BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 2

HAMMONASSET RIVER TO EAST RIVER

7 FEBRUARY 1949

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

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CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON 10, MASS.

NEDVN 7 February 1949

SUBJECT: Beach Erosion Control Report on Cooperative Study of Connecticut, Area 2, Hammonasset River to East River.

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

SYLLABUS

This report, the second of eleven to cover the entire coast of Connecticut, covers study of the shore line from Hammonasset River, Clinton, to East River, Guilford, and includes the entire Madison shore. The purpose of the study was to determine the most suitable methods of stabilizing and improving the shore line in this area.

The Division Engineer finds that the entire area constitutes a resort development, that major extents of the entire shore constitute desirable locations for beach improvements, and that improvement of the shore requires artificial replenishment of the sand beaches. The Division Engineer also finds that the hydraulic pumping of sand on the shore from offshore depths is entirely practicable.

The Division Engineer recommends adoption of projects authorizing Federal participation to the extent of one-third of the first cost of the proposed improvement of the following publicly-owned shores:

a. Hammonasset Beach. - Widening of 50 feet at the east end increasing to 100 feet at the west end, 10,000 feet of beach by direct placement of sand, construction of two impermeable training walls at Toms Creek, 320 and 400 feet long, and construction of an impermeable groin at Hammonasset Point, 800 feet long, all at a cost for new work of $384,000 and $5500 annually for maintenance. The estimated amount of Federal participation is $128,000.

b. Middle Beach. - Revetment of 700 feet of sea-wall by placement of riprap for a width of 20 feet at a cost for new work of $33,000 and $200 annually for maintenance. The estimated amount of Federal participation is $11,000.

c. Middle Beach (Alternate Plan). - Contingent upon availability of public facilities, widening to a 100-foot width, 700 feet of beach by direct placement of sand and construction of one impermeable groin 300 feet long all at a cost for new work of $51,000 and $3400 annually for maintenance. The estimated amount of Federal participation is $17,000.

The total estimated amount of Federal participation in the above projects is $139,000; or if the alternate plan of improvement for Middle Beach is adopted, $145,000.

The Division Engineer recommends adoption by local interests of projects for improvement of the following privately-owned shores:

a. Webster Point to Seaview Beach, Madison (Toms Creek to 1600 feet east of inlet at west end Seaview Beach).

b. Seaview Inlet to East Wharf, Madison.

c. 700 feet west of East Wharf to Middle Beach, Madison.

d. Middle Beach to 500 feet east of West Wharf, Madison.

e. West Wharf to and including Canoe Harbor, Madison.

f. East limit Seafield Beach to westerly end of Half-Mile Road, Madison and Guilford (including Seafield Beach, Buffalo Bay, Hartford Bay, Highlands, Circle Beach and shore about 800 feet west of Circle Beach).

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 2

HAMMONASSET RIVER TO EAST RIVER

I. GENERAL

AUTHORITY

1. Basic Agreement. - A formal application dated 22 July 1947, from the State of Connecticut; acting through the Connecticut State Flood Control and Water Policy Commission, for a cooperative study of the problems of beach erosion and shore protection along the entire coast of Connecticut by the United States and the Connecticut State Flood Control and Water Policy Commission was approved by the Chief of Engineers, Department of the Army, 28 August 1947, in accordance with the authority conferred by the provisions of Section 2 of the River and Harbor Act approved 3 July 1930 and Public Law 166, 79th Congress, approved 31 July 1945. The approved application provided that the studies of specific areas and problems be defined in appendices; that separate reports be issued for each shore town; and that a composite report be issued for the State of Connecticut summarizing the recommendations contained in the individual reports.

2. Modification of Basic Agreement. - A request of the State of Connecticut dated 3 October 1947, approved by the Chief of Engineers on 20 October 1947, modified the basic agreement to permit separate reports on physiographical bases rather than on political boundaries.

In accordance with this modification the shore line of the State of Connecticut was divided into the following physiographical areas:

1. Ash Creek to Saugatuck River (Fairfield, part of Westport)
2. Hammonasset River to East River (Madison)

3. New Haven Harbor to Housatonic River (West Haven and Milford)

4. Connecticut River to Hammonasset River (Old Saybrook, Westbrook and Clinton)

5. Pawcatuck River to Thames River (Stonington and Groton)

6. Niantic River to Connecticut River (East Lyme and Old Lyme)

7. Housatonic River to Ash Creek (Stratford and Bridgeport)

8. Noroton River to Byram River (Stamford and Greenwich)

9. East River to New Haven Harbor (Guilford, Branford, East Haven and New Haven)

10. Thames River to Niantic River (New London and Waterford)

11. Saugatuck River to Noroton River (Part of Westport, Norwalk and Darien)

The locations of these areas are shown on Plate 1.

3. Appendices. - Appendix I to the basic agreement was approved by the Chief of Engineers on 20 October 1947. Appendices II and III were approved by the Chief of Engineers on 16 December 1947, and Appendices IV, V, VI and VII on 9 September 1948. Preparation of Appendices VIII, IX, X and XI is in progress. The subject of this report is Area 2, as defined by Appendix II.

PURPOSE

4. General. - The purpose of this study was to determine the most suitable methods of stabilizing and improving the shore line between Hammonasset River and East River.

5. Scope. - The scope of the study was as follows:

a. Determine the essential characteristics of littoral drift.

b. Determine the source and disposition of littoral material within this area.

c. Determine which sections of the shore line are now subject to undesirable changes, and the most suitable remedial measures for insuring reasonable stability of the shore line in these areas.

d. Analyze the effect of existing structures upon the shore line.

e. Determine which sections of the shore line are desirable locations for beach improvement, and the most effective measures for accomplishing the desired improvement.

f. Analyze the shore line improvements and protective measures considered, determine the advisability of adopting projects for such work, the public interest therein, and the share of the cost, if any, to be borne by the United States.

PRIOR REPORTS

6. The Physical History of the Connecticut Shore Line. - Bulletin No. 46 of the State Geological and Natural History Survey of Connecticut published in 1929 is a paper by Henry Staats Sharp, A.M., titled "The Physical History of the Connecticut Shore Line." This paper describes the geological history of Connecticut and the various topographical features of the shore line. The geological history discussed in Paragraphs 12 to 14 and Appendix B, is based principally upon this report.

