion and seaward shore line movement along the west half, the maximum movement being about 200 feet. Between 1883 and 1955 the movements appear to have been reversed with the east half moving up to 25 feet seaward and the west half about 50 feet landward. Due to lack of development, changes which have occurred have not caused any problem. The sand beach in its present natural state is in good condition for recreational use and should continue to be satisfactory unless something is done to upset its natural balance. Material for nourishment of the beach is apparently derived from erosion of the land behind it. This erosion is moderate. In order to provide for the continued existence of the natural source of supply of beach material, if the

area behind the beach is developed, consideration should be given to locating buildings far enough landward so that construction of sea walls or other structures which might cut off the supply of beach material will not be necessary.

IV - ECONOMIC ANALYSIS

32. General. - Detailed estimates of costs are included in Appendix H and detailed estimates of benefits are included in Appendix I. First costs have been estimated for all projects considered. Benefits were computed only for the project involving Neptune Park and Ocean Beach. Benefits could not be evaluated for the projects considered at the west shore of New London Harbor and at Goshen Cove Inlet. Projects have been considered as follows:

Area	Ownership	Paragraph Reference	Plate No.
West Shore of New London Harbor, New London	Private	15	10
Neptune Park and Ocean Beach, New London	Private & Public	18 and 19	10
Goshen Cove Inlet, Waterford	Private & Public	21	10

33. First Costs. - The first costs of projects computed in detail in Appendix H, are as follows:

Project	Work Items	Estimated Cost
West Shore of New London Harbor	1 groin	$11,700
Neptune Park and Ocean Beach	Beach fill	64,000
Goshen Cove Inlet		
Alternate Plans	(a) 2 jetties and channel revetment	80,000
	(b) Culvert, channel revetment and beach fill	39,000

34. Benefits. - The estimated benefits are based on direct damages prevented, increased earning power or value of shore land and the recreational value of increased public beach space. Benefits from increased value of areas behind and adjacent to improved shore property, increased business returns and recreational value from improvement of private beaches have not been estimated. Direct damages prevented have been evaluated as a saving in the maintenance cost of existing protective structures and on the reduction of storm damages to the existing shore development. Benefits from increased earning power or value of shore lands have been evaluated on the basis of increased returns to owners resulting from increased area of shore front property and also on the resulting broadening

of the tax base. The recreational benefit has been evaluated for increased public beach area on probable beach use by assigning a per capita value for beach use estimated as the minimum fee which patrons would be required to pay if the beach was a private enterprise. Estimated annual benefits are as follows:

Project	Direct Damages Prevented	Increased Earning Power	Recreational	Total
West Shore of New London Harbor		Not evaluated		
Neptune Park and Ocean Beach	$500	$1,800	$700	$3,000
Goshen Cove Inlet		Not evaluated		

35. Interests. - There is no Federal interest in any of the projects considered since none of the shore involved is owned by the United States. Non-Federal public interest is defined as, (a) the benefits accruing to a State or political subdivision thereof as a land owner and, (b) the benefits accruing to the general public. Private interest is defined as the benefits derived by individuals or non-public groups of individuals on account of ownership of lands and business enterprises affected. The classification of estimated benefits in accordance with the interest involved is as follows:

Project	Federal	Non-Federal Public	Private	Total
Neptune Park and Ocean Beach	0	$1,500	$1,500	$3,000

36. Apportionment of Costs. - Public Law 826, 84th Congress established a policy of Federal aid for restoration and protection against erosion of the shores of the United States, its Territories and possessions. In accordance with this policy the Federal share of the cost can equal but not exceed one-third of the first cost of construction, but not the maintenance, of the project. Private shores are eligible for Federal assistance if there is benefit such as that arising from public use or from the protection of nearby public property or if the benefits to those shores are incidental to the project. Factors governing the Federal and non-Federal apportionment of costs of contemplated projects are discussed in Section V of this report entitled "Conclusions and Recommendations". All estimated costs of projects have been determined to be non-Federal costs.

37. Annual Costs. - Interest has been computed at a rate of 2.5 percent. A useful life of 50 years has been assumed in determining amortization charges. Maintenance estimates of sand fill are based on maximum rates of loss determined from past shore recession with an assumed minimum rate of one foot per year. Estimated annual costs are summarized below:

Project	Interest	Amortization	Maintenance	Total
West Shore of New London Harbor	$ 290	$120	$ 90	$ 500
Neptune Park and Ocean Beach	1,600	700	3,000	5,300
Goshen Cove Inlet				
Alternate Plans				
(a) Jetty Construction	2,000	800	800	3,600
(b) Culvert Construction	970	400	390	1,760

38. Justification. - The estimated annual benefits and costs and the resulting ratios of benefits to costs are summarized below:

Project	Estimated Annual Benefits	Estimated Annual Costs	Ratio of Benefits to Costs
West Shore of New London Harbor	Not evaluated	$ 500	---
Neptune Park and Ocean Beach	$3,000	5,300	0.6
Goshen Cove Inlet			
Alternate Plans			
(a) Jetty Construction	Not evaluated	3,600	---
(b) Culvert Construction	Not evaluated	1,760	---

39. Coordination with Other Agencies. - Close coordination has been maintained with the Connecticut State Flood Control and Water Policy Commission, the official agency representing the State of Connecticut in this cooperative study. Officials of the towns concerned have been contacted and their views sought. The Connecticut Development Commission, State Park Department, State Highway Department and State Board of Fisheries and Game have been contacted concerning aspects of the study pertaining to their interests. In addition, personal contact has been made with shore residents to obtain information concerning their problems.

40. Comments of Local Interests. - The cooperating agency, the Connecticut State Flood Control and Water Policy Commission, has been informed of the findings and recommendations contained in this report. The commission has approved the report. It is of the opinion that the findings and recommendations are sound and in the best interests of the State of Connecticut and local communities.

V. CONCLUSIONS AND RECOMMENDATIONS

41. Conclusions. - The Division Engineer concludes that the following are practicable plans for restoration, protection and, or improvement of shore areas which merit consideration, all as shown on Plate 10.

(a) West Shore of New London Harbor, New London. - Construction of an impermeable groin near the apex of the cuspate sandy beach opposite Mitchell Junior College in the vicinity of Profile 1.

(b) Neptune Park and Ocean Beach, New London. - Widening approximately 800 feet of beach by direct placement of sand fill to a width of 125 feet in front of existing sea walls at Neptune Park, the width diminishing southward along the north end of Ocean Beach.

(c) Goshen Cove Inlet, Waterford. - Maintenance of flow into Goshen Cove by (1) inclosure of the inlet in a culvert and revetment of the banks of the inlet channel or (2) construction of two riprap jetties at its inlet and revetment of the banks of the inlet channel.

42. Complete protection against flooding of shore areas and damages to buildings at and in the vicinity of Osprey Beach which result from hurricanes and exceptional storms of infrequent occurrence accompanied by extreme high tides is not considered economically feasible. Reduction of damages can probably be effected most economically by increasing the structural strength of structures located in vulnerable areas or by constructing them out of reach of wave action.

43. Protection of the sandy shore between the Goshen Cove inlet and Seaside Sanatorium against continued retreat and loss of land can be effected if needed for existing or future development by construction of a sea wall or revetment with riprap or both generally as has been done at Seaside Sanatorium. Groins might be helpful in reducing beach losses but beach maintenance by periodic placement of fill would still be required.

44. At Seaside Sanatorium, in order to insure continued shore protection, the existing sea wall should be maintained by periodic repairs and by placement of riprap along its toe as needed to prevent undermining and the existing groins should be maintained sufficiently to prevent loss of the existing beach.

45. The project considered for Neptune Park and Ocean Beach is not justified by evaluated benefits. Benefits which have not been evaluated or cannot be evaluated in monetary terms may make it advisable for local interests to adopt the project considered.

46. Benefits to be derived from the projects considered for the west shore of New London Harbor and for the Goshen Cove inlet could not be evaluated due to lack of information and the intangible nature of the benefits. The project for the west shore of New London Harbor is for a privately-owned beach which is not considered to be eligible for Federal assistance in the cost of construction according to the requirements of Public Law 826, 84th Congress. The project for the Goshen Cove inlet is principally for the solution of a drainage problem caused by shore processes rather than

for beach erosion control. Therefore, even though the cove inlet is located adjacent to state owned Harkness Memorial State Park and its improvement would benefit the public park, the project is not considered to be eligible for Federal assistance under Public Law 826, 84th Congress.

47. Recommendations. - It is recommended that no project be adopted by the United States for protection of any of the shores in this study area located between New London Harbor and Niantic Bay. It is further recommended that protective measures which may be undertaken by local interests, based upon their determination of economic justification, be accomplished in accordance with plans and methods proposed in this report.

ROBERT J. FLEMING, JR.
Brigadier General, U. S. Army
Division Engineer

Inclosures:
11 Appendices
18 Plates

APPENDIX A

DESCRIPTION AND COMPOSITION OF BEACHES

1. General. - Detailed descriptive data concerning the entire shore line of Area 10 was obtained by field inspections. Descriptions of the shore, divided generally into areas in accordance with the physical character of shore features are given below in geographic sequence from New London Harbor to Niantic Bay. In addition, samples of surface beach material were obtained at selected locations and a mechanical analysis of the samples was made to determine median diameter and classification. Beach sample analysis results and locations are shown on Plates 8 and 9. A complete photographic record was made of the shore. Selected photographs are shown on Plates 13-20.

New London

A. West Shore New London Harbor (North End)

(1) Location: The sandy cuspate beach at the east limit of the study area north of the residences on the shore side of the road.
(2) Shore Length: 1200 feet.
(3) Beach Width Above High Water: 75 to 100 feet.
(4) Ownership: Private.
(5) Beach Use: Limited amount of bathing by residents.
(6) Public Facilities: None
(7) Composition of Shore: A medium to fine sand beach fronting grass covered dunes. There is a layer of boulders along the apex of the beach, probably placed as revetment.
(8) Protective Structures: Boulder revetment at the apex of the beach and a series of short boulder groins to the south.
(9) Character of Development: Residential. Mitchell Junior College and residences on the landward side of the shore road.

B. West Shore of New London Harbor (South End)

(1) Location: From the sandy cuspate beach at the north limit southward to and including the point at the New London Harbor Light.
(2) Shore Length: 5,000 feet.
(3) Beach Width Above High Water: Varies irregularly. Sand beaches generally only in pockets. Width 50 to 75 feet fronting residences along north end, decreasing southward. Pocket beaches to and around the rocky point at Glenwood Avenue are up to 60 feet wide. A sandy pocket beach 50 to 60 feet wide just north of Quinnipeag Rocks and another just north of New London Harbor Light decreases in width southward from about 200 to 30 feet.

(4) Ownership: Private.
(5) Beach Use: Probably limited use for bathing by residents.
(6) Public Facilities: None
(7) Composition of Shore: Sandy shores are composed of fine to medium sand with gravel, cobbles and boulders in the foreshore north of Glenwood Avenue. Bedrock is exposed at Glenwood Avenue and at a number of places along the shore to the south including the point opposite Quinnipeag Rocks and several hundred feet of shore at and south of New London Harbor Light.
(8) Protective Structures: From north to south structures include short boulder groins and rubble masonry walls fronting residences, a new rubble masonry wall fronted by 4 short groins of similar construction along an open grassy backshore area, riprap groins, a considerable length of riprap revetment and more rubble masonry walls to the point at Glenwood Avenue. There are rubble masonry or concrete walls to the south either fronting homes or behind sandy pocket beaches and a cut stone masonry wall south of New London Harbor Light.
(9) Character of Development: Residential.

C. Osprey Beach
(1) Location: Between the rocky point at New London Harbor Light and the walled residential area on the shore side of the road at the rocky point to the south.
(2) Shore Length: 2200 feet.
(3) Beach Width Above High Water: Sand beach decreases from about 100 feet at the north end to about 60 feet at the timber bathhouse near the south end, thence varies with the sand beach in pockets at the south side of groins up to 80 feet in width. No sand beach at extreme south end.
(4) Ownership: Private.
(5) Beach Use: Private bathing beach.
(6) Public Facilities: None. Small private concrete bathhouse and a few fireplaces along the north half. A larger private timber bathhouse at the south half.
(7) Composition of Shore: Most of beach composed of fine sand above high water. Scattered bedrock outcrops both on and offshore. Medium and coarse sand below high water along south end. The extreme south end is stony (covered with boulders, riprap, etc.) and it merges into a bedrock point.
(8) Protective Structures: There is a rubble masonry wall behind most of the beach. Along the south end there are rubble masonry, cut stone, Portland

cement block and concrete walls, concrete and riprap groins and riprap bank revetment.

(9) Character of Development: A private bathing beach. Residences on the landward side of the shore road.

D. Neptune Park

(1) Location: The shore fronting residences on the seaward side of the shore road between Osprey and Ocean beaches.

(2) Shore Length: 1500 feet.

(3) Beach Width Above High Water: Sand beaches in pockets of varying width. No sand beach along rocky north end of area. Width in three pocket beaches from north to south are about 50 to 60 feet, 30 feet and 50 to 60 feet. Adjacent to Ocean beach at the south end, the beach width fronting walls is about 30 to 40 feet.

(4) Ownership: Private.

(5) Beach Use: Bathing limited to residents.

(6) Public Facilities: None.

(7) Composition of Shore: An irregular shore with sand pocket beaches between rock outcrops. Composition in the three pockets from north to south is (a) fine sand above and medium sand below high water, (b) coarse sand and gravel and (c) fine to medium sand above and coarse sand and some gravel below high water. The southerly portion of the shore adjacent to Ocean Beach (about 300 feet long) is composed of fine sand.

(8) Protective Structures: Concrete and rubble masonry walls protect lawns in front of residences.

(9) Character of Development: Residential.

E. Ocean Beach Park

(1) Location: North of and adjacent to Alewife Cove inlet.

(2) Shore Length: 2000 feet.

(3) Beach Width Above High Water: Increases from about 100 feet at the extreme north end to 300 feet a short distance to the south and thence decreases to about 200 feet at the south end of the boardwalk and 120 feet at the extreme south end of the beach in front of a ball field.

(4) Ownership: Public. City of New London.

(5) Beach Use: A public bathing beach and amusement park.

(6) Public Facilities: Bathhouse, parking area, swimming pool, game areas, boardwalk, restaurant, refreshment stands, roller skating, arcade, etc.

(7) Composition of Shore: A fine to medium sand beach. Small rock outcrops near the north end and also offshore opposite Alewife Cove. Low grass covered sand dunes in front of the ball field at the south end.

(8) Protective Structures: A row of riprap offshore long the south side of Alewife Cove entrance, probably the remains of a jetty.

(9) Character of Development: A public bathing beach and park adjoining a residential area.

Waterford

F. Between Ocean Beach and Harkness Memorial State Park

(1) Location: Alewife Cove entrance westward to Goshen Point.

(2) Shore Length: 2300 feet.

(3) Beach Width Above High Water: The entire width of the bar or tombolo fronting marsh and Alewife Cove is about 150 to 200 feet.

(4) Ownership: Private.

(5) Beach Use: Limited private use for bathing.

(6) Public Facilities: None. A small private bathhouse at the west end of the beach.

(7) Composition of Shore: A medium to fine sand tombolo tied to a bedrock island at its east end and to a bedrock shore at its west end.

(8) Protective Structures: None.

(9) Character of Development: None.

G. Harkness Memorial State Park (East Half)

(1) Location: From the tip of Goshen Point eastward to and including the projecting bedrock shore at the east limit of the park.

(2) Shore Length: 1900 feet.

(3) Beach Width Above High Water: No sand beach at the bedrock point at the east end. A sand beach immediately west of this point decreases in width westward from about 140 feet to 100 feet at the bathhouse and to no sand beach along the outer end of Goshen Point.

(4) Ownership: Public. State of Connecticut.

(5) Beach Use: A public bathing beach.

(6) Public Facilities: Bathhouses and picnic tables.

(7) Composition of Shore: Bedrock at the easterly projecting point. A fine to medium sand pocket beach west of this rocky point. No sand beach along the outer end of Goshen Point which is revetted with riprap. There are boulders and bedrock about 75 feet offshore from the tip of Goshen Point.

(8) Protective Structures: Some riprap along the edge of a dune at the east end. Riprap revetment along a considerable length of the west shore adjacent to the tip of Goshen Point.

(9) Character of Development: A state park with a public bathing beach.

H. Harkness Memorial State Park (West Half)

(1) Location: Between the tip of Goshen Point and the entrance to Goshen Cove.
(2) Shore Length: 1500 feet.
(3) Beach Width Above High Water: None at the east end. A sand beach gradually widens to the west to about 100 feet in front of a sand dune.
(4) Ownership: Public. State of Connecticut.
(5) Beach Use: None.
(6) Public Facilities: None.
(7) Composition of Shore: Riprap revetment and boulders along the tip of Goshen Point and vegetation covered sand dunes immediately to the west fronted by a gravelly to bouldery shore. This shore becomes gradually finer to the west changing to a medium sand beach trailing westward across the Goshen Cove entrance. Immediately west of the bouldery shore for about 200 feet, marsh deposits are exposed in front of the grass covered sand dunes.
(8) Protective Structures: Remains of a riprap jetty at the Goshen Cove entrance.
(9) Character of Development: A large estate which has been converted into a state park.

I. Between Harkness Memorial State Park and Seaside Sanatorium

(1) Location: West of and adjacent to the entrance of Goshen Cove.
(2) Shore Length: 3200 feet.
(3) Beach Width Above High Water: A sand bar about 150 to 200 feet wide.
(4) Ownership: Private.
(5) Beach Use: Limited use for bathing by residents.
(6) Public Facilities: None. Small private bathhouses on the bar.
(7) Composition of Shore: A fine to medium sand bar with grass covered dunes. There is considerable gravel on the sand beach fronting the dunes.
(8) Protective Structures: No structures along most of the shore. A dry stone wall fronts one cottage and riprap revetment protects the low sandy bluff along one large residence.
(9) Character of Development: A small group of cottages and residences along the west end of the area.

J. Seaside Sanatorium

(1) Location: East of and adjacent to Seaside Point.
(2) Shore Length: 1500 feet.
(3) Beach Width Above High Water: Varies irregularly with width larger at the west side of groins. The approximate widths within each of the five pockets

formed by groins vary from east to west as follows: (a) 90 feet to 50 feet; (b) 120 to 0; (c) 50 to 20; (d) 60 to 0; (e) 40 throughout.

(4) Ownership: Public. State of Connecticut.

(5) Beach Use: Bathing by patients at Sanatorium.

(6) Public Facilities: None.

(7) Composition of Shore: In the five pockets from east to west the composition is as follows: (a) first pocket - fine to medium sand with exposed bedrock at the west end; (b) second pocket - fine to medium sand with considerable gravel along the high water line and in patches on the berm; (c) third pocket - fine to medium sand with considerable gravel in the foreshore and cobbles and boulders near the wall; (e) fifth pocket - fine to coarse sand and gravel.

(8) Protective Structures: A stone masonry seawall protects the lawn along the entire shore. A system of riprap groins extend seaward from the wall at different angles.

(9) Character of Development: A tuberculosis sanatorium for children with buildings set well behind the shore.

K. Seaside Point and the Shore to the West to Magonk Point

(1) Location: From the west boundary of Seaside Sanatorium to the tip of Magonk Point.

(2) Shore Length: 1800 feet.

(3) Beach Width Above High Water: Generally little or no sand beach. A sandy pocket about 80 feet wide in the first indentation west of Seaside Point and a smaller sandy pocket in the indentation east of Magonk Point. The coarse shore east of Seaside Point is about 40 feet wide.

(4) Ownership: Private.

(5) Beach Use: Probably limited use for bathing by residents.

(6) Public Facilities: None.

(7) Composition of Shore: Bedrock shore at tip of Seaside Point and for about 200 feet to the west and at Magonk Point. Bedrock exposed at a number of locations between the two points. Coarse sand, gravel, cobble and boulder shore east of Seaside Point. Medium sand in pockets west of Seaside Point. Considerable coarse material (rock fragments, riprap or quarry waste, cobbles and boulders) within the area.