DESCRIPTION

7. Connecticut. - Connecticut is aptly termed the gateway to New England, and itself is among the most popular vacation and tourist areas of the country. Connecticut is approximately 100 miles long in an east-west direction, and 50 miles broad in a north-south direction. The entire southern boundary of the State is the shore of Long Island Sound, a rather narrow, sheltered arm of the Atlantic Ocean. Only that part of the shore facing open water of Long Island Sound or tributary bays is considered in these reports. This shore is quite irregular and is about 165 miles long.

The bulk of the population of Connecticut, which in 1940 was over 1,700,000 people is in close proximity to the shore. About 40,000,000 of the country's population live within 300 miles of Connecticut's shore with the result that there is considerable use of the Connecticut shore. The fact that Connecticut is located in a temperate latitude and that the waters of Long Island Sound are generally calmer and warmer than along the exposed ocean shores of the neighboring States further has induced intensive development of water-front activities. A further attribute of the State is that the flat plain which extends generally a mile or more inland is well suited to resort development. The Connecticut shore is also very irregular, dotted with bays, coves, promontories and near-lying islands, all adding variety to the area, and adding to its value for resort and other purposes. The existence of United States Route 1 along the site of the Old Kings Highway, following the shore entirely across the State, closely paralleled by the main line of the New York, New Haven and Hartford Railroad, has encouraged more intensive development of the Connecticut shore areas through the past generations than is the usual case.

8. Area 2. - The area of Connecticut shore considered in this report is an extent of some ten miles from Hammonasset River, emptying into Clinton Harbor on the east, to East River emptying into Guilford Harbor on the west. The area comprises the entire shore line of the Town of Madison, and extends just beyond the town boundaries at either end, including Cedar Island and about 3000 feet of the east shore of Hammonasset State Park, in the Town of Clinton, and an extent of about 4000 feet at the west end of the area in the Town of Guilford. This area is about midway between the metropolitan areas of New Haven and New London, and is about 25 miles east of New Haven, 100 miles east of New York, and about 10 miles west of the mouth of the Connecticut River at Saybrook. The shore area is mainly of a rural or summer

vacation development nature, the year-round settlements of Clinton, Madison and Guilford closely following United States Route 1 which parallels the shore about one-half mile inland. The permanent population of Madison is 2,000 but the summer population is four times that number. This area is particularly noteworthy for its inclusion of the Hammonasset State Park, the central and best known of three State-owned beaches spaced evenly along the Connecticut shore.

9. Shore Physiography. - Cedar Island at the easterly end of Area 2 is a low sandy island separated from the mainland of Clinton by the inner harbor, about one-quarter of a mile wide, and from the marshes and beaches of Hammonasset Park by a 300-foot wide breachway, called the Dardanelles. This breachway was artificially closed in 1891 as part of the Federal navigation project for Clinton Harbor, but has since partially reopened. Hammonasset State Park has a shore line of about three miles extent, and consists of barrier beaches anchored at Meigs Point, a fairly high glacial hill about one mile southwest of Cedar Island. The easterly beach area forms the western shore of Clinton outer harbor, trending in a northeast direction from Meigs Point, and is relatively inaccessible and undeveloped. Hammonasset Beach extends two miles in a northwesterly direction from Meigs Point. In general, the area behind these beaches for about a quarter of a mile inshore is marsh. The approximately four and one-half miles of shore from Hammonasset Park to Hogshead Point consists of a low narrow glacial plain crossed by small creeks emptying into Long Island Sound, each creek bordered by narrow marsh areas. Scattered small ledge outcrops also mark this generally sandy shore. Barrier beaches in front of large marsh areas extend about a half mile west of Hogshead Point, and from that point a sand spit trails about one-half mile in a sharply northerly direction to form the east shore of Guilford Harbor.

10. Beach Use. - In Connecticut private title exists only to the mean high water line; seaward the title rests in the State. Technically this means

that the public has access to the entire stretch of shore line below high water. Legally no restrictions are allowed against such public usage of the beaches below high water. Actually, limited accessibility restricts the public to beaches where the adjacent back-shore area is publicly-owned or open to the public on a commercial basis. Even where the beach areas are publicly-owned, use may be limited to area residents or town residents by parking restrictions, preferential admission rates or omission of facilities for travelers.

11. Description and Composition of Beaches. - Detailed descriptive data concerning the entire shore line of Area 2 were obtained by field inspection. The shore line was then divided consecutively from Hammonasset River to East River, generally in accordance with the physical character of shore features. A description based on these subdivisions is included as Appendix A. This description includes the name, location and extent of the area, the width of beach above high water and from low to high water, the ownership and use (whether public or private), facilities available to the public, and composition of beach below and above the high water line. The beach area above high water along the entire shore line of Area 2 with the exception of the undeveloped shore from Cedar Island to Hammonasset Point is narrow, averaging about 50 feet in width. About 45 percent of this shore is protected by sea-walls and bulkheads, and the high water line is generally at the foot of or less than 50 feet in front of these structures. The composition of beach material is fair to good, consisting mostly of coarse and generously mixed with gravel. Samples of beach material were taken at selected locations along the shore. A mechanical analysis of these samples was made to determine median diameter and classification. The results of this analysis indicate that on an average approximately 50 percent of the beach material consists of coarse sand, 30 percent of gravel and the remainder of medium and fine

sand. Tabulation of results and locations of samples are shown on Plates 11-13. A complete photographic record was made of the shore. Selected photographs are shown on Plates 19-27. The entire shore line of Area 2 is approximately 10.2 miles long, of which 3.6 miles is publicly-owned and the remainder privately-owned. This public ownership is divided between Hammonasset State Park (3.25 miles) and East Wharf, West Wharf and Middle Beach (0.35 miles, owned by the Town of Madison). About 1.9 miles of shore at Hammonasset State Park is used as a bathing beach open to the general public, the remainder of the shore of the park being undeveloped and largely inaccessible. There are small town beaches at East Wharf and West Wharf whose use is generally restricted to town residents. The Middle Beach area is a walled section of shore with no beach at high water. The remainder of the shore, all privately-owned, is developed into private residences ranging from cottages to large estates, and includes a beach club. The use of the beaches along privately-owned areas is limited to residents. The development and character of the area is shown on Plates 11-13 and on United States Coast and Geodetic Survey Charts 216 and 217.

GEOLOGY

12. General. - The present Connecticut shore line is the result of submergence following the lowering of the earth's surface in relation to the water surface of the ocean. The geological processes which effected this condition and the formation of Long Island Sound are discussed in Appendix B. The shore from Hammonasset River to East River can be classed as an immature shore line of submergence. Maturity will not be reached until the shore has been driven back by erosion to the heads of the drowned valleys. Much of the upland in this area is composed of stratified sand and gravel, the erosion of which has resulted in the formation of many excellent beaches. The entire shore line is characterized by a succession of concave short stretches in the shape of intersecting arcs of circles swinging from point to

to point, with beaches between the points.

13. Hammonasset Beach. - Hammonasset is one of the longest and most beautiful stretches of sand beach in the State. The eastern two-thirds is a tombolo connecting Hammonasset Point to the mainland. The point is about 20 feet above sea level and is composed of till containing many huge boulders. Offshore boulders and till testify to the former greater extent of the till, which before the building of the tombolo and the deposition of the marsh must have appeared as an island at a considerable distance from the mainland. Behind the beach there is an area of dune sand. These dunes have been breached at various times on the western end of the beach and material has been carried several hundred feet back over the marsh. These breaks usually take place during winter storms, at which times the marsh and low upland may be partly inundated.

14. Madison Shore Line. - West of Hammonasset Beach the shore line does not possess any features of great interest. The area is composed of stratified sands and gravels of low plain which has suffered severe erosion although the larger part of the shore is now protected by sea-walls. Shore-front property is valuable and shore defenses are proportionately expensive. Immediately west of Hammonasset Beach there has been rapid wasting of the shore and much material for that beach has its source here. The shore line is occasionally interspersed with a brief stretch of bedrock which invariably makes a slight projection. Tuxis Island and Gull Rock are rock islands which were probably at one time largely or entirely covered by loose material. Gull Rock is reported to have been formerly tied to the mainland by a tombolo, while Tuxis Island could be reached by stepping from stone to stone at low tide. At Hogshead Point the upland ends and the shore-front is formed by a low bar of sand lying before the extensive East River marshes. The end of this bar at East River shows two minor recurved hooks extending out into the marsh, denoting the former position of the shore line when the drift of material was more directly northward.

II. FACTORS AFFECTING SHORE PROCESSES

WIND

15. Wind Data. - Wind diagrams compiled from observations of the United States Weather Bureau at Block Island, Rhode Island; New Haven, Connecticut; and New York City, New York, are shown on Plates 3, 4 and 5. The periods covered by these observations are as follows: Block Island 1921-1939; New Haven 1932-1942; New York City 1921-1942. The wind diagrams show the percentage of wind movement and percentage of wind duration from the various directions averaged for the entire period of record and averaged for each of the 12 months of the year for the entire period of record. In addition to the above, wind diagrams showing the yearly cumulative average winds compiled from records of the United States Navy Hydrographic Office for the 5 degree squares nearest the shore line of Connecticut are shown on Plate 2.

16. Prevailing Winds. - At Block Island the prevailing wind is from the southwest from April through September, from the northwest during October to February, and from the west during March. On an annual basis there is a slight predominance of southwest winds, while those from the west and northwest are approximately the same.

At New York the prevailing wind is from the northwest from October to May, from the south from June to August, and equally from the southwest and northwest during September. On an annual basis there is a definite predominance of northwest winds. From the wind diagrams for the 5 degree squares, it is apparent that winds from the westerly quadrants prevail, which is in agreement with the records for Block Island and New York.

At New Haven the prevailing wind is from the south from May to August, from the north from September to February, from the northwest in March and from the north in April. On an annual basis there is a predominance of north and south winds, the greatest wind movement being from the north. The

prevailing winds at New Haven are distinctly different from those found in any of the adjoining areas. New Haven lies in a lowland which runs generally north and south through Connecticut. Winds in this lowland are evidently affected by the topography so that at New Haven the winds are funneled in a north-south direction. It appears that the prevailing winds at New Haven should therefore affect only that portion of the shore line lying at the foot of this lowland. This area might be defined approximately as extending from Pond Point in Milford to Branford River in Branford.

East of Branford River the wind data from Block Island represent the best available information applicable to the shore. West of Pond Point the wind data from New York represent the best available data applicable to the shore. Area 2, located east of Branford River, is therefore probably under the influence of winds with a prevailing direction similar to Block Island where the direction is southwest.

TIDES

17. Range of Tide. - Tidal range data for points in Area 2 are available from "Tide Tables, Atlantic Ocean," published by the United States Department of Commerce, Coast and Geodetic Survey. At Madison, near Tuxis Island, the mean range of tide is 4.9 feet and the spring range of tide is 5.8 feet. At Falkner Island the mean range of tide is 5.4 feet and the spring range of tide is 6.4 feet.

18. Storm Tides. - No record of storm tides is available for any point within Area 2. A primary tide station is maintained by the United States Coast and Geodetic Survey at New London, Connecticut. A summary of extreme tides occurring at New London for a ten-year period is given in Appendix C. High water elevations which occurred during the hurricane of 21 September 1938 were determined at locations along the shore of Connecticut and they are listed in Appendix C. These latter storm tides are the highest of record for the

State of Connecticut.

WAVES

19. General. - Wave sizes are markedly less in Long Island Sound than along shores completely exposed to the ocean. This is a result of the shelter afforded by Long Island, which acts as a natural breakwater shielding practically the entire shore of Connecticut. Wave sizes are dependent on wind velocity and on fetch or open expanse of water over which the wave may travel. It is evident from the storm data tabulated in Paragraph 21 that the frequency of storm winds at New Haven is considerably less than at Block Island and New York, which are more directly exposed to the ocean. The close proximity of Long Island to the Connecticut shore limits the fetch over which the winds may act to produce waves. These factors should and do act favorably in reducing wave action. The absence of surf bathing in Connecticut is an indication of the natural protection afforded this area.

20. Wave Study. - During the review of work items to be included in this study, consideration was given to the collection of wave data. Upon the request of the Beach Erosion Board, the State of Connecticut was consulted concerning their willingness to include in the study agreement a supplementary generalized appendix covering the study of wave form, energy and height in Long Island Sound, based on a special wave study estimated to cost $10,000. The State of Connecticut felt that in order to determine whether the funds which have been allocated are adequate, it would be advisable to delay any decision in this matter until the detailed studies already agreed upon had been completed to an extent where it would be possible to figure accurately the cost of completing the study. At the time of the writing of this report no decision has been made concerning the proposed wave study.