(8) Protective Structures: Rubble masonry and dry stone wall and riprap groins at and east of tip of Seaside Point. Quarry waste or riprap along the shore and wide riprap groin west of the small pond west of Seaside Point. Rubble masonry wall fronts

lawn at house at Magonk Point. Dry stone wall fronts part of low bluff behind Magonk Point.

(9) Character of Development: Residences well behind the shore at both ends. The intervening shore is undeveloped.

L. Magonk Point to White Point

(1) Location: Between the tip of both points.
(2) Shore Length: 1900 feet.
(3) Beach Width Above High Water: Sand pocket beach up to 75 feet wide along approximately 500 feet of shore adjacent to White Point. No sand beach elsewhere.
(4) Ownership: Private.
(5) Beach Use: Probably limited use by area residents.
(6) Public Facilities: None.
(7) Composition of Shore: Bedrock shore at the tip of Magonk Point and for several hundred feet to the west merges into a gravel, cobble and boulder strewn shore with scattered outcrops of bedrock. Composition becomes finer to the west. There is a coarse to fine sand pocket beach with low grass covered sand dunes adjacent to White Point, the tip of which consists of exposed bedrock. The sandy pocket beach which fronts a low marshy area is finer at its west end.
(8) Protective Structures: A dry stone wall, partly deteriorated, protects the bluff behind the bedrock shore along the west side of Magonk Point.
(9) Character of Development: None near the shcre. Widely spaced residences well behind the shore.

M. White Point to Pleasure Beach

(1) Location: From the tip of White Point northward to the end of the residential development adjacent to Pleasure Beach.
(2) Shore Length: 1500 feet.
(3) Beach Width Above High Water: Sand beach up to 75 feet wide in front of dune north of and adjacent to White Point. The beach narrows to the north so that high water is at walls and a bulkhead at the north end.
(4) Ownership: Private.
(5) Beach Use: Probably limited use for bathing by residents.
(6) Public Facilities: None.
(7) Composition of Shore: Bedrock at the tip of White Point and a coarse bouldery shore for about 200 feet to the north. A northward trailing sand spit at a creek entrance and a fine sand beach with low grass covered dune fronts marsh north of this coarse shore. There are scattered boulders in the

sandy beach in front of the residences along the north end.

(8) Protective Structures: Three riprap breakwaters offshore from White Point. Rubble masonry and concrete walls and a steel sheet pile bulkhead front residences along the north end of the area.

(9) Character of Development: One residence at White Point and a few residences along the north end of the area.

N. Pleasure Beach

(1) Location: The rocky island and sand beach south of it to the shore residences.

(2) Shore Length: 1500 feet.

(3) Beach Width Above High Water: The entire sand beach with dune varies from about 100 feet at the south end to about 125 feet at the north end.

(4) Ownership: Private.

(5) Beach Use: Probably limited private use for bathing.

(6) Public Facilities: None.

(7) Composition of Shore: A fine to medium sand bar with low grass covered dune fronting marsh and a pond. The bar is tied to a bedrock island at its north end.

(8) Protective Structures: Heavy stone blocks and riprap along the northwest corner of the island, apparently the remains of a former wharf. A dry stone wall projects northward from the causeway which connects the rocky island to the mainland.

(9) Character of Development: None.

O. Shore East of Jordan Cove Entrance

(1) Location: North from the rocky island and causeway at the north end of Pleasure Beach to the Jordan Cove entrance.

(2) Shore Length: 3000 feet.

(3) Beach Width Above High Water: High water generally at structures along the developed south end of the area. A narrow sandy shore behind the remains of a timber bulkhead at the south side of a triamgular filled area across the Jordan Cove entrance.

(4) Ownership: Private.

(5) Beach Use: Probably limited use for bathing by residents.

(6) Public Facilities: None.

(7) Composition of Shore: Shore fronting residences consists of walls and riprap revetment. Sandy shore along undeveloped triangular area across Jordan Cove entrance.

(8) Protective Structures: Rubble masonry, brick and cut stone walls and riprap revetment front developed area. Remains of a timber bulkhead along the south side of the triangular area across the Jordan Cove entrance.

(9) Character of Development: Residential. None on the filled area across the cove entrance.

P. Shore West of Jordan Cove Entrance

(1) Location: From the Jordan Cove entrance westward to and including the first prominent shore projection.
(2) Shore Length: 2900 feet.
(3) Beach Width Above High Water: Varies. Wider on west side of groins. Width decreases westward from 50 to 30 feet between groins fronting new development, is 75 feet at west side of groin at west limit of development and up to 120 feet fronting the shore road farther west. No sand beach around the shore projection at the west limit.
(4) Ownership: Private
(5) Beach Use: Limited private use for bathing.
(6) Public Facilities: None.
(7) Composition of Shore: Medium to coarse sand beach from the Jordan Cove entrance westward to the base of the shore projection. Coarse bouldery and heavy riprap covered shore and marshy foreshore around the shore projection.
(8) Protective Structures: Riprap groins, one at each end of a stone masonry wall fronting the residential development. Riprap revetment along about 50 feet of shore east of the most easterly groin. Another short riprap groin to the west and heavy riprap revetment around the shore projection.
(9) Character of Development: New residential development along the east end of the area, none elsewhere.

Q. Millstone Point

(1) Location: The entire shore between, but not including, the first shore projection west of the Jordan Cove entrance to the sandy pocket beach east of Bay Point.
(2) Shore Length: 8500 feet.
(3) Beach Width Above High Water: Generally no sand beach except in pockets along the east shore. The largest pocket at the east end of the area has a sand beach about 30 feet wide in front of a grassy dune and 50 or more feet wide in front of a shore road.
(4) Ownership: Private.
(5) Beach Use: None.
(6) Public Facilities: None.
(7) Composition of Shore: The sandy pocket beach at the east limit consists of fine to medium sand and some boulders with marsh in the foreshore along its south end. Bedrock is exposed at the south end of this pocket and at a number of other locations including the shore of Fox Island, the outer

tip of Millstone Point and the west limit of the area. Most of the shore is covered with stone quarry waste.

(8) Protective Structures: Most of shore protected by covering of stone quarry waste. Causeway to Fox Island and low pier-like structure north of it also consist of quarry waste.

(9) Character of Development: A stone quarry. Light wooden piers in boat basin at west side of point used by fishermen.

R. Between Millstone and Bay Points

(1) Location: The sandy pocket beach west of Millstone Point to the tip of Bay Point.

(2) Shore Length: 1400 feet.

(3) Beach Width Above High Water: Sand beach up to 80 feet wide in front of dunes.

(4) Ownership: Private.

(5) Beach Use: Used for Red Cross swimming classes with owner's permission.

(6) Public Facilities: None.

(7) Composition of Shore: A fine to medium sand beach with a scattering of gravel and cobbles on the surface fronting grass covered dunes. Bedrock exposed at Bay Point and Millstone Point. An eroding bluff behind the beach at Bay Point composed of material ranging from silt to cobbles.

(8) Protective Structures: None.

(9) Character of Development: None.

APPENDIX B

GEOLOGY

1. General. - The shore line of Connecticut is the result of a complicated series of geological changes. One of these changes led to the erosion of a lowland known as the Sound Lowland. This erosion was interrupted by a climatic change which resulted in the formation of a great ice sheet. This ice sheet or glacier, moving under the impulse of gravity, carried a tremendous amount of debris gathered from the country over which it passed. In Connecticut, it scraped away almost all of the thick mantle of soil and decomposed rock in its path. Much of the material was strewn over the surface of the state as the glacier advanced and retreated and it forms the present unevenly distributed soil which varies in depth from 0 to 20 or more feet. In addition to glacial erosion and deposition, a subsidence of this region occurred which might have been due to the enormous weight of the ice sheet. When the ice disappeared, the Sound Lowland was below sea level and the invading waters separated Long Island from the mainland. These waters now constitute Long Island Sound.

2. Since the withdrawal of the glacier from Connecticut, there has been a change in the level of the land with respect to the level of the sea. This resulted in the submergnce of land masses. The most recent submergence is estimated as about 20 to 25 feet. Since that period relative movements of the land sea ceased and the relation of the elevation of the land to the waters of Long Island Sound has remained constant. The last change in level of the land masses with respect to the level of the sea resulted in the present day shore line of submergence having all the irregularities of such a shore line due to the drowning of coastal valleys.

3. Connecticut is at present in a period of erosion. Erosional forces are working to the reduction of land masses to a surface worn down nearly to a plain with streams transporting materials from the uplands to the lowlands. Along the coast waves attack the shore line tending to cut back all headlands, building and rebuilding bars and spits of materials from eroded headlands until a regular even shore line is produced.

4. The shore line of Connecticut is in a youthful stage of development. The bedrock along the shore even on the most exposed promontories, has not been so much as trimmed by wave erosion. Beaches around the headlands are composed of boulders and cobbles from the reworking of the local till and along the shores of embayments of sand and gravel from the reworking of the lowest glaciolacustrine deposits left unsubmerged. These unconsolidated deposits have been gently cliffed and have retrograded but slightly while the stretches of bedrock have not been retrograded at all. The

depositional shore features are derived almost entirely from the unconsolidated glacial deposits and are therefore best developed where the latter are most abundant.

5. The lower course of the Thames River is an estuary caused by submergence of a former land area with resulting drowning of the lower part of the stream valley. The study area consists of two headlands, one between the Thames River estuary and Jordan Cove, the other, to the west, between Jordan Cove and Niantic Bay. The former headland is broad and blunt and culminates in Goshen Point while the latter is smaller and narrow culminating in Millstone Point.

6. The upland of the Goshen Point headland is composed of stratified sand and gravel apparently deposited as a glacial outwash plain. Its erosion has furnished an abundant supply of fine material resulting in the formation of a number of excellent sandy beaches. The many slight projections along the shore are due to exposed bedrock or boulders which have held up erosion while the shore on either side retreated more rapidly. Bedrock is exposed at many locations. Along the New London shore rock outcrops are particularly prominent between Osprey Beach and the shore projection at Glenwood Avenue to the north and between Osprey and Ocean Beaches. Rock outcrops also occur in a few places along the above beaches and in the offshore area. Along the Waterford shore the most prominent rock outcrops exist at the entrance to Alewife Cove, at the tip of Goshen, Seaside, Magonk and White Points and the north end of Pleasure Beach. Rock outcrops also occur within the pockets between the above points.

7. The Millstone Point headland is composed of hard rock. Rock outcrops are evident at a number of locations along its east and west shores and outer tip and also around Fox Island and at Bay Point. A large part of the shore of Millstone Point is covered with stone quarry waste from a stone quarry at this location.

8. Sandy beaches are mostly of the pocket type which sweep as crescents between shore projections composed of more resistant material. Ocean Beach, the largest sand beach in New London consists of a bar or beach deposit fronting Alewife Cove. The bar has been raised in elevation and widened by artificial fill without altering the general shape which it had in its natural state. Other sandy beaches within the New London study area are of the pocket type in indentations against the upland except for a sandy cuspate beach at the north limit of the area.

9. In Waterford, the sand beach immediately west of the Alewife Cove entrance is a sand bar having the form of a tombolo tied to a bedrock island at its east end and the Goshen Point headland at its west end. Pleasure Beach also has the form of a tombolo tied to a former bedrock island at its north end. The

shore fronting Goshen Cove has the form of a sandy barrier bar fronting marsh and a pond. The triangular shaped land across the Jordan Cove entrance is the result of artificial filling at the location of what probably was a northward trailing spit. Most other sandy beaches are of the pocket type lying in natural indentations or those created by construction of groins.

APPENDIX C

TIDES

1. General Characteristics. - The tides along the shore of the State of Connecticut are of two types. The eastern sector from Watch Hill Point, Rhode Island, to Cornfield Point, Connecticut, is subject to the normal ocean or progressive wave type of tide which causes high water to occur at increasingly later times as it progresses from east to west. The western sector from Cornfield Point, Connecticut, to the entrance to East River, New York, is subject to the stationary wave type of tide which causes high and low waters to occur almost simultaneously at all points within this sector, while the range of tide increases in a fairly uniform manner from east to west.

2. Tidal Range. - Tidal range data for points along the shore of Connecticut are given in tide tables, published by the United States Department of Commerce, Coast and Geodetic Survey. These are as tabulated below:

Location	Mean Range	Spring Range	Reference Station	Time Interval
Stonington, F. Is. Sd.	2.7	3.2	New London	-0 35
Noank, Mystic River Entrance	2.6	3.1	" "	-0 30
New London, State Pier	2.6	3.1	" "	0 00
Millstone Point	2.7	3.2	" "	+0 05
Saybrook Jetty	3.5	4.2	" "	+1 00
Duck Island	4.5	5.3	Bridgeport	-0 35
Madison	4.9	5.8	"	-0 30
Falkner Island	5.4	6.4	"	-0 25
Money Island, The Thimbles	5.6	6.6	"	-0 20
Branford Harbor	5.9	7.0	"	-0 15
New Haven Harbor, Entrance	6.2	7.3	"	-0 15
Milford Harbor	6.6	7.8	"	-0 10
Stratford, Housatonic River	5.5	6.5	"	+0 40
Bridgeport	6.8	8.0	"	0 00
Black Rock Harbor Entrance	6.9	8.1	"	-0 05
Saugatuck River, Entrance	7.0	8.3	"	-0 05
South Norwalk	7.1	8.4	"	+0 10
Greens Ledge	7.2	8.5	"	-0 05
Stamford	7.2	8.5	"	0 00
Cosoob Harbor	7.2	8.5	"	+0 05
Greenwich	7.4	8.7	"	0 00

3. Tidal Observations. - A primary tide station is maintained by the United States Coast and Geodetic Survey at New London. Daily tidal observations at New London for a nine-year period, from June 12, 1938 to June 31, 1947, show that tides exceeded the height of the plane of mean high water by one foot or more 880 times, by two feet or more 44 times and by three feet or more nine times. The average annual frequencies of these tides during the above period were 98, 5 and 1, respectively, for tides 1, 2, and 3 feet or more in excess of the mean high water plane. The frequency of occurrence and excess heights of extreme high tides at New London are considered to be similar to those occurring throughout the study area.

4. Extreme Hurricane and Storm Tides. - Elevations of high water marks referred to the plane of mean low water have occurred as tabulated below:

Location	Hurricanes 21 Sept. 1938	14-15 Sept. 1944	Southeast Storm of 25 Nov. 1950	Northeast Storm of 7 Nov. 1953	Hurricane of 31 Aug. 1954
	High Water Elevations Above Mean Low Water				
Stonington	11.0	7.7	7.6		
Mystic	10.8				
Moank	10.3				
New London	11.1	7.6	8.1	7.1	10.5
Old Lyme				7.7	
Saybrook	13.4	8.0	8.75	9.5	10.8
Clinton			9.0	9.7	11.1
Branford	11.8		10.9		
New Haven	13.0		10.6	11.7	13.9
Milford			11.3	11.3	12.3
Housatonic R.				12.1	
Bridgeport	13.8		12.0	12.1	12.6
Southport	13.4				
Black Rock Hbr.			12.2		
Saugatuck R.			12.0		
South Norwalk	11.6		12.1	12.8	13.3
Five Mile R.			12.1	12.3	
Rowayton	14.3				
Stamford	15.6		12.9		13.8
Greenwich	15.0		13.5	12.2	11.2

APPENDIX D

STORMS

1. Tropical Storms. - Hurricanes can be defined as tropical cyclones with a central barometric pressure of 29.0 inches or less and winds near the center of more than 60 miles per hour in some points in the path. In the northern hemisphere they are known to consist of winds revolving in a counter-clockwise direction about a calm center or "eye". This calm center has an average diameter of approximately 14 miles. The diameter of hurricanes varies considerably, some being 50 to 75 miles; the majority greater in many instances exceeding 500 miles. Winds at the outer limits are usually light, increasing to moderate and gusty toward the center, and they blow with great fury adjacent to the "eye". Hurricanes move bodily along a path in a motion of translation at an average speed of approximately 12 miles per hour. The greatest damage caused by these tropical cyclones to shore areas is due to the inundation which usually accompanies them. This is especially true where there is a bay to the right of the point where the hurricane center moves inland. The rise of water in Narragansett Bay, Rhode Island, during the hurricane of September 1938, which moved inland west of this bay is an example of the devastating effect which such a condition can engender. The strong currents created by hurricanes is an important factor in the destruction caused by such storms. Only a few hurricanes which have passed through the New England area are known to have caused considerable destruction. Ivan Ray Tannehill, in his book "Hurricanes," mentions ten which occurred between 1635 and 1944. The paths of several of these, and some more recent ones are shown on Plate 2. The most destructive in New England struck on September 21, 1938 and August 31, 1954. Past hurricanes point to certain attendant characteristics which can be expected to result in great damage. The 1938 and 1954 hurricanes struck about normal to the shore line at a time when tides were high. The 1944 hurricane struck obliquely to the shore at low tide. The latter hurricane did not produce the inundation and consequent destruction which occurred during the former.

2. Hurricane of September 21, 1938. - On September 21, 1938, the New England area was struck by a devastating hurricane which originated around the Cape Verde Islands. It traveled in a curved path in a northwesterly and then northerly direction, arriving in the New England area during mid-afternoon of the 21st of September. It entered Connecticut with its center just west of New Haven at 3:30 p.m., E.S.T., and continued northward at 50 to 60 miles per hour. Its eye was clearly observed at New Haven. Winds that were easterly since noon died down between 3:00 and 4:00 p.m., and were then followed by increasing southwesterly winds. The region of strongest wind lay in the dangerous semi-circle about 75 miles to the right of the storm center. Minimum barometric pressures were

reported as follows: at Bridgeport 28.30 inches, at New Haven 28.11 inches at 3:50 p.m., at Hartford 28.04 inches at 4:17 p.m. They dropped gradually until noon, and then dropped rapidly to their lowest pressures until about 4:00 p.m. Pressures then rose rapidly until 8:00 p.m., when the noon pressure was attained, then rose gradually. Maximum wind velocities in miles per hour for five minute periods and for gusts, respectively, were observed as follows; New Haven 38 and 46, Hartford 46 and 59, over an area 80 miles wide from Saybrook, Connecticut, to Martha's Vineyard, Massachusetts 70 to 90 and probably in excess of 100. The precipitation directly attributable to the hurricane is difficult to determine due to the fact that it rained for two days before it reached New England. The total precipitation ranged from 2 to 5 inches along the Connecticut shore, the major portion of which was probably directly due to the storm. Tides rose above their predicted heights. Tidal heights were increased more to the east of the hurricane center than to the west because of the counter-clockwise wind rotation. Reported high tide during the hurricane occurred 2 to 2-3/4 hours before the time of predicted tide. The effect of the hurricane was an addition of about 9 to 10 feet to the predicted high tide at the entrance to Long Island Sound, this addition decreasing to 7 feet at Bridgeport and increasing to 9 feet at the west end of the Sound. Wave action accompanying the storm produced a devastating effect upon the shore line, pounding it mercilessly and resulting in widespread damage. Wave heights ranged from 10 feet at New London to 15 feet at New Haven and Bridgeport.

3. Hurricane of September 14-15, 1944. - On September 14, 1944, the New England area was struck by a tropical hurricane which originated in the West Indies. This hurricane traveled in a northwesterly then northerly direction to Cape Hatteras, then swerved north northeast across Long Island, reaching the mainland in the vicinity of Westerly, Rhode Island about 11:00 p.m., E.S.T. From there, it proceeded northeastward across Providence, Rhode Island, and thence followed closely along the New England coast and passed over Newfoundland and out to sea. The greatest wind intensities occurred to the east of the storm center. The calm during the passage of the "eye" and the shift in the wind direction after its passage, were clearly noted at Westerly and Providence. The following minimum barometric pressures in inches were reported in the Connecticut area on September 14: New Haven 28.86 at 9:50 p.m.; Hartford 28.94 at 10:50 p.m.; Fishers Island 28.41 at 10:45 p.m.; Groton 28.40 at 11:00 p.m.; Westerly 28.30 at 11:00 p.m.; Block Island 28.34 at 11:09 p.m. Maximum wind velocities in miles per hour for five minute periods and for gusts, respectively, were reported as follows: New Haven N 33 and NE 38, Hartford N 50 and N 62, Block Island SE 82 and SE 88, gusts only New London 70 and Westerly 75. Gusts were mostly estimated. Heavy rainfall was reported practically throughout the coastal portion of the Providence District, which extended from New York State to Cape Cod. In Providence, a total of 4.49 inches fell from 5:55 p.m. to midnight on 14 September. Tides rose above their predicted heights. The hurricane effect occurred on the ebb tide

about 3 to 5 hours after predicted gravitational high water in the area from Watch Hill, Rhode Island, to Wood's Hole, Massachusetts.