STORMS AND THEIR EFFECTS

21. Tropical Storms. - Tropical storms of hurricane intensity occasionally pass across or near the Connecticut shore. Ivan Ray Tannehill, in his book "Hurricanes," lists ten such storms which have been particularly severe in the New England area. The dates of these storms and the known paths of five of them are shown on Plate 2. The paths of many more hurricanes are known to have passed over New England but their strength has been largely dissipated before reaching this area so that their effects on the shore have not been severe in New England. Two recent hurricanes of exceptional violence have struck across the Connecticut shore. These occurred on 21 September 1938 and 14-15 September 1944. A description of hurricanes in general, and of these two in particular, is given in Appendix D.

22. Storm Data. - Summaries of records of winds equal to or greater than 40 miles per hour at New York City, New York, and of winds equal to or greater than 32 miles per hour at New Haven, Connecticut, and Block Island, Rhode 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

23. Analysis of Storm Data. - From the observed data the probable frequency of occurrence of storm winds from various directions has been computed on the basis of a 100 year period and the results are shown in the last column of the above tabulations. It should be noted that the storm winds occurring at New York and Block Island are similar in that they show a high preponderance in a northwest direction. The frequencies of occurrence at these stations are 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) determined between 32 and 40 m.p.h. winds in 1947 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.

Due to the location of New Haven about midway between New York City and Block Island, it would be natural to expect the wind frequency and direction at New Haven to be somewhere between those for New York City and Block Island. This is definitely not so. Storm winds occur here without any marked differences in frequency from the west clockwise around to northeast and from the south. It is the stated opinion of weather bureau officials that winds at New Haven are peculiar to that area alone and do not indicate winds which can be expected along Long Island Sound. An explanation of this phenomenon has been given in Paragraph 16. Records for Block Island and New York City give a more accurate picture of the direction of wind expectancy in Long Island Sound. It should be born in mind that 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 winds occurring at Block Island and New York City can be expected to occur along the Connecticut shore.

24. Storm Damage. - The area between Hammonasset River and East River is sheltered from storms from all but the southerly quadrants. From the southwest there is an open fetch of water of from 28 to 29 miles. From the southeast there is an open fetch of water of from 12 to 18 miles. From the wind data tabulated above the number of winds from the southerly quadrants equal to or in excess of 32 miles per hour that can be expected to occur annually at New York is about 17, at New Haven about 2, and at Block Island about 10. Since New York and Block Island lie outside the sheltered area of Long Island Sound, winds in the Sound are less intense than at these two stations. The frequency of occurrence of storm winds

in the study area is probably close to that at New Haven, although any direct comparison to New Haven winds is unreliable due to the fact that these winds are found only in the lowland in which New Haven lies. It appears that severe storms likely to result in shore damage are infrequent. A search of newspaper files at Bridgeport, New Haven, New London and Westerly for stories of storm damage in this area was made. The absence of such stories indicates that storm damage is generally not a serious problem. Considerable damage has occurred along the shore during the recent hurricanes of 1938 and 1944, but such storms are comparatively rare.

III. EFFECTS OF SHORE PROCESSES

SHORE LINE AND OFFSHORE DEPTH CHANGES

25. General. - Plans showing the location of the shore line and the 6, 12 and 18-foot depths have been prepared from United States Coast and Geodetic Survey data by the Beach Erosion Board for the period from 1838 to 1933. For this study a survey during 1948 located the entire shore line and offshore depths on selected profiles spaced about 400 to 1800 feet apart. Shore line changes are shown on Plate 7 and offshore depth changes are shown on Plates 8 to 10, and Plate 14. Detailed descriptions of the principal changes which have occurred since 1838 are included in Appendix E. In general the entire shore line of Area 2 presents a picture of erosion during the past century, the amount being in the order of 1 to 3 feet per year. The greatest changes in the shore line are found in the Middle Beach area opposite Tuxis Island and at the East River spit where recession of about 3 feet per year has occurred. The Middle Beach area is now continuously protected by seawalls; while the East River sand spit continues to grow westward, changes in the shore line along its seaward side since 1933 having been alternately and irregularly erosion and accretion. The western end of Hammonasset Beach has eroded about 1 to 1-1/2 feet per year, while the eastern end of the beach has built seaward a corresponding amount. This change appears to be continuing. West of Hammonasset Beach from Toms Creek to and including Seaview Beach, erosion of 1 to 1-1/2 feet per year has occurred, the recession in recent years having been arrested by the construction of protective structures. The area along East Wharf and from West Wharf to Hogshead Point has generally eroded between projecting points, not exceeding about 1 foot per year. This area is subject to irregular changes and at present is influenced largely by numerous protective structures. Offshore depths between 1838 and 1948 have generally increased

along the entire area. In recent years along some sections there are indications that deepening is continuing, while at others there is little apparent change.

26. Comparative Profiles. - Forty-three selected profiles were run along the shore of Area 2, spaced about 400 to 1800 feet apart, extending from above the high water line seaward to the 18-foot depth contour in Long Island Sound. Their locations are shown on Plates 11 to 13 inclusive. These lines varied in length from about 800 feet to 5000 feet. They were run to determine depth changes which have occurred offshore by comparison with data previously obtained by the United States Coast and Geodetic Survey, and also to serve as a basis for comparison with any depth determinations which may be obtained in the future. In order to determine the character and extent of any seasonal changes which may be occurring along the shore, it was planned that periodic check surveys be made along some of the profiles at intervals a few months apart. Twelve of the profiles are shown on Plate 14. Also shown on this plate are the locations of the 6, 12 and 18-foot depths as determined in 1838, 1883-1884 and 1894. The descriptions of offshore changes which have occurred from 1838 to 1948 are included in Appendix E. At present insufficient data is available to determine the extent and character of seasonal changes which might be occurring along the shore.

In addition to their use in determining offshore depth changes, the profiles have served as a basis for the design of the plans of improvement.

LITTORAL DRIFT

27. Direction of Drift. - The littoral currents in the Hammonasset River to East River area, as in the rest of the Connecticut shore, vary in direction and intensity from place to place, and vary seasonally. The drift, or material moved by the littoral current, also varies, dependent on

the sources of supply. There is no question but that the littoral drift is much less than formerly due to loss of natural supply, although the littoral currents are probably of about the same magnitude as before. Throughout much of the area, sand spits trail westward, and creek inlets are turned to the west. However, this is a general observation as to the net effect of the littoral drift, and does not hold true at all points throughout the area. Compilation of various indices of drift are tabulated below.

Area	Indicated Direction of Drift	Evidence	Authority
East shore of Hammonasset State Park	Eastward	Growth of Cedar Island sand spit	Shore line changes
Hammonasset Beach	Eastward	Erosion at west end and accretion at east end	1. Shore line changes 2. Local testimony
Toms Creek to Seaview Beach	Westward	1. Direction of inlet toward west. 2. Groins trap sand generally on east side 3. Gradation of beach materials	1. Survey map 2. Visual inspection 3. Beach sample analyses
Seaview Beach to East Wharf	Minor	Obstructions on shore indicate little drift	Visual inspection
East Wharf to Middle Beach	Eastward	Wharf and groins catching sand on west side	Visual inspection
Middle Beach to West Wharf	Westward	Groins catching sand on east side	Visual inspection
West Wharf to Garvin Estate	Eastward	Accretion at West Wharf and erosion at Garvin Estate	Shore line changes
Garvin Estate to Gunther Estate	Westward	Erosion at Garvin and Hotchkiss Estates; accretion at Gunther Estate	Shore line changes

Area	Indicated Direction of Drift	Evidence	Authority
Gunther Estate to Overshores	Eastward	Usual direction of inlet mouth	Local testimony
Lee Manor	Varies	Local testimony	None
Canoe Harbor	Eastward	Erosion at west end	Shore line changes
Seafield Beach to Hartford Bay	Eastward	1. Accretion at Seafield Beach 2. Groins catching sand on west side	1. Shore line changes 2. Visual inspection
Highlands to East River sand spit	Westward	1. Groins catching sand on east side 2. Erosion at east end of area 3. Direction and growth of sand spit 4. Gradation of beach material	1. Visual inspection 2. Shore line changes 3. Survey map and shore line changes 4. Beach sample analyses

IV. EXISTING PROTECTIVE STRUCTURES

28. General. - The area under study has been influenced largely by the construction of protective structures. About 45 percent or 18,000 feet of the shore line between Hammonasset Point and East River is protected by sea-walls and bulkheads. In addition there are about 65 groins, having an aggregate total length of about 5000 feet, along this shore. Revetment has been used in some places, generally in front of walls and bulkheads, in order to provide additional protection. A description of each structure in detail would be repetitious and of doubtful value. Typical structures have been selected for description and analysis of effects, and their discussion is included in Appendix F. The natural process of supply of beach material formerly obtained from erosion of undeveloped areas and transmitted alongshore by littoral currents has been interrupted by the construction of sea-walls and other protective measures. This has resulted in diminishing the effectiveness of groins, structures primarily designed to improve a shore area by interception of littoral drift. Such groins are now relegated to the role of holding existing beach material. As elsewhere in Connecticut, the existing groins are too small to function effectively. Sea-walls and bulkheads have stopped or retarded the recession of the shore, a process which was formerly occurring with alarming rapidity at a number of points in this area. Erosion still continues in front of these structures and has resulted in the disappearance of beaches and the lowering of the level of the shore. This is evident from the exposure of the footings of structures and the necessity to add revetment to provide further protection. Only by constant maintenance of protective structures will it be possible to preserve the shore against the attacks of Long Island Sound.

V. PLANS OF IMPROVEMENT

IMPROVEMENTS DESIRED

29. Connecticut-General. - The problem involved along the Connecticut shore line as a whole, and the area included in this report results in part from storm damage but is more particularly that of gradual deterioration caused by ordinary wave attack. The problem is not of recent origin but has become of increasing importance with increased use of the shore as a summer and permanent residential or resort and vacation area and has been aggravated by the deterioration and disappearance of protective beaches as a result of direct wave attack on the extensive development along the Connecticut shore. The problem has been further intensified by general lack of knowledge of shore processes and changes to be expected and the resultant lack of control, planning and foresight. Increased widespread development has accelerated the deterioration of the shore as a whole by removing natural sources of supply through protection of formerly eroding undeveloped areas. The problem is, therefore, to stabilize and improve the shore line so that existing and future developments on the shore front may benefit from restored beach conditions and also to prevent future damages and losses which will otherwise inevitably result from the present deterioration. Local interests throughout the State have become increasingly aware of the growing problem. Evidence of this widespread concern is seen in the application for Federal studies at Compo Beach, Westport in 1935, and at Hawks Nest Beach, Old Lyme in 1939. Studies by private engineering firms at Ocean Beach, New London in 1938, and at Shippan Point, Stamford in 1941, further indicate this interest. In addition, preliminary discussions have been initiated in the past by many towns, beach associations and other interests concerning the

conduct of cooperative studies. These various local movements toward separate studies were unified as a result of the State-wide destruction experienced in the 1938 and 1944 hurricanes. At a conference at Clinton in July 1946 attended by 250 representatives of all shore towns and inland interests, a Beach Erosion Control Committee was appointed to initiate a State-wide study of the problems affecting the entire State shore line. Variation in degree of damage suffered was recognized in the resulting State appropriation for this study by enumeration of seven towns critically affected by shore erosion. The area included in this report is one of the seven so named.

30. Area 2-General. - The problem in the area considered in this report is largely one of deterioration and gradual loss of beaches. In addition consideration has been given to the protection of sections which are suffering from destructive wave action. The condition is fundamentally caused by the loss of natural sources of supply resulting from the nearly continuous development of the entire water front and the protection of areas previously eroding and furnishing material to the littoral drift supplying neighboring areas. This loss of supply has accelerated the processes of erosion and exposed developed areas to destructive wave attack necessitating the construction of expensive protective works. In general, the plans of improvement are based on artificial restoration of beach losses and revetment of critical areas. Plentiful sources of sand have been determined to exist offshore within practicable distance for hydraulic dredging and pumping to shore. Construction of groins to prevent alongshore erosion of restored beaches is, in general, considered advisable in view of losses due to erosion in the past; construction of jetties to stabilize inlets, subject to undesirable movement has also been considered. Construction

of bulkheads and sea-walls has not been considered where beach restoration has been found to be practicable, since such restoration would offer equivalent protection in addition to furnishing the shore recreational area so important to the Connecticut shore. Offshore breakwaters are not regarded as offering a solution for this area in view of the extreme expense involved and the limited benefit to be derived therefrom as the problem is more one of gradual losses from ordinary wave attack than one of damage by violent ocean waves. Additional protection in the form of riprap revetment has been deemed advisable in critical areas not suitable for artificial restoration of beaches. The plans are considered for each specific area in the following paragraphs.