4. Storm of November 25, 1950. - On November 25, 1950, the New England area was struck by an east to southeast storm which moved north northwestward from Virginia, reaching Connecticut during the early hours of the morning and continuing through Massachusetts until the early hours of the 26th. Interior Connecticut, nearer to the storm center, recorded gusts up to 100 miles per hour. Sustained five minute winds of 34 miles per hour and greater were recorded at New Haven during each hour from 4:00 a.m. to 5:00 p.m. The prevailing wind direction was southeast. Maximum velocities recorded at New Haven were as follows: fastest mile, 57 m.p.h. and maximum gusts, 66 m.p.h., and 77 m.p.h. (5-second gust). The above maximums were probably exceeded between 8:00 p.m. and 9:00 p.m., a period for which no velocities were recorded. The wind died down suddenly after the above period. Heavy rainfall generally exceeding two inches occurred during the night of the 25th-26th in southern New England. Tides rose in Long Island Sound above their predicted heights. Flood tides which occurred about midday of the 25th exceeded predicted tides by about 5 feet from Bridgeport eastward along the Connecticut shore and up to 6 feet west of Bridgeport to Greenwich. At 9:18 p.m., on the 25th at New London, the flood tide reached 6.1 feet above its predicted height. The storm subsided before the time of high tide along the western part of Connecticut, and the night tides did not reach the maximum heights which occurred during midday. Shore damage along the Connecticut shore was widespread. The greatest amount of shore damage occurred west of New Haven. Wave action was exceptionally violent causing considerable destruction to coastal highways, sea walls, cottages and small craft.

5. Hurricane of August 31, 1954. - Hurricane Carol entered southern New England on August 31, 1954. It traveled in a north northeastward direction from a central position about 100 miles off the Virginia Capes at midnight of August 30th and swept over the extreme eastern end of Long Island nine hours later. Its center moved on a northward course up the Connecticut-Rhode Island border into east central Massachusetts. Sustained winds and gusts, respectively, were recorded as follows: New Haven 40 N and 65 N; Block Island 100 SE and 135 SE; Providence 90 ESE and 105, Nantucket 72 SE and 77 ESE, Boston 86 SE and 100 SE; Portland 69 E and 78 E. Minimum barometric pressures and total precipitation, respectively, were recorded in inches as follows: New Haven 28.77 (910 EST) and 2.75; Block Island 28.40 (1000 EST) and 3.31; Providence 28.69 (1045 EST) and 2.79; Nantucket 29.32 (1100 EST) and 1.89; Boston 28.83 (1148 EST) and 2.60; Portland 29.15 (1412 EST) and 2.26. The hurricane was most violent during the morning over the region extending eastward 100 miles from the center line of passage. Sustained hurricane winds ravaged extreme eastern Connecticut, Rhode Island and Massachusetts. Similar but lesser devastation occurred

in the strip of Massachusetts and Connecticut west of the hurricane's center line to the Connecticut River. Damages from flooding occurred at low shore areas throughout Connecticut as a result of extremely high tides. Damages from wave attack were particularly severe only east of the Connecticut River, increasing in severity to the east with the greatest damages in the town of Stonington. Some damages due to wave attack occurred between New Haven and the Connecticut River at shore developments which were particularly vulnerable because of their locations at low beach areas. The greater part of all statewide losses resulted from water damage to industrial plants, business establishments and shorefront residences while east of the Connecticut River heavy losses resulted from damages to fishing and pleasure craft and harbor facilities and physical destruction of shorefront residences and bathing beach establishments.

6. Storm Data. - Summaries of records of winds equal to or greater than 40 miles per hour at New York City and 32 miles per hour at New Haven and Block Island, compiled from United States Weather Bureau data covering the periods indicated, are tabulated below:

Winds Equal to or Greater than 40 Miles per Hour

New York City, N. Y., 1911-1947

Direction	Number	Percent of Total	Probable Number in 100 Years
N	73	5	197
NE	29	2	80
E	15	1	40
SE	44	3	118
S	117	8	316
SW	88	6	236
W	161	11	434
NW	934	64	2527
TOTAL	1461	100	3948

Winds Equal to or Greater than 32 Miles per Hour

New Haven, Connecticut, 1905-1947

Direction	Number	Percent of Total	Probable Number in 100 Years
N	38	15	88
NE	41	15	90
E	12	5	28
SE	24	9	56
S	40	15	93
SW	25	10	58
W	34	13	79
NW	46	18	107
TOTAL	260	100	599

Winds Equal to or Greater Than 32 Miles Per Hour

Block Island, Rhode Island, 1936-1945

Direction	Number	Percent of Total	Probable Number in 100 Years
N	78	10	780
NE	102	13	1020
E	63	8	630
SE	45	6	450
S	24	3	240
SW	35	4	350
W	117	14	1170
NW	341	42	3410
TOTAL	805	100	8050

7. Analysis of Storm Data. - From the observed data the probable 100-year frequency of occurrence of storm winds from various directions has been estimated. Storm winds occurring at New York and Block Island are similar in that they show a high preponderance in a northwest direction but their frequency of occurrence is not comparable since 40 mile per hour winds are listed for New York and 32 mile per hour winds are listed for Block Island. At New York City during 1947 there were 110 winds of 32 miles per hour or greater, as against only 42 winds equal to or greater than 40 miles per hour. Applying the ratio (110/42 = 2.6) to the total number of winds listed in the table above for New York City (2.6 x 3948), it appears that approximately 10,300 winds of intensity equal to or greater than 32 miles per hour can be expected during a 100-year period as against 8050 at Block Island.

Storm winds at New Haven occur without any marked differences in frequency from the west clockwise around to northeast and from the south. New Haven is located in a lowland which runs generally north and south. Winds in the lowland are directed in a north-south direction creating wind conditions that are peculiar to New Haven. Records for Block Island and New York City give a more accurate picture of the direction of wind expectancy in Long Island Sound. The Connecticut shore is well sheltered by Long Island, Fishers Island, and other islands extending to the east. Therefore, neither the frequency nor intensity of storms occurring at Block Island and New York City can be expected to occur along the Connecticut shore.

8. Storm Damage. - The following selected accounts mostly condensed from newspaper reports indicate the type of storm damage experienced in the study area.

Location	Account
New London	Feb. 8, 1941. Southeast to northeast storm, gusts 56 m.p.h., high tides, heavy seas, slight damage to beach front.
	March 8, 1941. Northeast storm, snow, heavy seas. Area escapes with light damage.
	March 3, 1942. East southeast to northwest storm, huge seas, tide four feet above normal. Considerable damage to shipyards, small craft and piers. Green Harbor and Osprey Beaches eroded leaving boulders.
	Sept. 14, 1944. Tropical hurricane. Considerable damage to harbor structures. Bathing pavilions levelled at Osprey Beach. Sea wall undermined, section of concrete walk destroyed and four cottages undermined at Neptune Park. Only light damage to cottages at Ocean Beach where a layer of clean white sand was left.
	Dec. 1, 1944. West southwest to south storm, heavy seas. Minor shore damage.
	Nov. 23, 1945. Southeast storm. Considerable damage along shore.
	March 3, 1947. Southeast storm, 60 m.p.h., huge waves, high tides. Minor shore damage. Lower streets flooded.
	Feb. 14, 1948. Northeast storm, huge seas. Minor shore damage.
	Nov. 25, 1950. Southeast storm, high tides, violent wave attack. Estimated $5,000 damage at Ocean Beach. Bathhouses at Osprey Beach were destroyed. Damages to light piers and boats.
	Dec. 11, 1953. Northeast storm, high tides. Harbor structures damaged and small boats stranded. Waterfront roads made impassable by sand and water. Minor damage to dwellings and business establishments.
	Aug. 31, 1954. - Tropical hurricane, high tides. Flood damage to business establishments. Many boats lost or swamped. Bathhouse wrecked at Osprey Beach. Residences at Pequot Avenue and Neptune Park received brunt of storm. Water up to boardwalk at Ocean Beach caused flooding of electrical equipment and $36,000 damages to amusements.

9. Exposure of the Shore. - The shore line faces open water across Fishers Island and Long Island Sounds and the Atlantic Ocean from the east clockwise around to the west-southwest. The maximum fetch across Fishers Island Sound to the east is about 11 miles. The fetch to the southeast is limited by Fishers Island five to six miles away and Long Island about 22 miles away but waves and swells can approach from this direction across the Atlantic Ocean through an opening between the Islands known as the Race. Fetches across Long Island Sound to the south and southwest to Long Island are about 22 and 32 miles, respectively, while the fetch along the length of Long Island Sound to the west-southwest is approximately 90 miles. Records of winds at Block Island indicate that the prevailing wind direction is southwest and the greatest frequency of storms occur from the northwest, the latter, a direction from which the shore is not exposed to wave attack. The indicated storm frequency across appreciable fetches is greatest from the west and least from the south, southwest and southeast. The study area has the form of two peninsulas projecting southward so considerable extents of the shore are sheltered from the prevailing storm direction and storms from most directions which can cause damage are relatively infrequent.

APPENDIX E

SHORE LINE AND OFFSHORE DEPTH CHANGES

1. Basic Data. - Maps showing the locations of the shore line during the years 1838-39, 1846 and 1882-83 and the 6, 12 and 18-foot depth contours during the years 1839 and 1882-83 were prepared by the Beach Erosion Board from United States Coast and Geodetic Survey data. A field survey was run during 1955 for this study locating most of the shore line and determining elevations and depths on selected profiles. Surveys by the Corps of Engineers of the New London shore line during 1913 and of profiles and the shore line of Waterford in the vicinity of Goshen Creek during 1954 were also available. Locations of portions of the shore line not located during 1955 were determined from vertical aerial photographs flown during 1949. Shore line and offshore depth changes are shown on Plates 5-6. Due to the scale (1:10000) used on these maps, it is obviously difficult to determine small changes with accuracy. Change descriptions contained in the following paragraphs have therefore been limited to those large enough to permit measurement. Amounts of change when given in feet are necessarily scaled distances and, therefore, approximate. No attempt has been made to describe all changes in minute detail. The changes described can generally be considered accurate in indicating the trend in the area and approximate only in indicating the actual quantitative change.

2. New London Harbor Shore North of Osprey Beach. - This shore at the east limit of the study area extends northward approximately 6,000 feet from New London Harbor Light at the west side of New London Harbor. The 850 feet of shore north of Profile 1 moved landward 100 to 150 feet from 1838-39 to 1846 while from 1846 to 1882-83 the shore line moved irregularly landward and seaward. Accretion occurred in this area from 1916 to 1955 moving the shore farther seaward for a distance ranging from 50 to 100 feet. Larger changes occurred along the 1,200 feet of shore south from Profile 1. These changes consisted of recession of up to 100 feet along 600 feet of shore adjacent to Profile 1 between 1838-39 and 1846, recession of up to 250 feet along this entire area from 1846 to 1882-83 and little change thereafter to 1955. The only other appreciable shore line change occurred along a shore indentation, 200 to 300 feet long located just north of New London Harbor Light. The change consisted of a seaward shore line movement of up to 200 feet between 1846 and 1882-83 with little change thereafter to 1955.

3. Comparative locations of the 6, 12 and 18-foot depth contours, available only for the offshore area opposite the southerly 1,000 feet of shore for the years 1839 and 1882-83, indicate that deepening and a small landward movement of depth contours occurred. Comparison of Profile 1 run during 1955 with the above contours for 1882-83 indicates a landward movement of about 50 feet for the 6-foot contour, and about 130 feet for the 12-foot contour and no change in the position of the 18-foot contour.

4. Osprey Beach. - This section of shore extends about 2,600 feet south from New London Harbor Light. Shore line changes along its northerly 300 feet which is characterized by rock outcrops were small and irregular. Along the next southerly 500 feet of shore along the sandy portion of Osprey Beach accretion from 1846 to 1882-83 moved the shore line up to 125 feet seaward while from 1882-83 to 1955 only a small additional accretion occurred resulting in a seaward shore line movement probably not exceeding 25 feet. Along the remainder of this beach to the south the shore line generally moved landward, the largest movement occurring between 1846 and 1882-83 generally not exceeding 100 feet with the larger movement along the south end. Shore line movements along this southerly portion of beach were irregular and small between 1882-83 and 1955.

5. Offshore depth changes between 1839 and 1882-83 consisted of deepening accompanied by landward movements of the 6, 12 and 18-foot depth contours of up to 200,500 and 200 feet respectively. Comparison of Profile 2, run during 1955 with the 6, 12 and 18-foot depth contours located during 1882-83 indicates that there was little or no change in depth during the intervening period.

6. Neptune Park. - The 1,500 feet of shore between Osprey and Ocean Beaches, known as Neptune Park, fronts residences contiguous to a beach area composed alternately of exposed bedrock and sandy pockets. Along the northerly 250 feet, the 1955 shore line was up to 50 feet seaward of its 1882-83 position, probably as a result of artificial filling and sea wall construction. The shore line of the 300 foot sandy pocket south of and adjacent to this area moved landward up to 150 feet between 1846 and 1882-83 but thereafter to 1955 the shore line of the north half of the pocket moved seaward 50 to 75 feet and recession of less than 50 feet continued along the south half. The next southerly sandy pocket of about 200-foot length was subject to accretion resulting in a seaward shore line movement of about 100 feet between 1846 and 1882-83 with no apparent change thereafter to 1955. The shore line southwest of the last pocket extending to Ocean Beach moved seaward 100 to 125 feet between 1846 and 1882-83 and moved landward about 25 feet between 1882-83 and 1955. The recession of this latter shore has reportedly occurred since about 1954.

7. Offshore depth changes consisted of deepening which resulted in general landwared movement of the 6, 12 and 18-foot depth contours between 1839 and 1882-83, the largest movement at each depth curve being approximately 300 feet. No comparative data is available to show changes after 1883.

8. Ocean Beach. - The shore line of Ocean Beach extends about 2,000 feet northward from the Alewife Cove inlet. It was generally subject to accretion between 1839 and 1882-83 which moved the shore

line up to 100 feet seaward in the area north of Profile 3 and 50 to 75 feet seaward south of Profile 3. From 1883 to 1955 changes were smaller, consisting generally of erosion which moved the shore line north of Profile 3 less than 50 feet landward and south of Profile 3, 25 to 50 feet landward. During the period of 1839 to 1955 the north shore of the Alewife Cove inlet moved about 100 feet to the south.

9. Offshore depth changes from 1839 to 1883 consisted of deepening and landward movement of depth contours as follows: 6-foot up to 400 feet, 12-foot up to 300 feet, 18-foot up to 200 feet. At Profile 3, run during 1955, the 6 and 12-foot depth contours moved seaward about 60 and 80 feet respectively between 1883 and 1955 while the 18-foot depth contour moved up to 190 feet landward. At Profile 4, also run during 1955, changes since 1883 were small with no apparent change at the 12-foot depth, a slight seaward movement of the 6-foot contour and a slight landward movement of the 18-foot contour.

10. Shore Between Ocean Beach and Harkness Memorial State Park. - The shore line of this area extends approximately 2,300 feet eastward from Harkness Memorial State Park to the Alewife Cove inlet. The area is in the form of a tombolo with an island at its easterly end. The shore line bordering the inlet moved about 100 feet southward with southward migration of the inlet during the period 1839 to 1955. The east tip of the tombolo moved seaward about 200 feet between 1846 and 1883 and moved landward about 300 feet from 1883 to 1955. The south shore of the area moved continuously seaward between 1839, 1846 and 1883, the total movement varying between 100 and 200 feet. Since 1883 the south shore has eroded and moved landward for a distance generally less than 50 feet, with a maximum movement of about 100 feet.

11. Offshore depth changes between 1839 and 1883 generally consisted of deepening resulting in a landward movement of the 6-foot depth contour of up to 450 feet, irregular movements of the 12-foot contour both landward and seaward and an irregular movement of the 18-foot depth contour, generally in a landward direction. Comparison with Profile 5, run during 1955 indicates that there was slight deepening in the vicinity of the 12-foot depth after 1883 and no change in the vicinity of the 6-foot depth during the same period.

12. Harkness Memorial State Park. - The shore of the park, about 3,400 feet in length is bounded on the west by the Goshen Cove inlet and extends east and west from the tip of Goshen Point. Comparison of shore line positions for 1838-39, 1846 and 1882-83 indicates that there was continuous accretion during the period with the shore line generally moving 100 to 200 feet seaward. Between 1883 and 1955 the shore east of the tip of Goshen Point receded slightly, the landward shore line movement averaging about 25 feet, while during the same period accretion continued along

the shore west of the tip of Goshen Point resulting in a seaward shore line movement of up to 50 feet. Comparative surveys of the shore run during 1954 and 1955 and field observation during 1956 indicate that the only appreciable shore line changes occurred in the vicinity of the Goshen Cove inlet and they consisted of growth of bars or spits which tended to close the entrance.

13. Offshore depth changes indicated by 6, 12 and 18-foot depth contours for the years 1839 and 1882-83 consisted of deepening and landward movement of the 12 and 18-foot contours generally opposite the entire shore while deepening and landward movement of the 6-foot contour occurred only east of Goshen Point and shoaling and seaward movement of this contour generally occurred at and west of Goshen Point. Comparison of 1882-83 depth contours with Profiles 6, 7 and 8 which were run during 1955 indicates the following offshore depth changes; at Profile 6, a slight deepening in the vicinity of the 6 and 12 foot depths; at Profile 7, shoaling in the vicinity of the 6-foot depth and no change at the 12 and 18-foot depths; at Profile 8, shoaling in the vicinity of 6 and 12-foot depths and deepening at the 18-foot depths.

14. Shore Between Harkness Memorial State Park and Seaside Sanatorium. - This shore area extends about 3,200 feet west from the Goshen Cove inlet to Seaside Sanatorium. The entire shore was subject to accretion between 1839 and 1846 resulting in a seaward shore line movement of varying amount up to 100 feet. Between 1846 and 1955 there has been a regular pattern of change with accretion occurring east and erosion west of a nodal point, located about 800 feet west of Goshen Cove Inlet. The amount of seaward shore line movement at the inlet was approximately 100 feet and it decreased westward to the nodal point, and thence changed to landward movement which in turn increased westward up to a maximum of about 150 feet.

15. Comparison of the 6, 12 and 18-foot depth contours for 1839 and 1882-83 indicates that offshore depth changes were as follows: shoaling in the vicinity of the 6-foot depth opposite the west half of the shore and little or no change at this depth opposite the east half; shoaling in the vicinity of the 12-foot depth opposite the westerly two-thirds of the shore and deepening opposite the easterly third; deepening opposite most of the shore in the vicinity of the 18-foot depth. Profiles 10 and 11, run during 1955 indicate that there has been little or no depth change in the vicinity of the 18-foot depth since 1883 and deepening in the vicinity of both the 6 and 12-foot depths.

16. Seaside Sanatorium. - The shore line of Seaside Sanatorium extends about 1,500 feet eastward from Seaside Point. From 1838-39 to 1846 and again from 1846 to 1882-83 shore line movements were generally seaward. A seaward movement of 75 to 100 feet occurred along the entire shore during the former period while

during the latter period there was little change along the east half of the shore and an additional 50-foot seaward movement along the west half. Between 1883 and 1955 the shore line retreated irregularly landward for varying distances, not exceeding 75 feet.

17. Movements of the 6, 12 and 18-foot depth contours were predominantly seaward from 1839 to 1882-83 indicating shoaling. Comparison of Profile 12, run during 1955 with the above depth contours for 1882-83 indicates that there has been little change in offshore depths during the intervening period.