SPECIFIC PLANS OF IMPROVEMENT

31. Hammonasset State Park. - The problem involved is (1) the narrowness of the existing bathing beach, (2) the necessity for an enlarged beach due to the present use and proposed expansion of the park facilities, and (3) the encroachment of sand dunes over the beach road and around the existing park buildings. The shore area now used as a public beach extends about 10,000 feet from Hammonasset Point, westward to Toms Creek, and consists of a barrier bar fronting marshes. It is about 50 feet wide at high water and possesses a steep foreshore which limits the area between high and low water to 25 to 50 feet. The park buildings are located toward the westerly end of the park within 100 to 150 feet of the water. During the past hundred years this westerly beach area has eroded on an average of 1 to 1-1/2 feet per year while the easterly end of the shore has built outward a corresponding amount. In view of the proposed plans by the State to replace the existing wooden buildings with new and more permanent structures located generally along this western portion of the park, stabilization and widening of the beach area in this vicinity is required to insure

the safety and permanence of any development. The park at present has large public facilities including parking areas, bathhouses, sanitaries, camping grounds, refreshments, and is staffed with life-guards and attendants. Despite this, the large public use of the park requires further expansion. The plan of improvement considered most satisfactory is (1) the widening of the beach by the artificial placement of sand so as to increase the width above high water by 100 feet at the western end diminishing to 50 feet at the eastern end; (2) to stabilize the inlet at Toms Creek by the construction of two steel sheet pile training walls, one of these to be the extension of an existing steel sheet pile groin; and (3) the construction of a long impermeable groin at the eastern end of the beach at Hammonasset Point to catch and hold eastward littoral drift, and to deflect tide rip currents in this area and offer beach protection from southeast storms. The plan of improvement is shown on Plate 16. Consideration has been given to the construction of a barrier to stop the landward movement of sand dunes over the beach into the marshes behind it. It is felt that the proposed widening of the beach will give sufficient protection to the areas behind it so as to lessen the problem of migrating sand, thereby making it possible to maintain the existing dunes by planting of grass or periodic handling of small amounts of material.

32. Toms Creek to Seaview Beach. - This area, extending from Hammonasset State Park one-half mile to the west, is featured by a narrow sand beach in front of a nearly continuous sea-wall. The problem in this area is the narrowness of the beach, and the danger that any further erosion will expose the shore structures to more direct attack. The plan of improvement considered most satisfactory consists of widening the beach by artificial placement of sand.

The plan of improvement is shown on Plate 16.

33. Seaview Beach. - Seaview Beach is one of the more fortunately situated beach areas in this entire extent of shore. This beach extends some 2000 feet west of the area last described to a tidal inlet. The beach is of medium to fine sand, and is about 50 feet wide, backed by 100 to 200 feet of beach or marsh grass to the steeply rising developed area in the rear. This beach now benefits by such westward littoral drift as now remains, and is sheltered on the west by the inlet and a projecting rocky point. No improvement is considered necessary for this beach at this time. The present exercise of good judgment in not allowing development on the low backshore area should be continued. The beach may recede slowly but is so situated that such recession across the grass area to the rear is of little consequence.

34. Seaview Beach to East Wharf. - This area, extending about 1200 feet, is marked by minor ledge outcrops, and by a narrow sandy beach in front of sea-walls. The area appears fairly stable, anchored to some extent by the ledge outcrops and by the projection of East Wharf. The problem in this area is again the very narrow beach in front of sea-walls. Any further erosion in this area will be immediately reflected in serious damage to these shore structures. The plan of improvement considered most suitable for this area is (1) widening of the beach to a 100-foot width by artificial placement of sand, and (2) retention of the placed sand by construction of an impermeable groin.

35. East Wharf. - East Wharf is an L-shaped wharf, faced east, holding a beach about 150 feet long on either side of the wharf. This is a town beach restricted to residents of Madison, and of very limited capacity. This beach is relatively stable, sheltered by the Wharf, and is considered not adaptable to any practical methods of improvement. Any widening of

the beach would encroach on private shore property now developed.

36. East Wharf to Middle Beach. - This section of shore about 1500 feet long is immediately west of East Wharf. The beach is 25 to 50 feet wide at its east end, diminishing to no width at the west end. The existence of the beach is due to the eastward littoral drift holding the existing sand against the projection of East Wharf. The problem in this area is the lack of any further source of sand to the west, and, therefore, the inevitable result that gradual erosion and diminishing of the beach will expose the shore structures to increasing attack. The plan of improvement considered most feasible for this area is (1) the widening of the existent beach or creation of a beach where none exists to effect a beach generally 100 feet wide, and (2) construction of one impermeable groin at about the midpoint of the proposed beach.

37. Middle Beach. - This publicly-owned stretch of shore extends about 200 feet east and 300 feet west of the long steel sheet pile groin extending to a small rocky island near Tuxis Island. The public highway runs along the shore in this area, and a massive sea-wall and retaining wall protects this highway. This area forms the most seaward part of the general bulge of the shore in this area and consequently suffers the most serious attack. In view of this unfavorable location, the plan of improvement considered most feasible for this area is the placing of heavy riprap in front of the sea-wall as shown on Plate 17. An alternate plan of improvement considered for this area consists of creation of a beach 100 feet wide by artificial placement of sand, and construction of an impermeable groin at the west end of the area. The area does not appear too suitable for such a development, as no backshore area exists for parking space or similar public beach needs. If local interests determine that arrangements can be

made for practical use of a public beach in this area, the most suitable method of creating and holding such a beach is shown on Plate 17.

38. Middle Beach to Madison Beach Yacht Club. - This 400 feet of shore adjacent to and west of Middle Beach is similar in character and problem encountered, except that this area is privately-owned, and that the sea-walls, at some points in serious danger of undermining, immediately front fine summer homes. The plan of improvement considered most suitable, in view of the probably slight need for recreational beach area for the few residences concerned, consists of protecting the exposed toe of these sea-walls with heavy riprap. If local interests feel a need for recreational beach area, in alternate plan of improvement may be adopted by constructing a beach 100 feet wide by artificial placement of sand, and retention of the beach by construction of impermeable groins at the ends of the area. If the interests representing the Middle Beach public area adjoining, and this area both decide to adopt a beach construction program, the construction of the groin on the common boundary could be a joint venture. The alternate plans of improvement are shown on Plate 17.

39. Madison Beach Club to West Wharf. - This extent of some 2000 feet of shore presents the typical problem encountered in Area 2. A narrow sand beach in front of sea-walls for most of the area presents the problem of diminishing beach recreational area and beach protection exposing the shore structures to direct attack. No natural sources of sand remain in the area, so the existing groins cannot materially improve the beach by intercepting the westward littoral current, but do slow down the erosion occurring. The plan of improvement considered most suitable for this area is (1) the widening of the beach to a 100-foot width by artifical placement of sand, and (2) retention of the placed sand by construction

of an impermeable groin. This plan of improvement is shown on Plate 17.

40. West Wharf. - This area is practically identical with that at East Wharf described above. A small public beach of limited capacity, held stable by the projection of the wharf, offers little opportunity for any improvement.

41. West Wharf to Garvin Estate. - This area of about one-half mile of shore is similar to the previously discussed areas west of East Wharf and west of the Madison Beach Yacht Club. The sandy beach of moderate width at its east end, diminishes in width until there is no beach at all in front of the Garvin Estate. Immediately east of that estate, where the Country Club property runs to the shore, there is no particular problem while this part of the shore remains in its present undeveloped state. Toward the east, however, sea-walls protecting shore property indicate that further erosion in this area would create a problem. It is believed that there is at this time sufficient beach material in the area to warrant consideration of a plan of improvement consisting of construction of one impermeable groin at about the midpoint of this area. This plan of improvement would necessarily need to be amplified to include construction of a beach by artificial placement of sand if the western part of this area is developed in the future. The plan of improvement is shown on Plate 17.

42. Garvin-Hotchkiss-Gunther Estates. - This extent of 2,000 feet of shore is featured by projecting ledge outcrops near its east limit, and 1,000 feet to the west, and the existence of the inlet at its west limit. Between the ledge outcrops there is an extremely narrow beach in front of an elaborate shore protective system consisting of a bulkhead and sea-wall. Partial undermining and collapse of the sea-wall in 1948 forced construction

of a supplementary toe wall, the first of a series of similar additional protective measures to be anticipated. The plan of improvement considered most feasible for this area consists of widening the beach to a 100-foot width by artificial placement of sand, retention of the sand in the natural pocket formed by the ledge outcrops by construction of impermeable groins to extend these projections, and formation of a pocket to the west by construction of an impermeable jetty at the east bank of the inlet, insuring maintenance of the inlet opening. The plan of improvement is shown on Plate 17.

43. Overshores and Lee Manor. - This extent of 800 feet of shore is featured by a narrow sandy beach bounded on the east by the inlet mouth and on the west by a ledge outcrop slightly offshore. The inlet mouth tends to fluctuate in its direction with the prevailing wind. Temporary closures of this inlet are caused by shifting of sand back and forth in this area. The plan of improvement considered most practicable for this area consists of (1) widening the beach to a 100-foot width by artificial placement of sand, (2) construction of an impermeable jetty on the west bank of the inlet, and (3) construction of an impermeable groin in extension inshore and offshore of the ledge outcrop at the west limit of the area. The plan of improvement is shown on Plate 18.

44. Canoe Harbor. - This stretch of 1800 feet of shore is featured by the strong ledge outcrop projection at its west end. The beach is narrow and of coarse sand. Sea-walls and groins protect the development near the middle of this area. The west part of the area is at present little developed. The plan of improvement considered most feasible for this area consists of widening the beach to a width of 100 feet by artificial placement of sand, and retention of the placed sand by construction of an impermeable groin at the east end of this area. This groin would jointly serve the

areas east and west, and has been included in the discussion of the Lee Manor area. Chipman Point, the ledge outcrop at the west end of the area, together with this proposed groin, would form a pocket to retain the placed sand. The plan of improvement is shown on Plate 18.

45. Seafield Beach to Highlands. - This extent of nearly a mile of shore consists of three shallow crescents of narrow beaches between slight projections of ledge outcrop, namely Seafield Beach, Buffalo Bay, and Hartford Bay, and about 500 feet of shore known as the Highlands, a narrow beach extending from the rock projection at the west end of Hartford Bay to the sea-wall and riprap construction running to Hogshead Point. Seafield Beach is not as highly developed as the other areas, but the scattered residences in this area are at the high water line, necessitating bulkhead protection. Massive sea-walls protect the development in the remaining areas. No material sources of supply of beach material to these areas appears to remain. The plan of improvement considered most practicable consists of widening the beach for this entire extent to a width of 100 feet by artificial placement of sand, and retention of the placed sand by construction of five impermeable groins, located at the ends of the area and at the natural projecting ledge outcrops. This plan of improvement, shown on Plate 18, lends itself to accomplishment in its entirety or separately for any of the four natural subdivisions named.

46. Hogshead Point. - This area, considered to include about 1200 feet of shore, is one of the most exposed points along this entire shore. Massive sea-walls and heavy riprap front the shore. One broken section of this heavy wall testifies to the severity of wave attack. Under such conditions it is considered impracticable to attempt to hold a beach in this area. The plan of improvement considered most feasible consists of increasing the riprap protection now afforded. The plan of improvement is shown on Plate 18.

47. Circle Beach. - Circle Beach is a narrow sandy beach at the extreme west end of the Madison shore line. The beach is crescent shaped, in a natural pocket formed by the projection of Hogshead Point on the east and the Fuller Estate on the west. The protection afforded by the projecting headland on the west is not as great as that afforded by Hogshead Point on the east. The plan of improvement considered most suitable for this area is the widening of the beach to a width of 100 feet by artificial placement of sand, and extension of that point west of Circle Beach by construction of an impermeable groin. This plan of improvement is shown on Plate 18.