18. Seaside Point to Magonk Point. - This shore area is about 1,800 feet long and extends westward from Seaside Sanatorium around Seaside Point to the tip of Magonk Point. Shore line changes have been irregular consisting of accretion and a varying amount of seaward movement of up to 100 feet between 1846 and 1882-83 and erosion and landward shore line movement between 1883 and 1955, the latter varying from about 50 to 75 feet at Seaside Point to about 25 feet or less along the easterly half of the shore between Seaside and Magonk Points and 50 to 100 feet along the rest of the shore at and adjacent to Magonk Point.

19. The 6, 12 and 18-foot offshore depth contours moved 100 to 300 feet seaward from 1839 to 1882-83 indicating shoaling. No comparative depths were available to indicate changes after 1883.

20. Magonk Point to White Point. - This shore line extends about 1,900 feet from the tip of Magonk Point to the tip of White Point. Between 1846 and 1882-83 there was a varying seaward movement of the entire shore line. The maximum movement of approximately 200 feet occurred along the east and central portion of the area. Comparison of the 1882-83 and 1955 shore lines indicates that there was little change in the vicinity of Magonk Point and erosion and landward movement of 50 to 75 feet along the central and western portion of the shore.

21. The 6, 12 and 18-foot offshore depth contours moved seaward between 1839 and 1882-83 for varying distances up to 500,300 and 200 feet respectively indicating shoaling. Comparison of Profile 13, run during 1955 with the above depth contours for 1882-83 indicates that the only appreciable change during the period consisted of deepening in the vicinity of the 6-foot depth.

22. White Point to Pleasure Beach. - The shore line in this area extends about 1,500 feet northward from the tip of White Point to Pleasure Beach. Shore line changes between 1846 and 1882-83 consisted of a seaward movement throughout the area of about 50 to 150 feet. Between 1883 and 1955 there was an additional seaward movement of the shore line along the southerly two-thirds of the shore, with the largest movement during the period approximately

150 feet while along the northerly one-third of the shore there was an irregular landward movement not exceeding about 50 feet.

23. The 6, 12 and 18-foot depth contours for 1839 and 1882-83 generally moved seaward indicating that shoaling occurred offshore during the intervening period. No comparative depths were available to determine offshore depth changes after 1883.

24. Pleasure Beach. - This shore area with a length of about 1,700 feet extends northward along a sandy beach to and around a rocky point. Changes along the sandy beach along the southerly 650 feet of shore consisted of accretion and seaward movement of about 150 feet between 1846 and 1882-83 and erosion and landward movement of about 50 to 75 feet between 1883 and 1955. Changes along the remainder of the shore have been irregular during the above periods, consisting principally of seaward movement, probably more the result of construction of shore structures and artificial filling rather than natural shore processes.

25. The 6, 12 and 18-foot depth contours moved seaward between 1839 and 1882-83 along the entire offshore area indicating shoaling. Comparison of Profile 14, run during 1955 with the 1882-83 depth contours indicates that there was no change in the vicinity of the 12 and 18-foot depths and a slight deepening in the vicinity of the 6-foot depth.

26. Pleasure Beach to Jordan Cove Entrance. - The shore line has a length of approximately 3,000 feet extending northward from the Pleasure Beach area to the Jordan Cove entrance. During 1838-39, 1846 and 1882-83, the northerly 1,200 feet of the area consisted of a northward trailing spit which in 1955 was included in the artificially filled triangular land area which extends almost across Jordan Cove. During the period 1838-39 to 1846 the shore generally moved landward about 100 to 150 feet throughout its length. From 1846 to 1882-83 there was little change in the position of the southerly 300 feet of the shore while the rest of the shore moved about 100 feet seaward. Between 1883 and 1955, there was little change along the southerly 600 feet of shore, irregular landward movement along the next northerly 600 feet and a large seaward movement along the north end of the area resulting from artificial filling around 1931 of the triangular shaped land area at the Jordan Cove entrance.

27. The 6, 12 and 18-foot depth contours moved seaward opposite the entire area from 1839 to 1882-83 indicating shoaling. Comparison of Profile 15, run during 1955 with the 6-foot depth contour for 1882-83 indicates that there was some deepening in the vicinity of the 6-foot depth.

28. Shore West of Jordan Cove Entrance. - This shore area extends westward from the Jordan Cove entrance about 2,500 feet

to the tip of the first prominent shore projection between Profiles 17 and 18. During the period 1838-39 to 1882-83 there was a seaward movement of the easterly 1,500 feet of shore. This movement was about 250 feet at the cove entrance and it diminished progressively to the west. During the above period, the rest of the shore line moved irregularly landward and seaward. From 1883 to 1955 the entire shore line moved landward for distances varying from about 50 feet to 150 feet with the smaller recession along the shore projection at the west end of the area.

29. The 6, 12 and 18-foot depth contours moved seaward opposite the entire area from 1839 to 1882-83 indicating shoaling. Comparison of Profiles 16 and 17, run during 1955, with the 6-foot depth contours for 1882-83 indicates that there was a small amount of deepening in the vicinity of the 6-foot depth.

30. Millstone Point. - This area includes the entire shore of Millstone Point, about 8,500 feet in length, from the shore projection between Profiles 17 and 18 to the east end of the sandy beach located about 1,400 feet east of the tip of Bay Point. Changes in the position of the shore line along the east side of the point between 1838 and 1955 consisted of erosion and landward movement varying from about 50 to 200 feet. Along the south shore they consisted of an irregular seaward movement up to 200 feet between 1838-39 and 1882-83 followed by a smaller landward movement, generally less than 100 feet, from 1883 to 1955. Along the west shore, from 1838 to 1955 the shore line moved predominantly seaward with the largest movement about 400 feet. This accretion appears to have occurred artificially by disposal of the stone quarry waste which now constitutes most of the shore line.

31. Offshore depth changes between 1839 and 1882-83 are indicated by the movement of offshore depth contours. Opposite the east shore of Millstone Point, the 6-foot depth contour moved irregularly indicating little change in the vicinity of the 6-foot depth while the 12 and 18-foot depth contours moved seaward indicating shoaling. Opposite the south shore of the point, the 6, 12, and 18-foot depth contour movements were small and generally seaward indicating shoaling. Opposite the south half of the west shore of the point the 6 and 12-foot depth contours moved generally landward indicating deepening while 18-foot contour movements were irregular. Opposite the north half of the west shore of the point the 6 and 12-foot depth contours moved seaward indicating shoaling while the 18-foot depth contour moved landward indicating deepening. Comparison of Profile 18, run during 1955, with the 1882-83 6-foot depth contour indicates that there was a small amount of deepening in the vicinity of the 6-foot depth.

32. Between Millstone Point and Bay Point. - This section of shore, about 1,400 feet in length, is located between the west limit of the study area at Bay Point and Millstone Point. Between

1838-39 and 1882-83 there was a landward shore line movement along the easterly half of the area of varying amount up to 200 feet, and seaward shore line movement, increasing westward up to about 200 feet along the west half of the area to Bay Point. There was little change at Bay Point. Between 1882-83 and 1955 shore line positions indicate that accretion occurred along the east half of the area with the seaward shore line movement not exceeding 25 feet while erosion along the west half of the area moved the shore line landward for a distance generally not more than 50 feet.

33. The 6, 12 and 18-foot depth contours moved seaward opposite the entire area from 1838-39 to 1882-83 indicating shoaling in the vicinity of these depths. Comparison of Profiles 19 and 20, run during 1955, with the 6, 12 and 18-foot depth contours for 1882-83 indicate that deepening occurred in the vicinity of all depths, with the amount of deepening larger at the greater depth.

APPENDIX F

LITTORAL DRIFT

1. Listed below are indices of littoral drift obtained from field inspections, comparative shore line change maps and aerial photographs. Direction of littoral drift was interpreted as being in the direction of growth of sand spits, toward the sides of groins or other projections at which accretion was found or toward the ends of beaches where material was finer as shown by variation of beach composition from coarser to finer material.

Indices of Drift

Shore Area	Indicated Direction of Drift	Evidence	Date	Authority
New London shore north of New London Harbor Lighthouse	North	Material impounded on south side of groins	Nov.15, 1955 Feb.18, 1949	Field inspection Aerial photos
do	North	Pocket beach wider south side rock outcrop	Nov.15, 1955 Feb.18, 1949	Field inspection Aerial photos
Osprey Beach	North	Material impounded on south side of groins and beach composition finer at north end of beach	Nov.15, 1955 Feb.18, 1949	Field inspection Aerial photos
North end of Ocean Beach	South	Sand impounded at north side of rock outcrop	Nov.15, 1955	Field inspection
East shore of Goshen Point (East half of Harkness Memorial State Park)	North-east	Beach composition finer to north and wider sand beach held at south side of rock outcrop	Nov.16, 1955 Feb.10, 1949	Field inspection Aerial photos

Shore Area	Indicated Direction of Drift	Evidence	Date	Authority
Harkness Memorial State Park West of tip of Goshen Point	West	Westward trailing sand spit across Goshen Cove entrance and beach composition finer to the west	Nov.16, 1955	Field inspection
Seaside Sanatorium	East	Sand impounded on west side of groins	Nov.22, 1955 Feb.10, 1949	Field inspection Aerial photos
Between Magonk and White Points	West	Material impounded at east side of rock outcrops	Nov.11, 1955	Field inspection
About 400 feet North of White Point	North	Northward trailing sand spit across creek entrance	Nov.22, 1955 Feb.10,1949	Field inspection Aerial photos
East shore south of Jordan Cove entrance	North	Northward trailing spit	1838-39,1846 and 1882-83	Shore line change map
West shore south of Jordan Cove entrance	East	Sand impounded at west side of groins	Nov.22, 1955	Field inspection

APPENDIX G

EXISTING PROTECTIVE STRUCTURES

1. General. - Protective structures consisting of sea walls, bulkheads, groins, revetment and breakwaters exist throughout the study area. Most structures have been built by individuals or private groups and detailed information concerning them is not available. Structures have generally been built to protect the immediate shores which they front. In most cases they have had little or no effect on adjacent shore lines. Information concerning the types of structures existing at specific localities obtained from inspection of the area during November 1955 is included in Appendix A. Structures in New London consist principally of sea walls and revetment protecting residences, the shore road and low land areas all located close to the water's edge north of Ocean Beach. There are also a few short groins in this area. Ocean Beach does not have any shore structures. In Waterford, the principal structures consist of sea walls, bulkheads and groins at Seaside Sanatorium and along the small residential developments immediately north and south of Pleasure Beach and along the shore at the west side of the Jordan Cove entrance. Riprap revetment has been used to protect a considerable extent of Goshen Point and most of the shore of Millstone Point is covered with stone quarry waste. A limited amount of information is available from Federal permits issued for structures and from the field survey run for this study and it is included below.

2. Seaside Sanatorium Seawall and Groins. - The shore fronting Seaside Sanatorium is fronted by a rubble masonry sea wall and five riprap groins. The two longest groins make an angle of about 60 degrees with the wall. They were constructed according to a Federal permit around 1932 to lengths of 500 and 360 feet, respectively, 4 feet wide and with top elevation 1.4 feet above mean low water. The other three groins also according to a Federal permit, were constructed around 1938 each to a length of 200 feet, width of 20 feet and top elevation approximately equal to mean high water. They are the end and center groins of the system. No permit was issued for the wall but it is understood that it was built during the same period. During 1955, a field survey determined the top of wall was 14.2 feet above mean low water at Profile 12. The groins hold beach material on their west sides. They have deteriorated due to lack of maintenance but are still effective in reducing erosion. The wall appears to be in good condition and it adequately protects the lawn behind it. Riprap has been used in places along the toe of the wall to protect against undermining.

3. Timber Bulkhead at Jordan Cove Entrance. - During 1947 a timber bulkhead was constructed across the south or seaward shore of the triangular filled land area extending westward from the shore on the east side of the Jordan Cove entrance. According to a Federal permit the bulkhead was 2100 feet long with a top

elevation 5 feet above mean high water. A timber jetty about 100 feet long was constructed perpendicular to the bulkhead at its west end and 6 groins, each about 10 feet long, were built perpendicular to the east end of the bulkhead. The filling of the land and construction of another timber bulkhead, believed to be on the landward side of the area was done according to a previous permit around 1931. During November 1955 it was found that the bulkhead built during 1947 was largely destroyed and the backfill was partly washed out permitting the shore line to recede to a position behind the bulkhead remains. The bulkhead on the landward side was still comparatively intact.

4. Sea Wall and Groins at West Side of Jordan Cove Entrance. - Two riprap groins and a rubble masonry sea wall have recently been constructed along the shore immediately west of the Jordan Cove entrance. Work was started during 1954 in connection with construction of a new residential development and it was still in progress during November 1955. The most easterly groin near the cove entrance is about 10 feet wide and 140 feet long. The other groin about 650 feet to the west is about 30 feet wide and 170 feet long. The rubble masonry wall extends westward from the easterly groin behind the sand beach along most of the shore to the other groin. For a short distance to the east or downdrift of the easterly groin riprap revetment has been placed, apparently to stop recession of the shore in this area. The sea wall at Profile 16 has a top elevation of 14.0 feet above mean low water. The groins impound or hold a wider sand beach on their west sides. According to a Federal permit issued for this work, the groins already built are only two of a system of five planned, with one proposed at a point midway between the two now existing, and two more proposed at 250-foot intervals west of the most westerly existing groin.

APPENDIX H

ESTIMATES OF COSTS OF IMPROVEMENTS

1. General. - A useful life of 50 years has been assumed in determining amortization charges. A rate of interest of 2.5 percent per annum has been used. Maintenance requirements of sand fills are based on maximum rates of loss determined from past shore recession with a minimum rate of loss of one foot per year. Annual maintenance costs for groin, jetty and culvert construction have been estimated as one percent of the first cost of construction.

2. West Shore of New London Harbor. - The plan of protection consists of construction of a groin near the apex of the sand beach opposite Mitchell Junior College.

(a) First Cost of Construction

Groin, 600 tons riprap @ $15.00	$9,000
Contingencies	1,400
Subtotal	$10,400
Engineering and design	500
Subtotal	$10,900
Supervision and administration	800
Total First Cost	$11,700

(b) Annual Charges

Interest	$ 290
Amortization	120
Maintenance, 6 tons riprap @ $15.00	90
Total Annual Charges	$ 500

3. Neptune Park and Ocean Beach. - The plan of protection consists of direct placement of sand fill along the south end of Neptune Park and the adjoining north end of Ocean Beach.

(a) First Cost of Construction

Sand Fill, 40,000 cu. yds. @ $1.25	$50,000
Contingencies	7,500
Subtotal	$57,500
Engineering and design	1,800
Subtotal	$59,300
Supervision and administration	4,700
Total First Cost	$64,000

(b) Annual Charges

Interest	$ 1,600
Amortization	700
Maintenance	
Sand fill, 2,000 cu. yds, @ $1.50	3,000
Total Annual Charges	$ 5,300

4. Goshen Cove Inlet. - The plan of protection consists of (1) construction of two jetties at the Goshen Cove inlet or (2) inclosure of Goshen Cove inlet in a culvert.

(a) First Cost of Construction

Plan Involving Jetty Construction

Two jetties, 5,000 tons riprap @ $12.00	$60,000
Channel revetment, 500 tons riprap @ $6.00	3,000
Contingencies	9,500
Subtotal	$72,500
Engineering and design	2,200
Subtotal	$74,700
Supervision and administration	5,300
Total First Cost	$80,000

Plan Involving Inclosure of Inlet in a Culvert

Pipe, 400 feet @ $25.00	$10,000
Concrete Headwall	900
Quarry run stone, 600 tons @ $6.00	3,600
Riprap, 900 tons @ $10.00	9,000
Sand fill, 5,000 cu. yds. @ $1.50	7,500
Contingencies	4,700
Subtotal	$35,700
Engineering and design	1,000
Subtotal	$36,700
Supervision and administration	2,300
Total First Cost	$39,000

(b) Annual Charges

Plan Involving Jetty Construction

Interest	$ 2,000
Amortization	800
Maintenance	
Jetty, 50 tons riprap @ $15.00	750
Revetment, 5 tons riprap @ $10.00	50
Total Annual Charges	$ 3,600

(b) Annual Charges (Continued)

Plan Involving Inclosure of Inlet in a Culvert

Interest	$ 970
Amortization	400
Maintenance, 1% of total first cost	390
Total Annual Charges	$ 1,760

APPENDIX I

ESTIMATES OF BENEFITS FROM IMPROVEMENTS

1. General. - The benefits computed herein are based on the promotion and encouragement of the healthful recreation of the people by protection and improvement of beaches, on protection of shore property and increased earning power or value of shore lands. Benefits accruing from increased value of areas behind and adjacent to shore property, increased business returns and recreational use of privately owned shores have not been evaluated. The United States does not own land in any of the areas considered for protection or improvement. Therefore, no Federal benefit will result from the plans considered.

2. West Shore of New London Harbor. - Stabilization of the sandy cuspate beach opposite Mitchell Junior College by construction of a groin could result in a private recreational benefit by providing for continued use of the beach in its present location. No information is available which can be used to evaluate this benefit.

3. Neptune Park and Ocean Beach

a. Direct Damages Prevented

(1) Private Benefit. - The proposed beach widening will reduce wave attack on the existing development and will result in (a) a saving in the maintenance cost of sea walls and (b) a reduction of storm damages to lawns and residences.

(a) Savings in Maintenance Cost of Existing Sea Walls

Estimated value of sea walls	$30,000
Estimated benefit or reduction in maintenance cost of sea walls, 1% or	$ 300

(b) Reduction of Storm Damages to Lawns and Residences. - Due to the narrowness of the fronting sand beach, breaking waves can overtop the sea wall during storms causing damage to lawns and residences. It is estimated that reduction of this type of damage by a wider sand beach will amount to at least $200 per year.

b. Increased Earning Power or Value of Shore Land

(1) Non-Federal Public Benefit. - The proposed plan of protection will increase the area of shore land, enlarge the tax base and be reflected in a lower tax rate. The benefit therefrom is evaluated as an increase in taxes on the estimated value of the additional privately owned shore land.

Increased area of privately owned land		40,000 Square Feet
Estimated value @ $0.50 per square foot		$20,000
Tax Rate	40 mills	
Estimated benefit	40 x 20	$800

(2) Private Benefit. - The proposed plan will increase the value of shore land. The benefit to owners therefrom is estimated as 5 percent of this increase.

Estimated increase in value of shore land	$20,000
Estimated annual gain or benefit @ 5%	$ 1,000

c. Recreational

(1) Non-Federal Public Benefit. - The proposed beach widening will provide approximately 14,000 square feet of additional area at Ocean Beach for public recreational use. It is assumed that this area is needed during periods of peak use (Sundays, holidays and Saturdays), the existing area being adequate during week days. Using a 10-week season during which peak use occurs during only 70% of the Sundays, holidays and Saturdays because of weather conditions, it is estimated that the additional area will be needed and used during 15 days. The benefit therefrom based on a desirable space standard of 75 square feet per person is evaluated as the minimum fee which patrons would be required to pay if the beach were a private enterprise. This minimum fee is $0.25 per person per beach use. The annual recreational benefit is therefor:

$$\frac{15 \times 14{,}000}{75} \times \$0.25$$ or approximately $700

d. Summary of Benefits - Neptune Park and Ocean Beach

Benefit	Non-Federal Public	Private	Total
Direct damages prevented	$ 0	$ 500	$ 500
Increased earning power or value of shore land	800	1,000	1,800
Recreational	700	0	700
Total	$1,500	$1,500	$3,000

4. Goshen Cove Inlet. - The benefit to be derived from the plans for maintaining the flow through the Goshen Cove inlet consists principally of elimination of a drainage problem which results in minor flooding or an offensive condition due to lack of tidal flushing. The benefit is largely intangible. No information is available that can be used to evaluate the benefit.

APPENDIX J

SANITARY STUDY OF THE CONNECTICUT SHORE

1. General. - The Department of Health of the State of Connecticut has periodically conducted bacterial and sanitary surveys of shore bathing waters to obtain specific information concerning their condition. The surveys have served to point out to municipal authorities and other interested persons the "danger spots" along the shore which are seriously affected by sewage pollution.

2. Bacterial Survey. - The bacterial survey consists of sampling of the water at approximate 1000-foot intervals along the shore in water depths of from 2 to 6 feet, such depths covering most of the areas used for bathing. The samples are taken as nearly as possible at four stages of the tide; namely, high, low, one-half ebb and one-half flood. Wind direction at the time of sampling is recorded but no attempt is made to take samples under different wind conditions as it is believed that the run of the tide is the principal factor influencing the travel of pollution along the shore. Three 10 milliliter, three 1 milliliter and three 0.1 milliliter portions of each sample are examined and the concentration of coliform organisms per 100 milliliter is reported. The most probable number of coliform organisms for each station is obtained by averaging the figures for the four tidal stages. The analytical figure for a shore section is obtained by averaging the results for different stations included. Classification is made as follows:

Bacterial Classification	Most Probable Number of Coliform Organisms for 100 Ml.
A	0-50
B	51-500
C	501-1000
D	over 1000

Class D waters are considered to be in a questionable category from the standpoint of bathing water safety.

3. Sanitary Survey. - In addition to the bacterial survey, a sanitary survey has been conducted. This includes the location of sewer outlets with data as to flows and character of untreated and treated sewage. The nearness of polluting influences and possibilities of shifting direction of travel of pollution under different wind conditions were taken into account in this part of the study. In connection with studies of shellfish areas in many harbors, floats had been set out to measure the rapidity of water travel

and these data were available in considering bathing waters in these localities. The sanitary survey was used to classify waters and afforded comparison with results obtained by the bacterial survey.

4. Classification of the Shore. - The shore was classified by bacterial analysis of samples collected during 1954. According to this classification the waters of New London Harbor between Long Rock at Neptune Park and the east limit of the study area are in Class D and therefore in a questionable category from the standpoint of bathing water safety. Other waters within the study area were found to be in satisfactory condition.

APPENDIX K

DESIGN OF PROPOSED STRUCTURES

1. Groin at New London Harbor Shore Near Profile 1. - The proposed groin is designed for riprap construction with a sand tight core of quarry run stone. Side slopes and sizes of cap and slope stones are determined from the graphs based on the modified Iribarren formula in Technical Report No. 4 of the Beach Erosion Board. The specific gravity of the stone is taken as 2.60 to provide a minimum unit weight of stone of 160 pounds per cubic foot. The wave height is determined as the maximum which could occur at the outer end of the groin based on a design tide 3 feet above the plane of mean high water. This wave height is the height of breaking waves from the relationship d/H = 1.28 where d is the depth of breaking and H is the wave height at breaking. There is sufficient fetch opposite this shore for winds to generate waves of the maximum size which could exist according to the above relationship.

Design Depth = d = depth at end of groin at mean low water + range of tide + 3
= 2+2.6+3 = 7.6 feet

Wave Height = $H = \frac{d}{1.28} = \frac{7.6}{1.28} = 5.9$ feet

From Plate D-6b and Table D-10 of T. R. 4 for a slope of 1 on 1.5

$\frac{W}{K'} = 3.3 \times 10^5$ where W = Weight of stones in pounds

and K' = stone size coefficient = .008

W = .008 (330,000)

W = 2640 pounds = 1.3 tons

Therefore, side slopes of 1 on 1.5 and cap and slope stones of 1 to 2 tons, average 1.5 tons, will probably be satisfactory.

2. Goshen Cove Inlet. - a. Slopes and Stone Sizes. - The proposed jetties are designed for riprap construction with a sand-tight core of quarry run stone. Side slopes and sizes of cap and slope stones are determined from the graphs based on the modified Iribarren formula in Technical Report No. 4 of the Beach Erosion Board. The specific gravity of the stone is taken as 2.60 to provide a minimum unit weight of stone of 160 pounds per cubic foot. The wave height is determined as the maximum which could occur at the outer end of the jetties and also 50 feet shoreward of the outer end based on a design tide 3 feet above the plane of mean high water. This wave height is the height of breaking waves from

the relationship d/H = 1.28 where d is the depth of breaking and H is the wave height at breaking. It has been determined from the wave forecasting method in Technical Report No. 4 that with the existing fetch of 19 miles and a wind speed of 50 miles per hour, waves of the size indicated by the above relationship can be generated.

Computation for Slopes and Stone Sizes

Outer End of Jetty		50' from Outer End of Jetty	
Water depth	= 6'		= 3.8'
Design depth	= 3/2.6/6 = 11.6'	= 3/2.6/3.8	= 9.4'
Wave Height	= $\frac{11.6}{1.28}$ = 9.0'	= $\frac{9.4}{1.28}$	= 7.3'

From Plate D-6b and Table D-10 of T.R. 4 for a Slope of 1 on 1.5

W/K'	= 1.2×10^6	= 6.4×10^5
Where K'	= .008	= .008
W	= 9600 lbs.	= 5120 lbs.
W	= 4.8 tons	= 2.6 tons

and for a Slope of 1 on 2

W/K'	= 3.2×10^5	= 1.7×10^5
Where K'	= .017	= .017
W	= 5440 lbs.	= 2890 lbs.
W	= 2.7 tons	= 1.5 tons

Therefore side slopes of 1 on 2 with top and slope stones of 2 to 4 tons, average 3 tons for the outer 50 feet and 1 to 2 tons, average 1.5 tons for the remainder of the jetties will probably be satisfactory. Similar slopes and stone sizes will probably also be adequate for cover stones for the proposed culvert.

b. Channel and Culvert Flow. - The proposed channel and culvert were designed to provide for a flow sufficient for flushing Goshen Cove. It was assumed that a flow which would produce a minimum tidal range of 1 foot in Goshen Cove with a mean range of tide of 2.6 feet in Long Island Sound would be satisfactory. Two plans were considered as follows:

(1) A 400-foot long culvert at the inlet connected to a channel 50 feet wide and 1200 feet long with bottom at mean low water elevation leading to the Goshen Cove pool.

(2) Jetties at the inlet entrance and a channel 50 feet wide and 1600 feet long with bottom at mean low water elevation leading to the Goshen Cove pool.

Fresh water flow constitutes only a minor portion of the total flow. Only tidal flow was provided for in the design. In the plan involving inclosure of the inlet in a culvert, in addition to a mean tidal range of 2.6 feet in Long Island Sound and 1.0 feet in the Goshen Cove pool, a range of 1.05 feet at the shore end of the culvert was estimated by trial and error to account for the head loss in the channel connecting the culvert to the pool. The following relationships were used for water elevations based on the same mean tidal level in all parts of the waterway, a tidal cycle of 12 hours and a rise and fall of the tide following a sine curve.

Culvert Plan

$$Y_1 = 1.30 \neq 1.30 \sin 30T$$
$$Y_2 = 1.30 \neq 0.525 \sin 30\ (T-2.2)$$
$$Y_3 = 1.30 \neq 0.50 \sin 30\ (T-2.8)$$

Jetty Plan

$$Y_1 = 1.30 \neq 1.30 \sin 30T$$
$$Y_3 = 1.30 \neq 0.50 \sin 30\ (T-2.25)$$

in which Y_1 = water elevation in Long Island Sound*
Y_2 = water elevation at shore end of culvert*
Y_3 = water elevation in Goshen Cove pool*
T = Time in hours based on the origin of the Long Island Sound tidal curve

* All water elevations refer to mean low water in Long Island Sound

For balanced flow, the above equations would have to be adjusted to account for differences in mean tide level between Long Island Sound, the shore end of the culvert and the Goshen Cove pool. Flow in the culvert was based on the following formula for concrete pipe with square cornered entrance flowing full:

$$Q_P = \frac{\frac{\pi D^2}{4}\sqrt{2g\,(y_1 - y_2)}}{\sqrt{1 \neq 0.31\,D^{0.5} \neq \frac{0.026\,L_P}{D^{1.2}}}}$$

in which Q_P = flow in the culvert
D = diameter of culvert
$Y_1 - Y_2$ = loss of head through the culvert
L_P = length of the culvert

Flow in the channel was based on Mannings' formula with two dimensional flow, expressed as follows:

Culvert Plan

$$Q_c = w\left(\frac{Y_2 + Y_3}{2}\right)\ \frac{1.486}{}\left(\frac{Y_3 \neq Y_2}{2}\right)^{2/3}\ \left(\frac{Y_2 - Y_3}{L_c}\right)^{1/2}$$

Jetty Plan

$$Q_c = w\left(\frac{Y_1 + Y_3}{2}\right)\ \frac{1.486}{n}\ \left(\frac{Y_3 + Y_1}{2}\right)^{2/3}\ \left(\frac{Y_1 - Y_3}{L_c}\right)^{1/2}$$

In which Q_c = flow in channel
w = width of channel
n = roughness factor = 0.025
L_c = length of channel

Based on the scaled area of Goshen Cove and a 1 foot tidal range, the required volume of flow during one tidal ebb or flood period (assumed as 6 hours) was determined to be 900,000 cubic feet. The volume (V) of flow in or out of Goshen Cove was computed as the summation of the flows during increments of time (Δt) for one ebb or flood period. Expressions for the total volume of ebb or flood flows are as follows:

Culvert Plan

$$V = \Sigma Q_c\ \Delta t = 154{,}600\ \Sigma\left(\frac{Y_2 + Y_3}{2}\right)^{5/3}\ (Y_2 - Y_3)^{1/2}$$

$$V = \Sigma Q_p\ \Delta t = 11{,}350\ \left(\frac{D^2}{\sqrt{1 + 0.31D}\ 0.5 + \frac{10.4}{D}\ 1.2}\right)\Sigma\left(\sqrt{Y_1 - Y_2}\right)$$

Jetty Plan

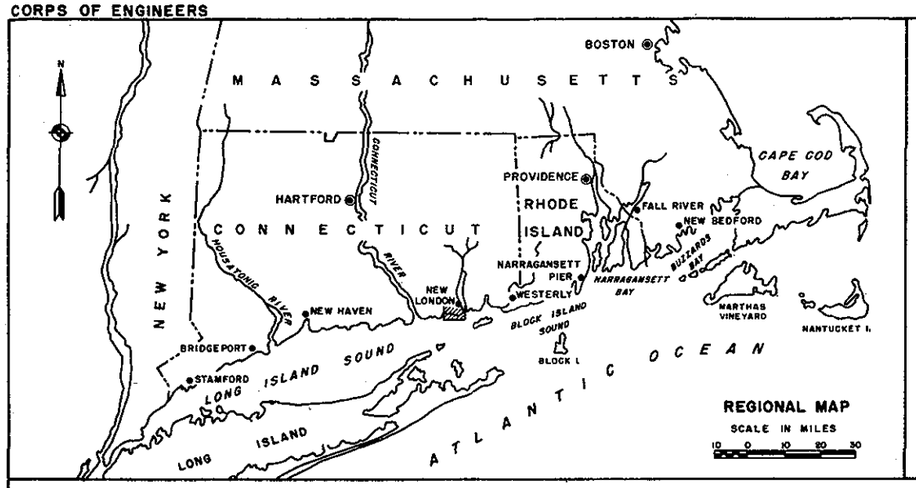
$$V = \Sigma Q_c\ \Delta t = 133{,}740\ \Sigma\left(\frac{Y_1 + Y_3}{2}\right)^{5/3}\ (Y_1 - Y_3)^{1/2}$$

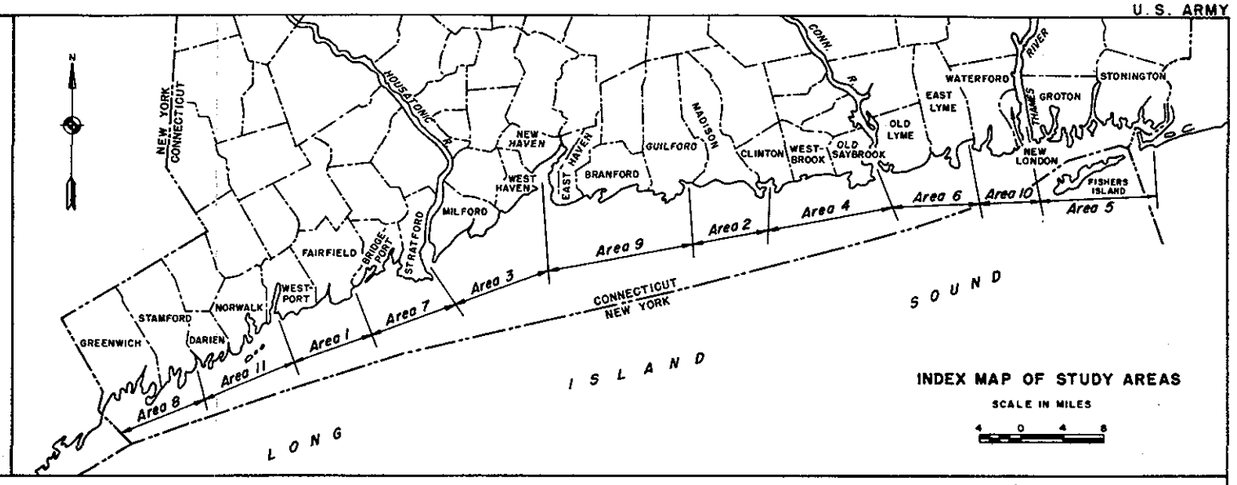
In which Δt = one-half hour

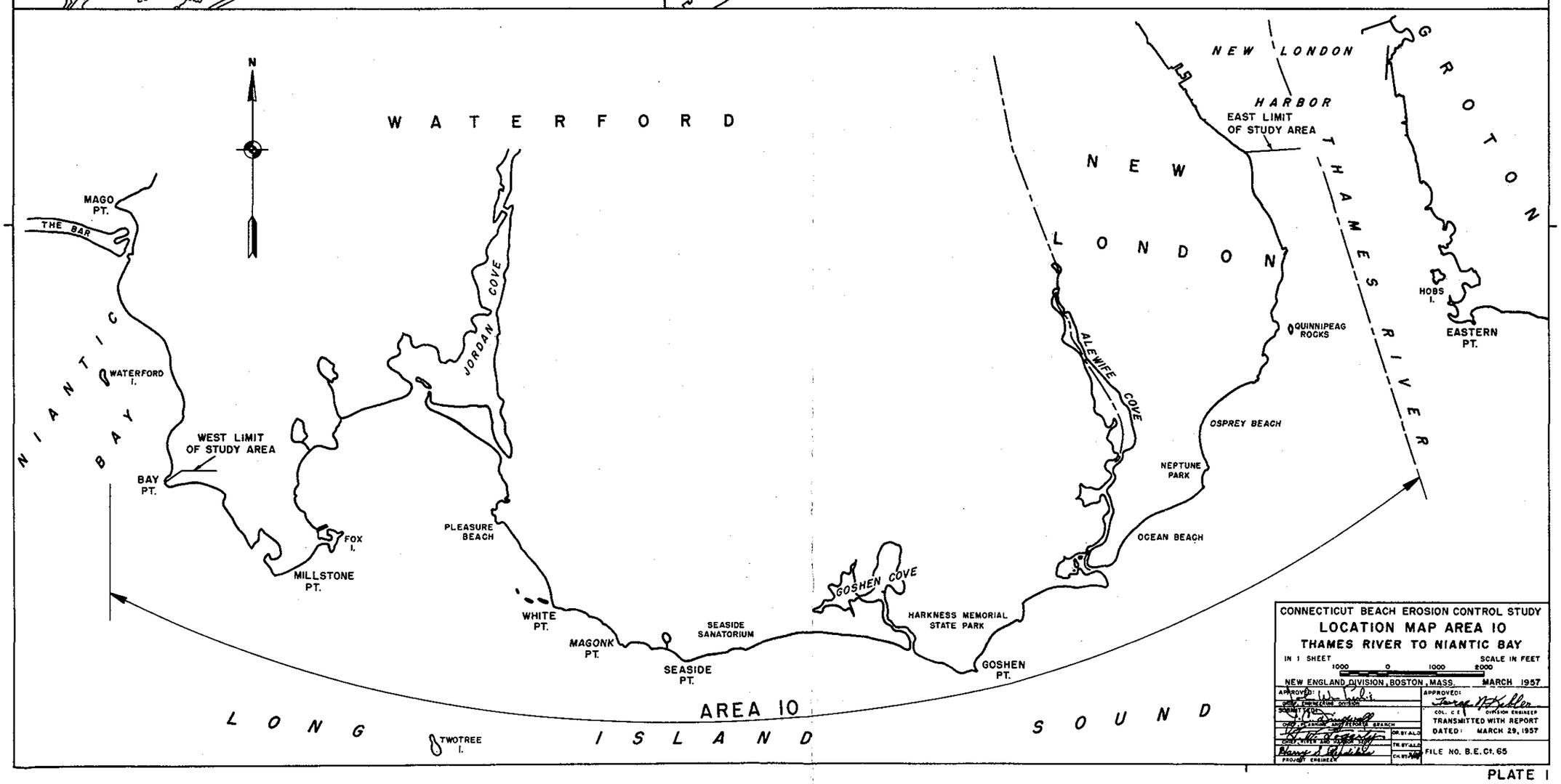
Computation of the flows for the culvert plan with the conditions described above, using various pipe sizes, indicate that an average flow (average of inflow and outflow) of slightly over 900,000 cubic feet would result if the pipe diameter were 4 feet. The computed inflow in this case was slightly larger than the outflow indicating that the mean tidal level in Goshen Cove would be slightly higher than that in Long Island Sound. Computation of the flows for the jetty plan indicated an average flow in excess of 2,000,000 cubic feet which would entail a tidal range in Goshen Cove in excess of the required minimum of one foot. The computed inflow in this plan was greatly in excess of the outflow indicating further that the mean tidal level in Goshen Cove would be higher than in Long Islana Sound. The minimum required volume of ebb or flood flow of 900,000 cubic feet was satisfied by both plans. Refinement of the water elevation equations to account for the differences in mean tidal height between Long Island Sound and Goshen Cove would not materially alter the results obtained from the above described method.

CORPS OF ENGINEERS

U. S. ARMY







CONNECTICUT BEACH EROSION CONTROL STUDY

LOCATION MAP AREA 10

THAMES RIVER TO NIANTIC BAY

IN 1 SHEET SCALE IN FEET 1000 0 1000 2000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

APPROVED: Chief, Engineering Division

SUBMITTED: Chief, Planning and Reports Branch

Chief, River and Harbor Section

Project Engineer

APPROVED: Col. C.E. Division Engineer

TRANSMITTED WITH REPORT DATED: MARCH 29, 1957

DR. BY A.L.D.

TR. BY A.L.D.

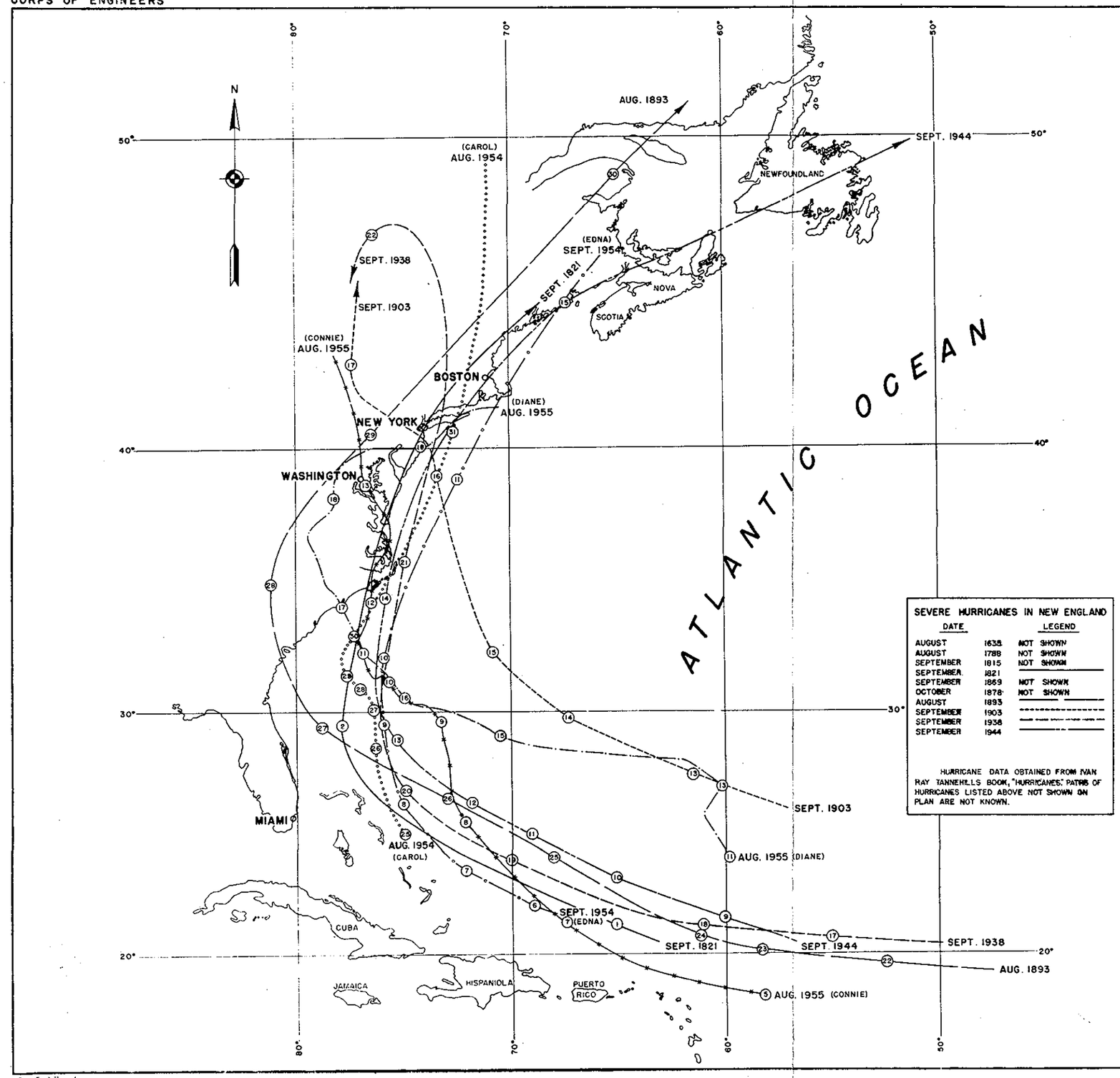
CH. BY

FILE NO. B.E. Ct. 65

PLATE 1

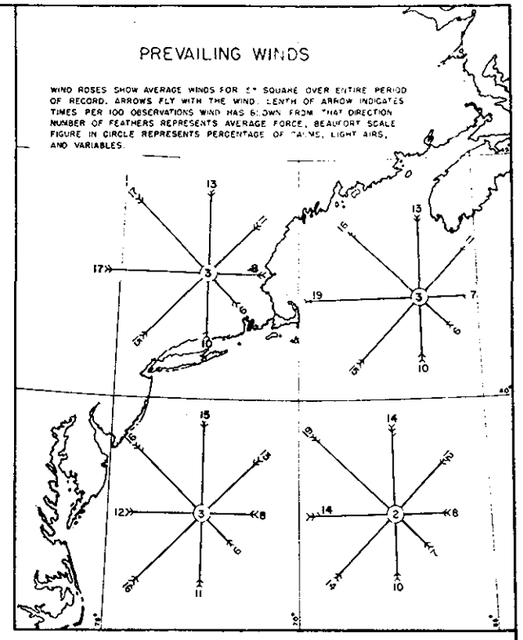
CORPS OF ENGINEERS

U.S. ARMY



PREVAILING WINDS

WIND ROSES SHOW AVERAGE WINDS FOR 5° SQUARE OVER ENTIRE PERIOD OF RECORD. ARROWS FLY WITH THE WIND. LENGTH OF ARROW INDICATES TIMES PER 100 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 VARIABLES.



RECENT HURRICANES

DATE	LEGEND	CODE NAME
AUG. 25-31, 1954	○○○○○○○○○○	CAROL
SEPT. 6-11, 1954	——○——	EDNA
AUG. 5-13, 1955	—×—×—×—	CONNIE
AUG. 11-19, 1955	—·—·—·—	DIANE

SEVERE HURRICANES IN NEW ENGLAND

DATE		LEGEND
AUGUST	1635	NOT SHOWN
AUGUST	1788	NOT SHOWN
SEPTEMBER	1815	NOT SHOWN
SEPTEMBER	1821	———
SEPTEMBER	1869	NOT SHOWN
OCTOBER	1878	NOT SHOWN
AUGUST	1893	— — —
SEPTEMBER	1903	- - - - -
SEPTEMBER	1938	— · — · —
SEPTEMBER	1944	———

HURRICANE DATA OBTAINED FROM IVAN RAY TANNEHILLS BOOK, "HURRICANES." PATHS OF HURRICANES LISTED ABOVE NOT SHOWN ON PLAN ARE NOT KNOWN.

NOTE

Figures in circles shown thus (13) represent location of the center of hurricane on the day of month of its occurrance.

REVISION	DATE	DESCRIPTION	BY
1	10/6/55	Hurricane paths during 1954 and 1955 added.	C.T.M.

CONNECTICUT BEACH EROSION CONTROL STUDY

HURRICANES AND PREVAILING WINDS

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED
Henry A. Littlefield
CHIEF, R & H OPERATIONS DIVISION

APPROVED
LT. COL., C.E., ASST. DIVISION ENGINEER

SUBMITTED
R & H PROJECTS AND REPORTS BRANCH

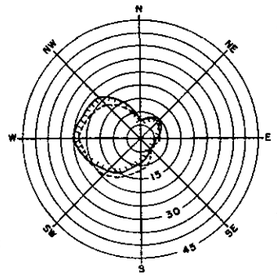
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949

DR. BY H.S.F.
TR. BY R.B.
CH. BY V.J.C.

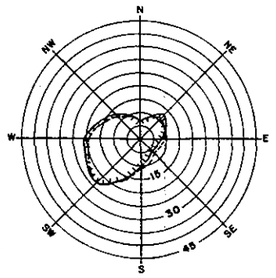
FILE NO. B.E.Ct.2

PLATE 2

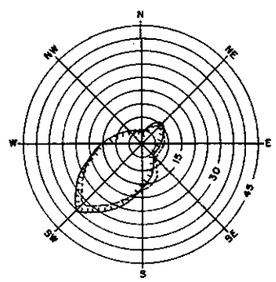
FEBRUARY



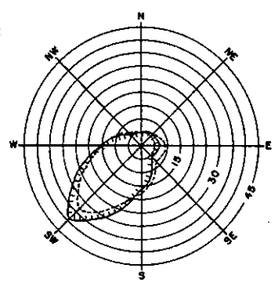
MARCH



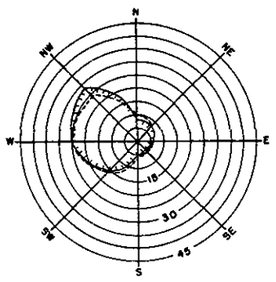
APRIL



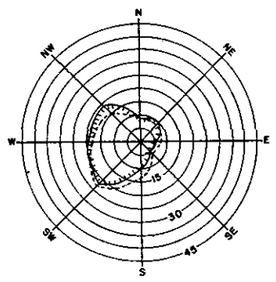
MAY



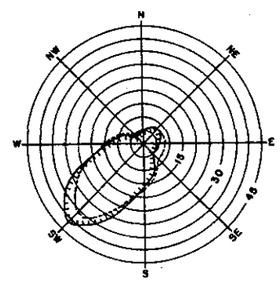
JUNE



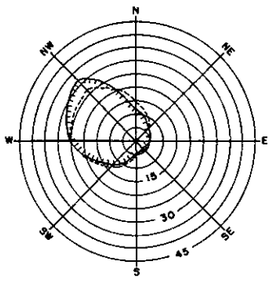
JANUARY



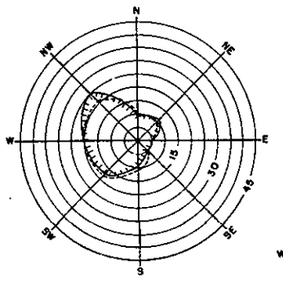
ANNUAL



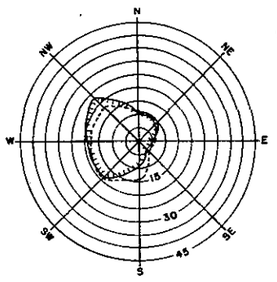
JULY



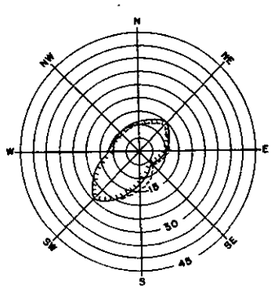
DECEMBER



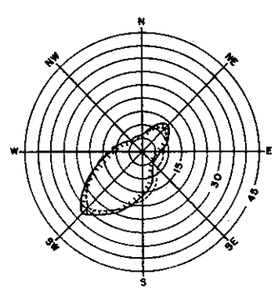
NOVEMBER



OCTOBER



SEPTEMBER



AUGUST

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

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 1921 TO 1939.

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

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. WEATHER BUREAU AT BLOCK ISLAND, RHODE ISLAND.

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

BLOCK ISLAND, RHODE ISLAND

1921 - 1939

IN 1 SHEET

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED
CHIEF, R & H OPERATIONS DIVISION

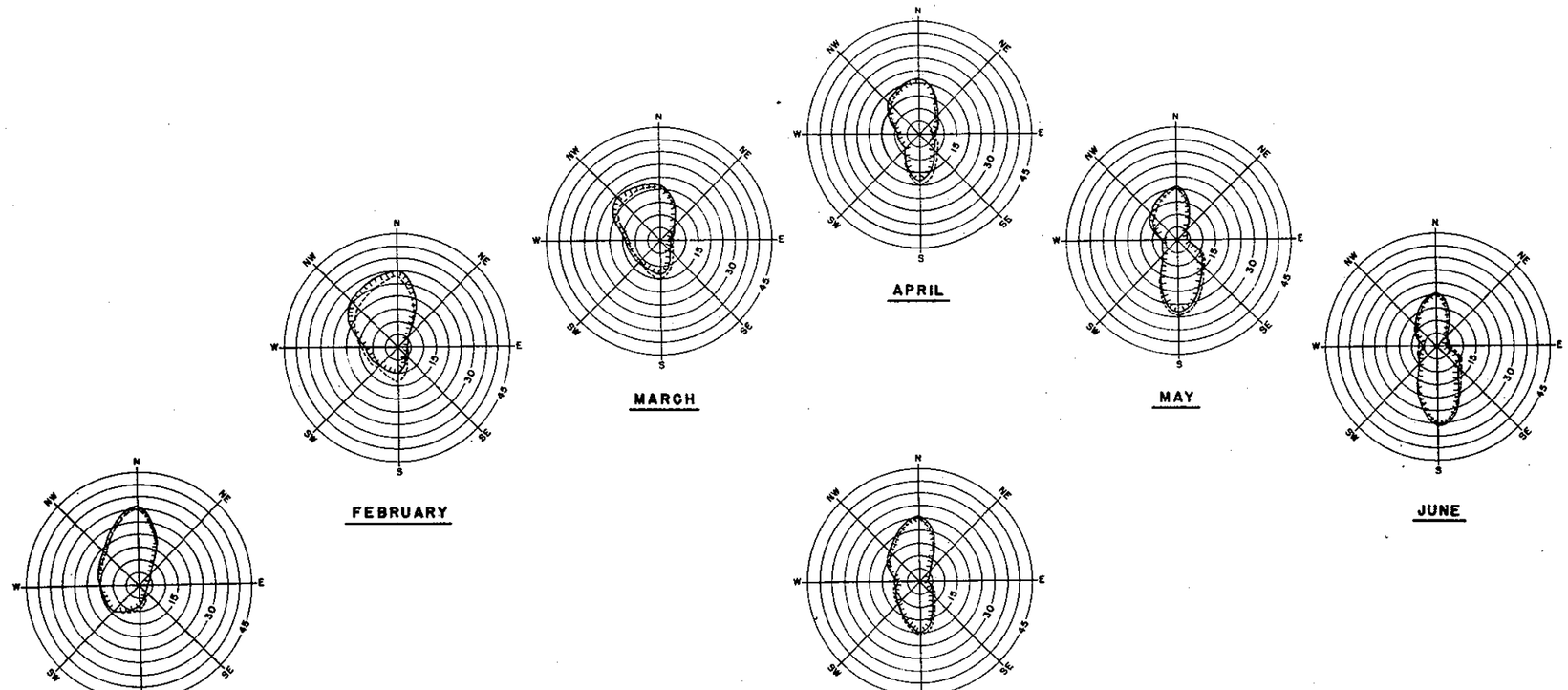
APPROVED
LT. COL. CE, ASST. DIVISION ENGINEER

SUBMITTED
R & H PROJECTS AND REPORTS BRANCH

DR. BY H.S.P.
TR. BY R.S.
CH. BY

FILE NO. B.E.Ct.3

PLATE 3



JANUARY

FEBRUARY

MARCH

APRIL

MAY

JUNE

JULY

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER

DECEMBER

ANNUAL

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 1932 TO 1942

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

BASIC DATA COMPILED FROM OBSERVATIONS OF THE U.S. WEATHER BUREAU AT NEW HAVEN, CONNECTICUT.

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

NEW HAVEN, CONNECTICUT

1932 - 1942

IN 1 SHEET

NEW ENGLAND DIVISION BOSTON, MASS. JAN. 20, 1949

APPROVAL RECOMMENDED
CHIEF, R & H OPERATIONS DIVISION

APPROVED
LT. COL., C.E., ASST. DIVISION ENGINEER

SUBMITTED
R & H PROJECTS AND REPORTS BRANCH

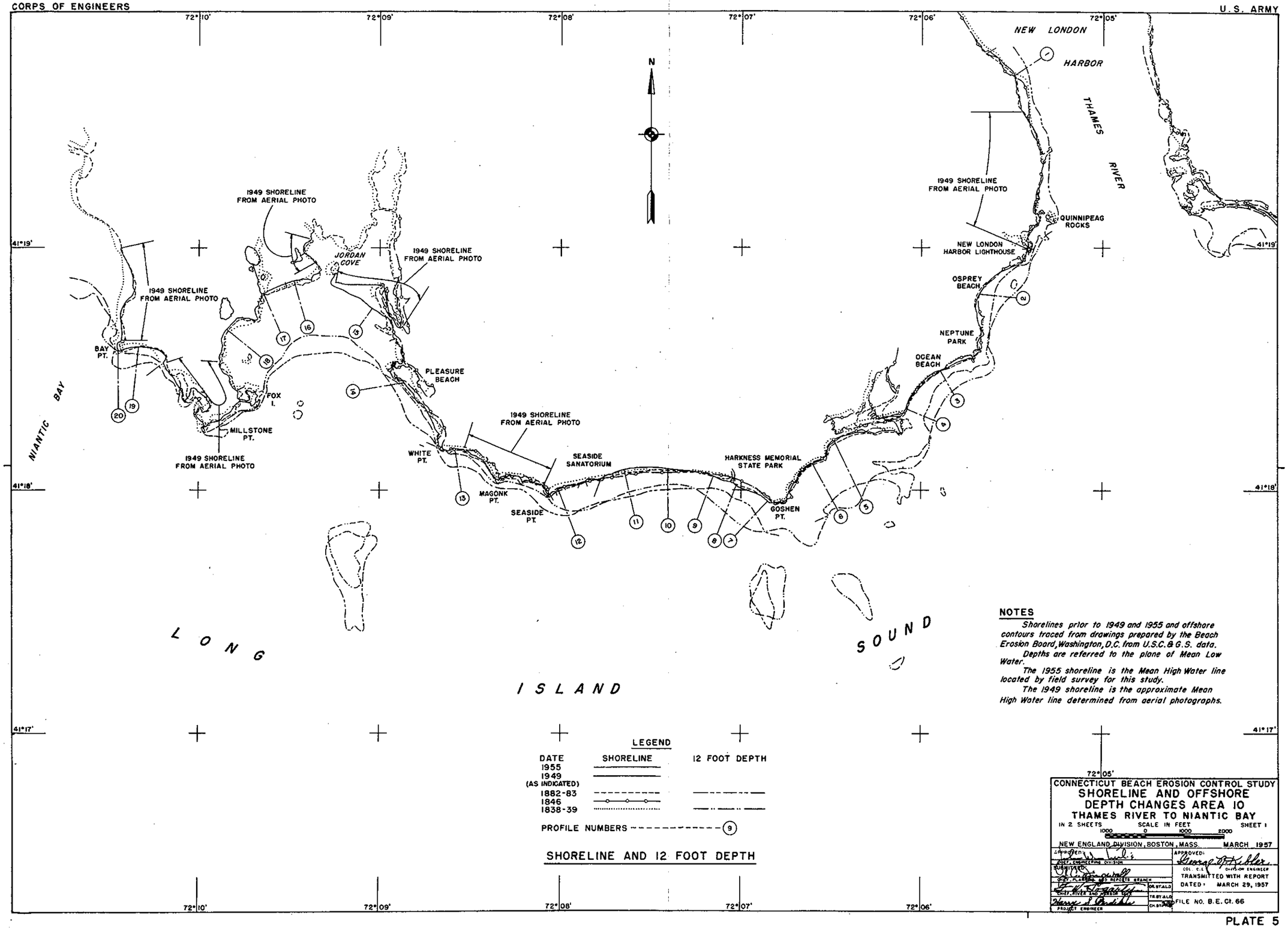
DR. BY H.S.P.
TR. BY W.S.
CH. BY

FILE NO. B.E.C1.4

PLATE 4

CORPS OF ENGINEERS

U.S. ARMY



NOTES

Shorelines prior to 1949 and 1955 and offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

Depths are referred to the plane of Mean Low Water.

The 1955 shoreline is the Mean High Water line located by field survey for this study.

The 1949 shoreline is the approximate Mean High Water line determined from aerial photographs.

LEGEND

DATE	SHORELINE	12 FOOT DEPTH
1955	———	
1949 (AS INDICATED)	———	
1882-83	- - - - - -	— — — —
1846	—○—○—○—	— — ·· — —
1838-39	·····	— ·· — ·· —

PROFILE NUMBERS ----------(9)

SHORELINE AND 12 FOOT DEPTH

CONNECTICUT BEACH EROSION CONTROL STUDY

SHORELINE AND OFFSHORE DEPTH CHANGES AREA 10 THAMES RIVER TO NIANTIC BAY

IN 2 SHEETS SCALE IN FEET 1000 0 1000 2000 SHEET 1

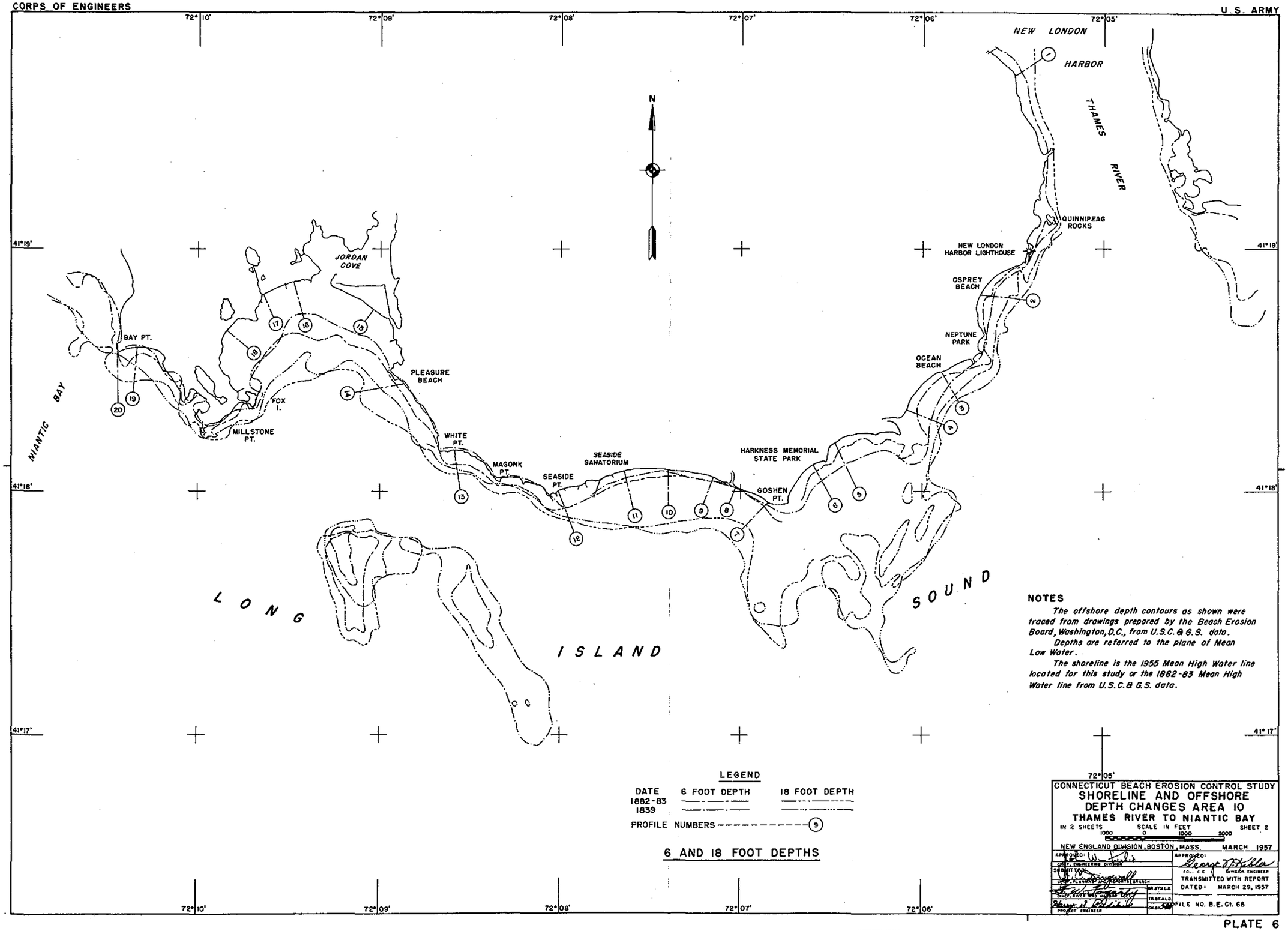
NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

SURVEYED:	APPROVED: George D. Keller
DRAWN:	COL. CE, DIVISION ENGINEER
TRACED:	TRANSMITTED WITH REPORT
CHECKED:	DATED: MARCH 29, 1957
PROJECT ENGINEER	FILE NO. B.E. Ct. 66

PLATE 5

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

DATE	6 FOOT DEPTH	18 FOOT DEPTH
1882-83		
1939		

PROFILE NUMBERS ---------- (9)

6 AND 18 FOOT DEPTHS

NOTES

The offshore depth contours as shown were traced from drawings prepared by the Beach Erosion Board, Washington, D.C., from U.S.C. & G.S. data.

Depths are referred to the plane of Mean Low Water.

The shoreline is the 1955 Meon High Water line located for this study or the 1882-83 Mean High Water line from U.S.C. & G.S. data.

CONNECTICUT BEACH EROSION CONTROL STUDY

SHORELINE AND OFFSHORE DEPTH CHANGES AREA 10

THAMES RIVER TO NIANTIC BAY

IN 2 SHEETS SCALE IN FEET 1000 0 1000 2000 SHEET 2

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

APPROVED: [signature] Col., C.E. Division Engineer

SUBMITTED: [signature] Chief, Planning and Reports Branch; [signature] Chief, River and Harbor Sec.; [signature] Project Engineer

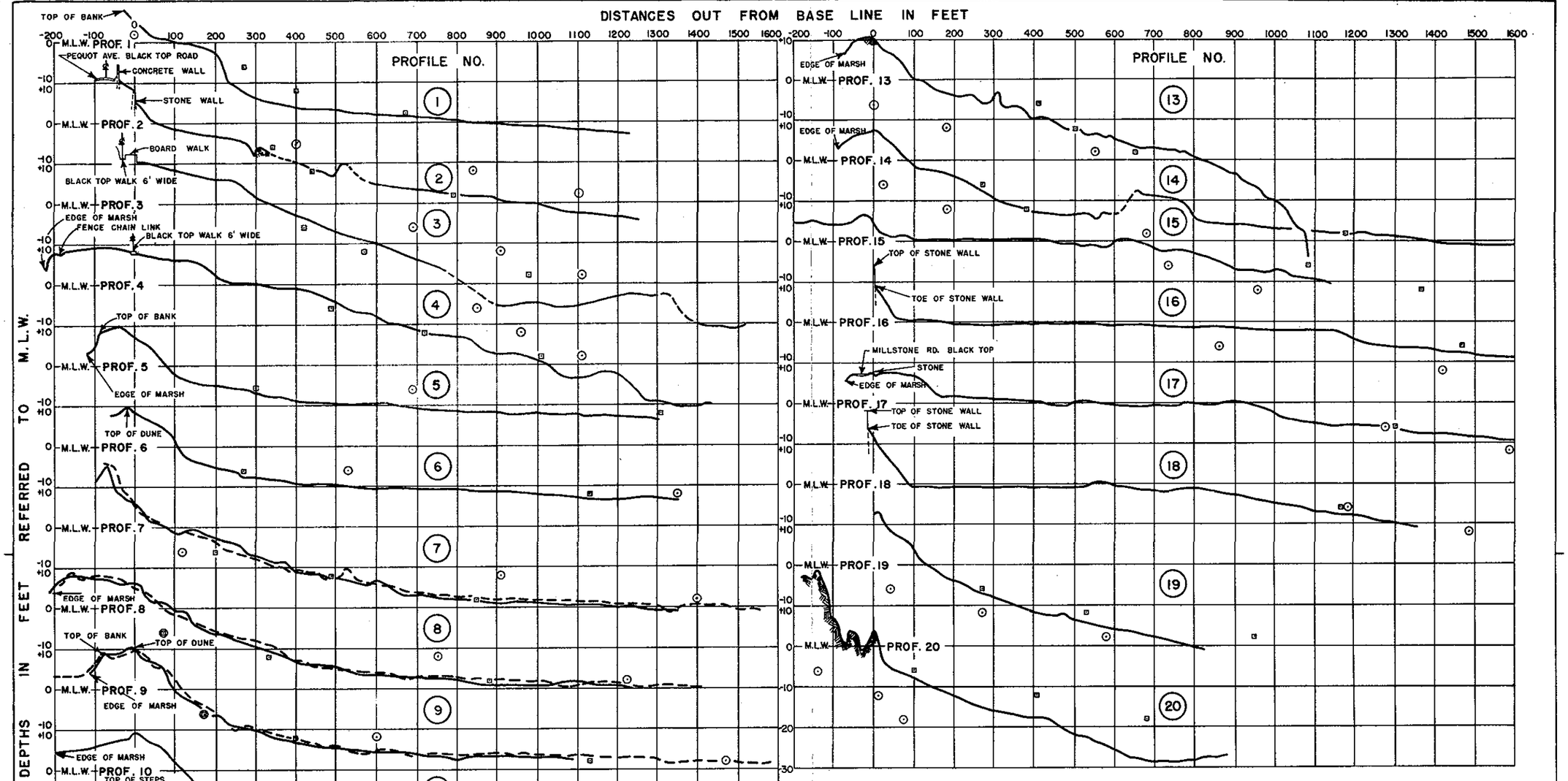
DRAWN: TRACED: CHECKED:

TRANSMITTED WITH REPORT DATED: MARCH 29, 1957

FILE NO. B.E. Ct. 66

PLATE 6

CORPS OF ENGINEERS U.S. ARMY



LEGEND

LOCATION OF 6, 12, AND 18 FOOT DEPTHS PRIOR TO 1954 SHOWN THUS:

DATE	SYMBOL	SURVEY BY
1839	⊙	U.S.C. & G.S.
1882-83	⊡	" " "

SURVEYS OF 1954-55 BY CORPS ENGINEERS, U.S. ARMY SHOWN THUS:

DATE	SYMBOL
JAN. 1954	– – – – – – – –
MAY-JUNE 1955	————

NOTE:
FOR LOCATION OF PROFILES, SEE PLATES 10 & 11.
LANDWARD PORTION OF PROFILES MAY 1955
SEAWARD " " " JUNE 1955

CONNECTICUT BEACH EROSION CONTROL STUDY

COMPARATIVE PROFILES AREA 10

THAMES RIVER TO NIANTIC BAY

IN 1 SHEE — SCALE IN FEET

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

APPROVED: Fred C. Scobey, CHIEF, ENGINEERING DIVISION

SUBMITTED: [signature], CHIEF, PLANNING AND REPORTS BRANCH; [signature], CHIEF, RIVER AND HARBOR SECT.; [signature], PROJECT ENGINEER

APPROVED: George W. Gibbon, COL., C.E., DIVISION ENGINEER

TRANSMITTED WITH REPORT DATED: MARCH 29, 1957

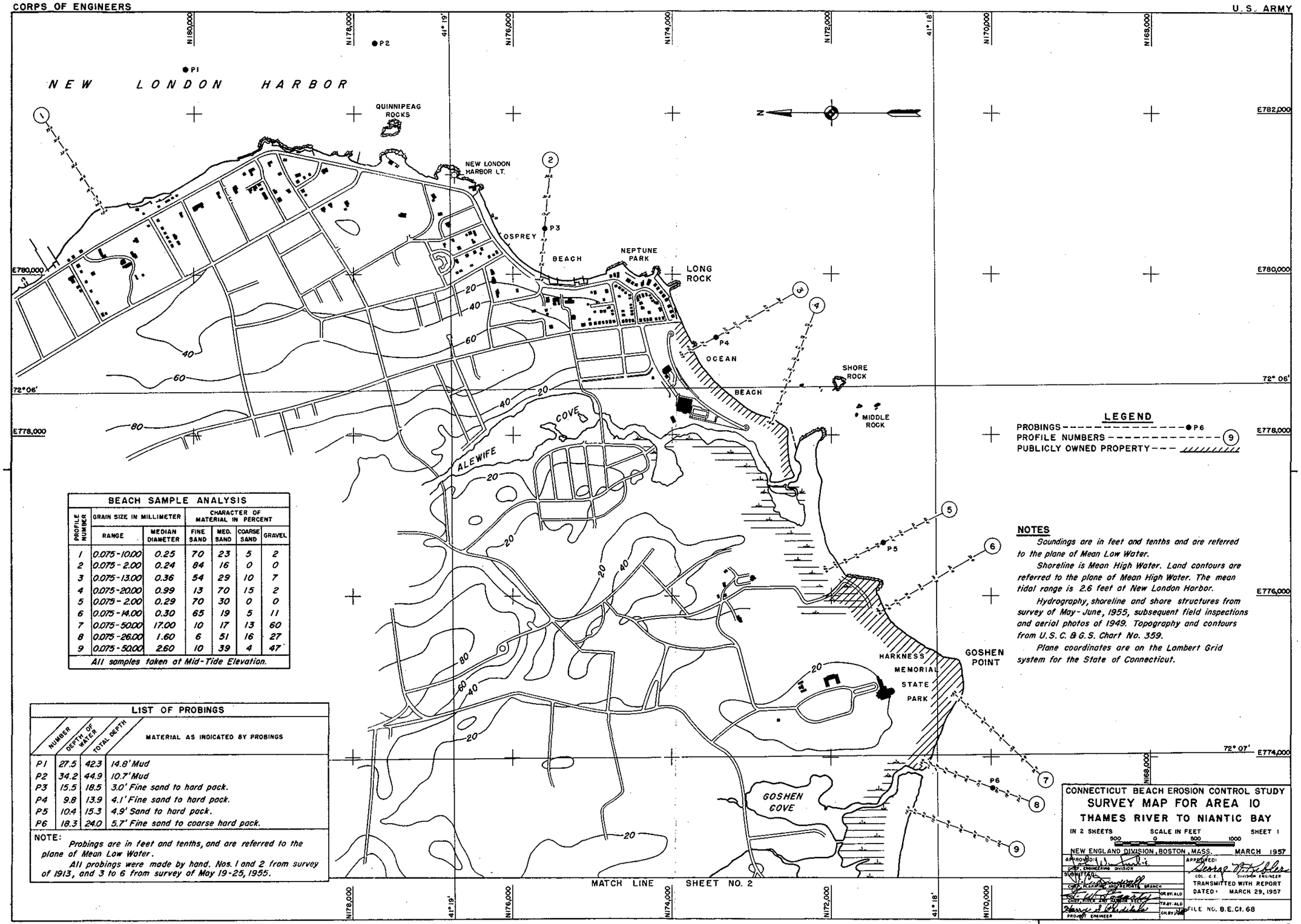
DR. BY W.J.H. TR. BY P.J.M. CH. BY

FILE NO. B.E.C.I. 67

PLATE 7

CORPS OF ENGINEERS

U.S. ARMY



LEGEND

PROBINGS ---------- ● P6

PROFILE NUMBERS ---------- (9)

PUBLICLY OWNED PROPERTY ---

BEACH SAMPLE ANALYSIS

PROFILE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
1	0.075-10.00	0.25	70	23	5	2
2	0.075-2.00	0.24	84	16	0	0
3	0.075-13.00	0.36	54	29	10	7
4	0.075-20.00	0.99	13	70	15	2
5	0.075-2.00	0.29	70	30	0	0
6	0.075-14.00	0.30	65	19	5	11
7	0.075-50.00	17.00	10	17	13	60
8	0.075-26.00	1.60	6	51	16	27
9	0.075-50.00	2.60	10	39	4	47

All samples taken at Mid-Tide Elevation.

LIST OF PROBINGS

NUMBER	DEPTH OF WATER	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P1	27.5	42.3	14.8' Mud
P2	34.2	44.9	10.7' Mud
P3	15.5	18.5	3.0' Fine sand to hard pack.
P4	9.8	13.9	4.1' Fine sand to hard pack.
P5	10.4	15.3	4.9' Sand to hard pack.
P6	18.3	24.0	5.7' Fine sand to coarse hard pack.

NOTE: Probings are in feet and tenths, and are referred to the plane of Mean Low Water.

All probings were made by hand. Nos. 1 and 2 from survey of 1913, and 3 to 6 from survey of May 19-25, 1955.

NOTES

Soundings are in feet and tenths and are referred to the plane of Mean Low Water.

Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 2.6 feet at New London Harbor.

Hydrography, shoreline and shore structures from survey of May-June, 1955, subsequent field inspections and aerial photos of 1949. Topography and contours from U.S.C. & G.S. Chart No. 359.

Plane coordinates are on the Lambert Grid system for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 10

THAMES RIVER TO NIANTIC BAY

IN 2 SHEETS — SCALE IN FEET (500 0 500 1000) — SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

APPROVED: CHIEF, ENGINEERING DIVISION

SUBMITTED: CHIEF, PLANNING AND REPORTS BRANCH; CHIEF, RIVER AND HARBOR SECTION; PROJECT ENGINEER

APPROVED: George W. Pickler, COL. C.E., DIVISION ENGINEER

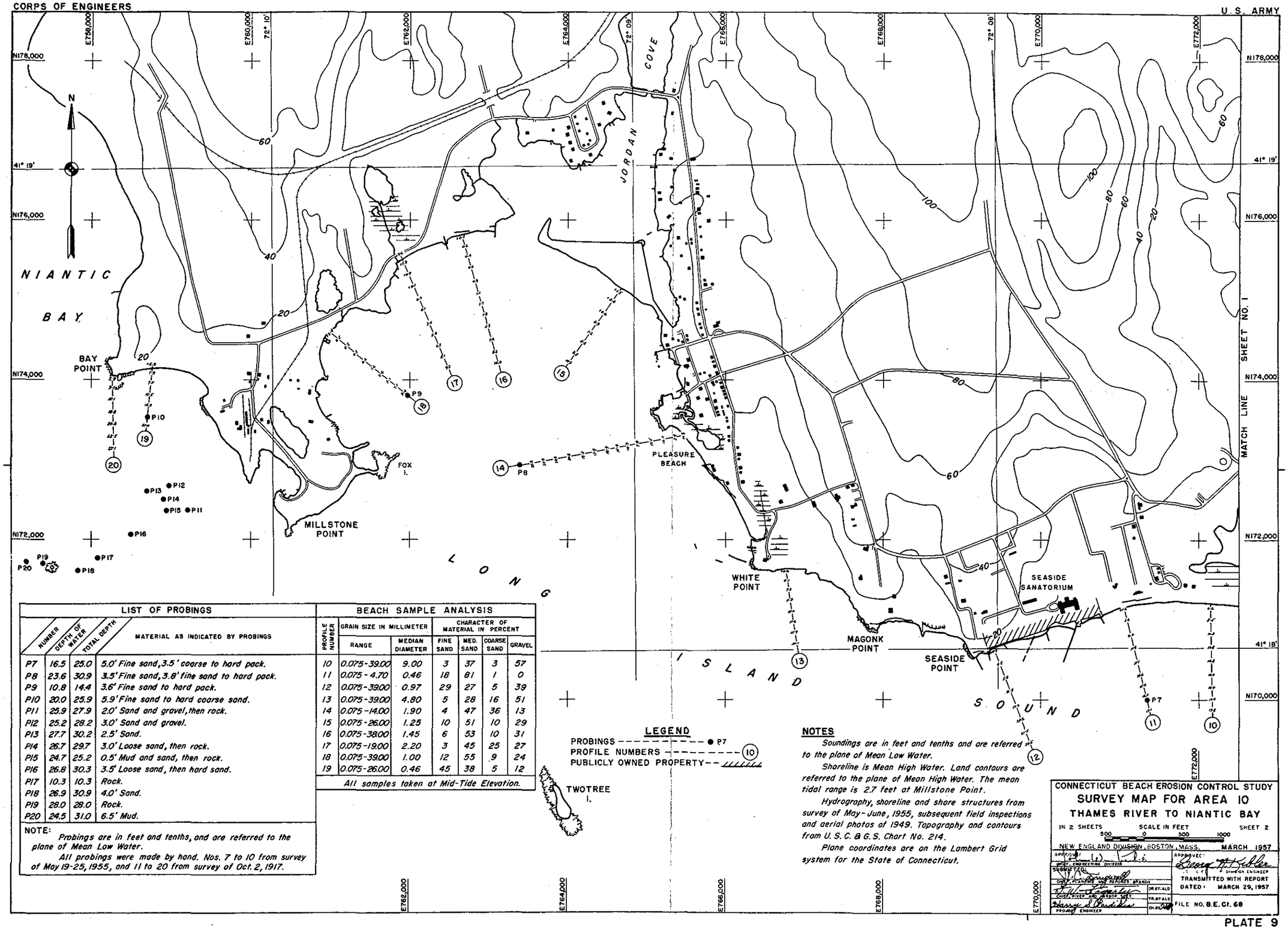
TRANSMITTED WITH REPORT DATED: MARCH 29, 1957

DR. BY: ALD; TR. BY: ALD; CH. BY: JTF

FILE NO. B.E.C. 68

PLATE 8

CORPS OF ENGINEERS — U.S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OF WATER	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
P7	16.5	25.0	5.0' Fine sand, 3.5' coarse to hard pack.
P8	23.6	30.9	3.5' Fine sand, 3.8' fine sand to hard pack.
P9	10.8	14.4	3.6' Fine sand to hard pack.
P10	20.0	25.9	5.9' Fine sand to hard coarse sand.
P11	25.9	27.9	2.0' Sand and gravel, then rock.
P12	25.2	28.2	3.0' Sand and gravel.
P13	27.7	30.2	2.5' Sand.
P14	26.7	29.7	3.0' Loose sand, then rock.
P15	24.7	25.2	0.5' Mud and sand, then rock.
P16	26.8	30.3	3.5' Loose sand, then hard sand.
P17	10.3	10.3	Rock.
P18	26.9	30.9	4.0' Sand.
P19	28.0	28.0	Rock.
P20	24.5	31.0	6.5' Mud.

NOTE:
Probings are in feet and tenths, and are referred to the plane of Mean Low Water.
All probings were made by hand. Nos. 7 to 10 from survey of May 19-25, 1955, and 11 to 20 from survey of Oct. 2, 1917.

BEACH SAMPLE ANALYSIS

PROFILE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
10	0.075-39.00	9.00	3	37	3	57
11	0.075-4.70	0.46	18	81	1	0
12	0.075-39.00	0.97	29	27	5	39
13	0.075-39.00	4.80	5	28	16	51
14	0.075-14.00	1.90	4	47	36	13
15	0.075-26.00	1.25	10	51	10	29
16	0.075-38.00	1.45	6	53	10	31
17	0.075-19.00	2.20	3	45	25	27
18	0.075-39.00	1.00	12	55	9	24
19	0.075-26.00	0.46	45	38	5	12

All samples taken at Mid-Tide Elevation.

LEGEND
PROBINGS ---------- ● P7
PROFILE NUMBERS ---------- (10)
PUBLICLY OWNED PROPERTY ----

NOTES
Soundings are in feet and tenths and are referred to the plane of Mean Low Water.
Shoreline is Mean High Water. Land contours are referred to the plane of Mean High Water. The mean tidal range is 2.7 feet at Millstone Point.
Hydrography, shoreline and shore structures from survey of May-June, 1955, subsequent field inspections and aerial photos of 1949. Topography and contours from U.S.C. & G.S. Chart No. 214.
Plane coordinates are on the Lambert Grid system for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY
SURVEY MAP FOR AREA 10
THAMES RIVER TO NIANTIC BAY

IN 2 SHEETS — SCALE IN FEET 500 0 500 1000 — SHEET 2

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

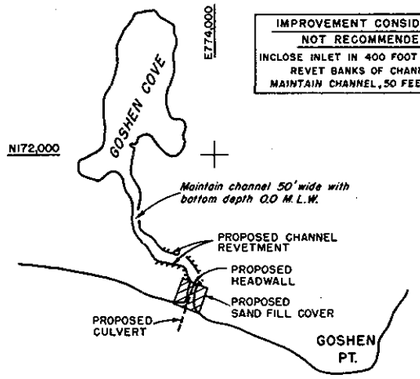
APPROVED: Chief, Engineering Division
SUBMITTED: Chief, Planning and Reports Branch
Chief, Design and Estimates Sect.
Project Engineer
APPROVED: Division Engineer
TRANSMITTED WITH REPORT DATED: MARCH 29, 1957
DR. BY: ALO
TR. BY: ALO
CK. BY:
FILE NO. B.E.Ct. 68

PLATE 9

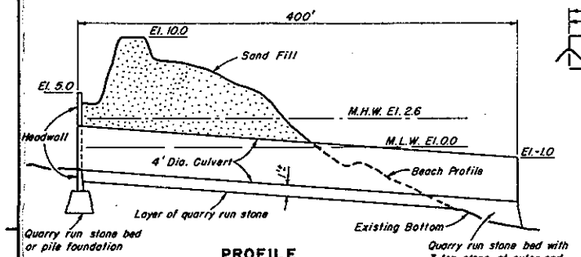
CORPS OF ENGINEERS

U.S. ARMY

IMPROVEMENT CONSIDERED
NOT RECOMMENDED
INCLOSE INLET IN 400 FOOT CULVERT
REVET BANKS OF CHANNEL
MAINTAIN CHANNEL, 50 FEET WIDE

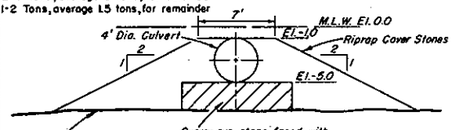


PLAN
SCALE IN FEET
500 0 500



PROFILE
SCALE IN FEET
HOR. 50 0 50 100
VER. 5 0 5 10

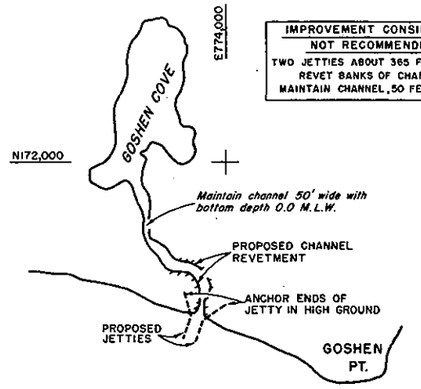
COVER STONE SIZES
2-4 Tons, average 3 tons, for outer 50'
1-2 Tons, average 1.5 tons, for remainder



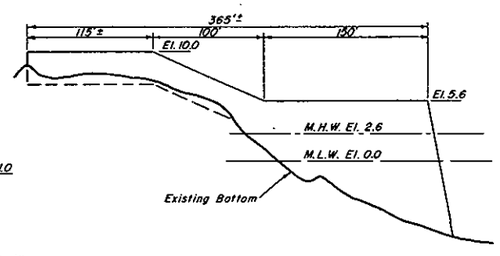
CROSS SECTION - OUTER END CULVERT
SCALE IN FEET
5 0 5 10

PROPOSED INCLOSURE
GOSHEN COVE INLET

IMPROVEMENT CONSIDERED
NOT RECOMMENDED
TWO JETTIES ABOUT 365 FEET LONG
REVET BANKS OF CHANNEL
MAINTAIN CHANNEL, 50 FEET WIDE

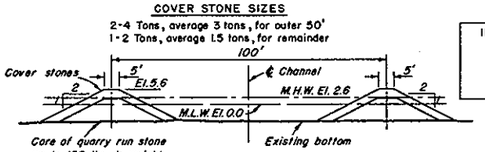


PLAN
SCALE IN FEET
500 0 500



PROFILE
SCALE IN FEET
HOR. 50 0 50 100
VER. 5 0 5 10

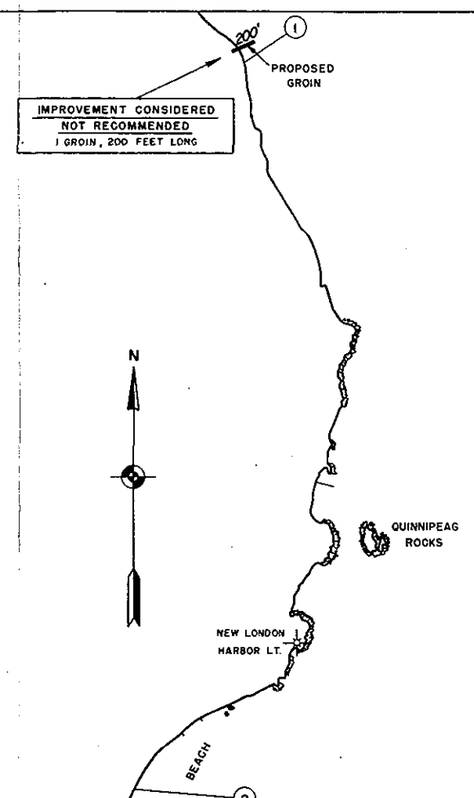
COVER STONE SIZES
2-4 Tons, average 3 tons, for outer 50'
1-2 Tons, average 1.5 tons, for remainder



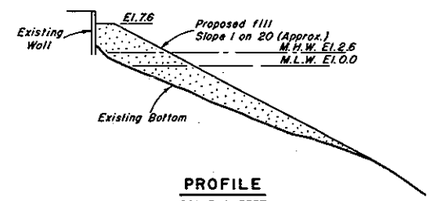
CROSS SECTION - OUTER END JETTIES
SCALE IN FEET
20 0 20 40

PROPOSED JETTIES
GOSHEN COVE INLET

IMPROVEMENT CONSIDERED
NOT RECOMMENDED
1 GROIN, 200 FEET LONG

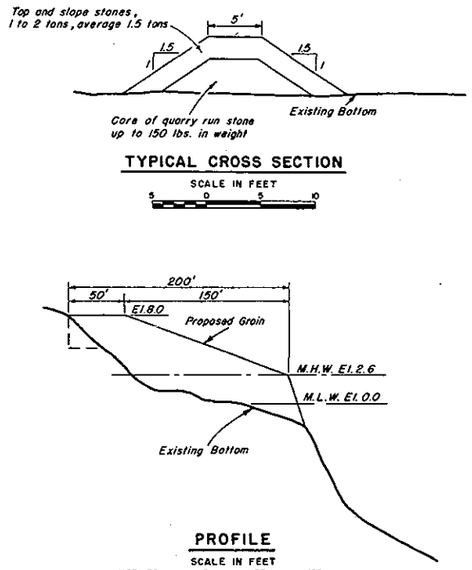


IMPROVEMENT CONSIDERED
FOR FEDERAL PROJECT
NOT RECOMMENDED
WIDEN BEACH BY DIRECT PLACEMENT OF SAND FILL



PROFILE
SCALE IN FEET
HOR. 100 0 100 200
VER. 10 0 10 20

PROPOSED SAND FILL
NEPTUNE PARK AND OCEAN BEACH



TYPICAL CROSS SECTION
SCALE IN FEET
5 0 5 10

PROFILE
SCALE IN FEET
HOR. 50 0 50 100
VER. 5 0 5 10

PROPOSED GROIN
NEW LONDON HARBOR SHORE
VICINITY PROFILE NO. 1

NOTES

Shoreline and shore structures from 1955 survey and aerial photographs of 1949.

Coordinates are on the Lambert Grid System for the State of Connecticut.

Publicly owned portions of shore shown thus: ▨

Profiles shown thus: ①

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 10

THAMES RIVER TO NIANTIC BAY

IN 1 SHEET — SCALE IN FEET 500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. MARCH 1957

APPROVED: Chief, Engineering Division

SUBMITTED: Chief, Planning and Reports Branch; Chief, River and Harbor Section; Project Engineer

APPROVED: George H. Keller, Col. C.E., Division Engineer

TRANSMITTED WITH REPORT DATED: MARCH 29, 1957

DR BY: A.L.D.; TR BY: A.L.D.; CH BY: J.A.P.

FILE NO. B.E.C. 71

PLATE 10

FIG. 1. NEW LONDON HARBOR, NEW LONDON. Nov. 15, 1955. Revetment and groins protect beach south of Profile 1.

FIG. 2. NEW LONDON HARBOR, NEW LONDON. Nov. 15, 1955. Sea wall and groins along coarse eroded shore.

FIG. 3. NEW LONDON HARBOR, NEW LONDON. Nov. 15, 1955. Sandy pocket beach between rock outcrops north of harbor lighthouse.

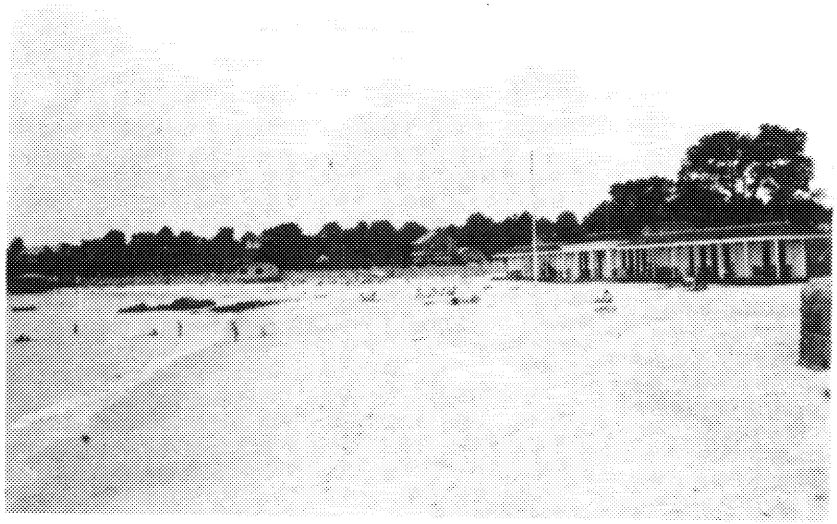


FIG. 1. OSPREY BEACH, NEW LONDON. July 19, 1948.
Sandy pocket beach with few outcrops of bedrock.

FIG. 2. OSPREY BEACH, NEW LONDON. Dec. 2, 1950. Bathhouse demolished by southeast storm. Compare with Fig. 1. above.

FIG. 3. OSPREY BEACH, NEW LONDON. Sept. 9, 1954.
Stony shore and damaged bathhouse after Hurricane Carol.

FIG.1. NEPTUNE PARK AND OCEAN BEACH, NEW LONDON. July 21, 1948.
Fairly wide sand beach fronts sea walls.

FIG.2. NEPTUNE PARK AND OCEAN BEACH, NEW LONDON. Nov. 15, 1955.
Compare with Fig. 1. above. Beach lower and nerrower.

FIG. 3. OCEAN BEACH, NEW LONDON. Nov. 15, 1955
Wide sandy public bathing beach.

PLATE 15

FIG. 1. WEST OF ALEWIFE COVE INLET, WATERFORD. Nov. 16, 1955. Tombolo ties Goshen Point to rocky island at cove inlet.

FIG. 2. HARKNESS MEMORIAL STATE PARK, WATERFORD. July 19, 1948. Sandy pocket bathing beach at east side of Goshen Point.

FIG.3. GOSHEN COVE INLET, WATERFORD. Aug. 13, 1947. Channel excavated one week before - has bar across its mouth.

FIG. 1. EAST OF SEASIDE SANATORIUM, WATERFORD. Nov. 17, 1947.
Sandy beach extends eastward fronting Goshen Cove.

FIG. 2. EAST OF SEASIDE SANATORIUM, WATERFORD. Nov. 22, 1955.
Compare with above. Note wave cut scarp.

FIG. 3. SEASIDE SANATORIUM, WATERFORD. Nov. 22, 1955.
Sandy pocket beach wall and groins front lawns.

FIG. 1. SOUTH OF MAGONK POINT, WATERFORD. Nov. 22, 1955. Sandy pocket beach and bedrock.

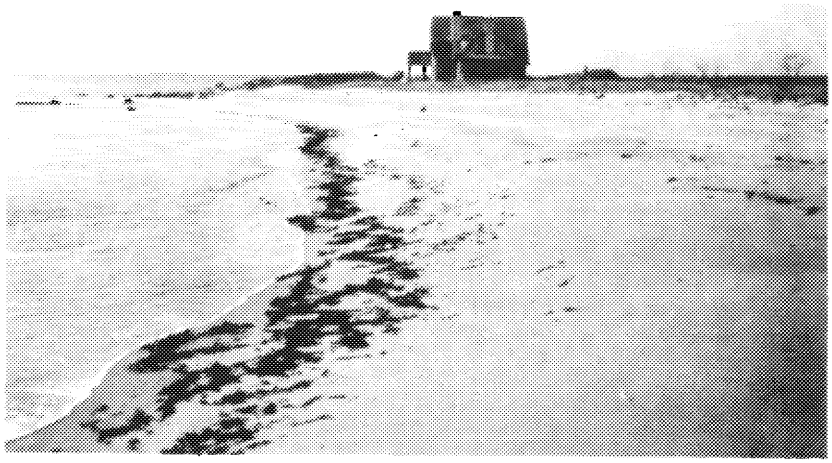


FIG. 2. WHITE POINT, WATERFORD. Nov. 22, 1955. Sandy pocket beach at south side of point.

FIG. 3. NORTH OF WHITE POINT, WATERFORD. Nov. 22, 1955. Sand beach. Walls and bulkhead front houses at waters edge.

FIG. 1. PLEASURE BEACH, WATERFORD. Nov. 22, 1955
Sandy tombolo fronts cove.

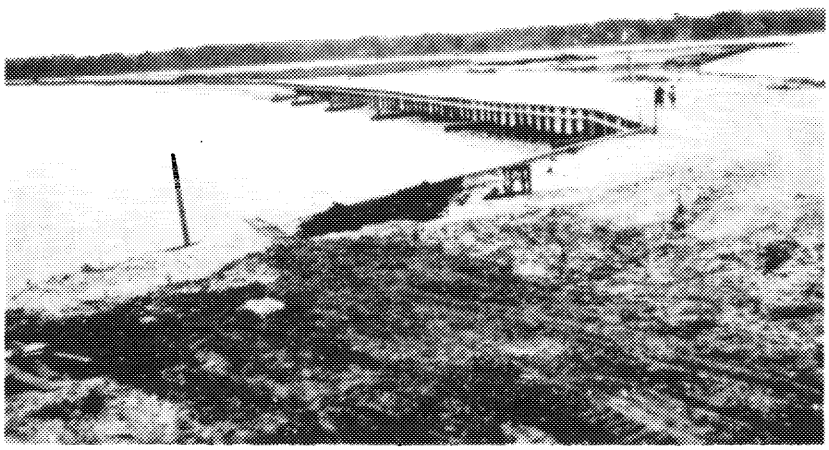


FIG. 2. JORDAN COVE, WATERFORD. July 19, 1948. Bulkhead and short groins along filled land east of cove entrance.

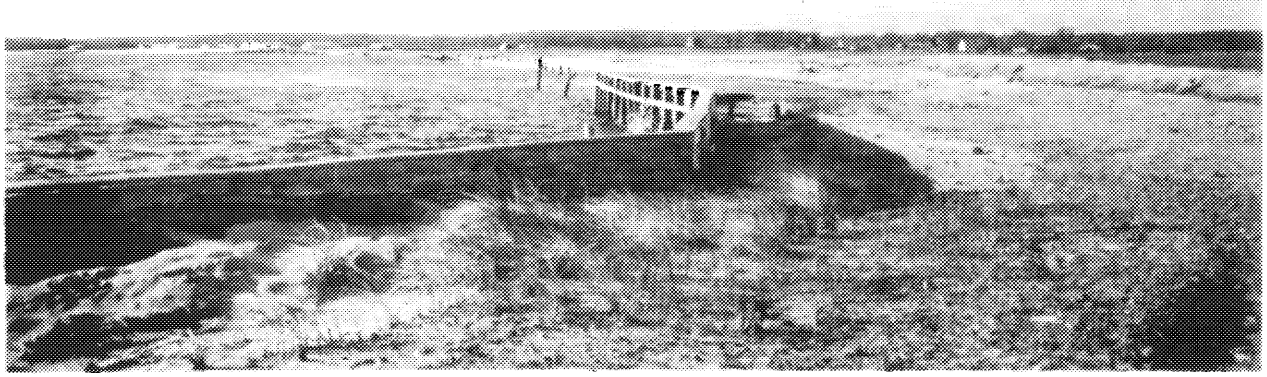


FIG. 3. JORDAN COVE, WATERFORD. Nov. 22, 1955. Remains of bulkhead. Compare with Fig. 2, above.

FIG. 1. JORDAN COVE, WATERFORD. Nov. 22, 1955.
New development along sandy beach west of cove entrance.

FIG. 2. MILLSTONE POINT, WATERFORD. July 20, 1948. Quarry waste covers shore southwest of Fox Island.

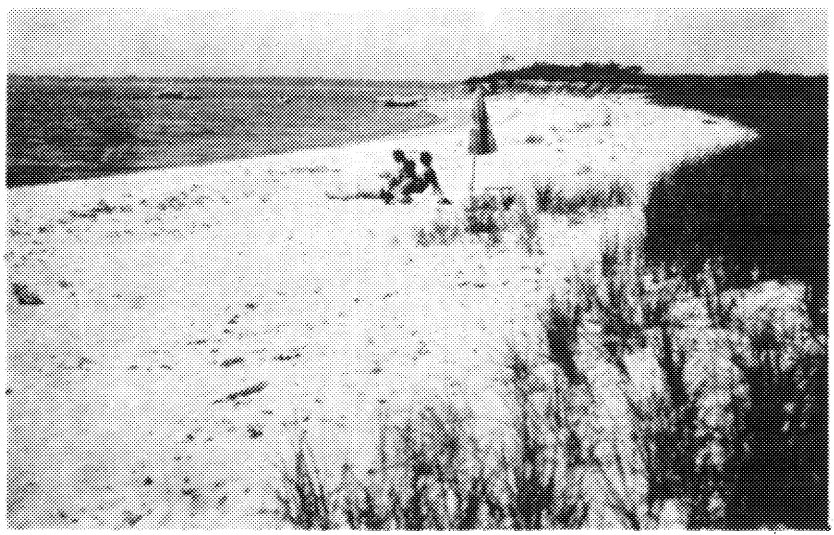


FIG. 3. EAST OF BAY POINT, WATERFORD. July 20, 1948.
Sandy pocket beach extends east from rocky Bay Point.