48. Half Mile Road Beach. - This extent of 700 feet of shore just west of the Madison - Guilford town line constitute the most western development east of Guilford Harbor and East River. The shore here is largely made up of marsh areas and a narrow coarse beach forming the base of the extensive East River Sand Spit. The area is very low and is flooded during winter storms. There is marked recession of the shore line in this area. With no natural source of supply remaining to feed the westward littoral drift, the spit is in danger of breaching at this point. The plan of improvement considered most suitable for this area, shown on Plate 18, consists of widening the beach to a width of 100 feet, and construction of two impermeable groins at the limits of the area. The groin at the east limit of the area is the same groin as that discussed in the plan of improvement for Circle Beach, and is necessary to either plan of improvement separately and both together.

49. East River Sand Spit. - This sand spit, extending 400 feet west from the end of Half Mile Road, turns sharply northward and extends 2400 feet to East River at the head of Guilford Harbor. The spit is a low narrow

barrier beach in front of extensive marsh areas. The beach material is quite coarse in composition. The area is not now developed and is not suitable to permanent development. No plan of improvement has been considered warranted for the East River Sand Spit at this time.

VI. ECONOMIC ANALYSIS

GENERAL

50. Statutory Authorization. - Public Law 727, 79th Congress, approved August 13, 1946, established a policy of Federal participation in the cost of protecting the shores of public-owned property. It provides in part that:

> "With the purpose of preventing damage to public property and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States to assist in construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States that are owned by States, municipalities, or other political subdivisions: Provided, That the Federal contribution toward the construction of protective works shall not in any case exceed one-third of the total cost."

As Federal contribution toward construction of shore protective works is limited to publicly-owned shores, economic analyses sufficiently detailed to serve as a basis for fund appropriations have been restricted to such shores. No privately-owned shores need be or have been considered in connection therewith. The only public shore areas for which improvements have been considered are Hammonasset State Park and Middle Beach. Other publicly-owned shores in Area 2 not considered for improvements are East Wharf and West Wharf, town public beaches of limited length and capacity. These beaches are satisfactory for their limited size, and are impracticable of development to increase their size.

In view of the fact that the cooperative study of which this report is one part has determined that the major problem involved is one of general deterioration and loss of beaches along the entire shore, and that the improvement considered most efficacious therefore is general restoration of the shore on a widespread scale by hydraulic pumping of

sand from offshore depths, a general analysis of the costs and benefits of such a program has been made to determine the practicability of large scale improvements of this type. This general analysis is given in detail in Appendices I and J.

COSTS

51. First Costs. - The first costs of the projects considered for Federal participation, computed in detail in Appendix G, are as follows:

Project	Quantity	Cost
Hammonasset Beach		$ 384,000
Sand fill	460,000 cubic yards	
Groin	8,400 tons riprap	
Training walls	9,600 square feet steel sheet piling	
Middle Beach		
Recommended Plan of Improvement		33,000
Revetment	2,850 tons riprap	
Alternate Plan of Improvement		51,000
Sand fill	32,000 cubic yards	
Groin	2,350 tons riprap	

BENEFITS

52. Theory. - The benefits anticipated from the plan of improvement for Hammonasset Beach are estimated solely on the recreational value of increased public beach area. Indirect benefits or benefits not susceptible of direct evaluation have not been used. Such indirect and unevaluated benefits include increased earning power of land and property not directly affected due to increased attendance at the beach areas, and the prevention of the loss of human life, by removal of bathing hazards. No benefits have been assumed for protection of State property against direct damage, although such secondary benefits are unquestionably existent.

The benefits anticipated from the recommended plan of improvement for Middle Beach are estimated solely on direct damages prevented to the public highways. The benefits anticipated from the alternate plan of improvement for Middle Beach are based on recreational value of created public beach area and prevention of direct damage to the public highway.

Evaluation of additional benefits has not been necessary to indicate the favorable ratio of benefits to costs for the recommended projects. Continuing compilation of this data will enable succeeding reports and the final comprehensive report to include a more comprehensive analysis of these benefits, increasing the favorable ratio more nearly to a true figure.

53. Basis of Recreational Benefit Evaluations. - The basis of recreational evaluations used is a careful estimate of the value of recreational use of the shore to those attending the beaches. This estimate includes actual expenditures now made by those using the beaches, and excludes additional values received. Beach attendance at public beaches existent in Area 2 is at substandard levels of space requirements for such attendance. The recommended improvements will raise these standards more nearly to the optimum recreational beach area standard. The major benefits to Hammonasset State Park are from raising the beach space standards, and secondary benefits are from expected increased attendance. Under the alternate plan of improvement for Middle Beach, the recreational benefits are from raising the beach space standards by relieving the congestion at East and West Wharves. No increase in total town public beach attendance is assumed.

54. Allocation of Costs. - The benefits from proposed improvements are divided into Federal interest, non-Federal public interest and private interest. Federal interest is defined as the benefit secured by the

United States as a land owner. The United States is not a land owner in the areas considered, so there is no Federal interest. 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 the ownership of lands and business enterprises affected. No private ownership is involved in the areas concerned, and no indirect benefits have been evaluated on any marginal private lands. Therefore, there is no private interest involved. The entire interest in these projects is non-Federal public interest. The Federal share of the costs of these projects is therefore set at the allowable maximum of one-third of the cost of the improvements, excluding costs of lands, easements, or rights-of-way, which must be furnished by local interests. Maintenance costs are allocated to local interests in accordance with the policy set forth in Public Law 727, 79th Congress.

55. Benefits. - Benefits for Hammonasset Beach and Middle Beach, computed in detail in Appendix H, may be summarized as follows:

Hammonasset Beach.....$157,500

Middle Beach

Recommended Plan of Improvement....$ 4,200

Alternate Plan of Improvement.....$14,900

Assessed values of land directly affected by the improvement are tabulated below:

Hammonasset State Park.....$535,000

Middle Beach.....$ 50,000

Present sale values are about 1.7 times the assessed values. There is no tax income from these public lands. Total grand list in Madison is $9,200,000. The tax rate is $18.00 per thousand.

ANNUAL CHARGES

56. Estimates of Annual Charges. - The Federal and non-Federal annual charges are summarized herein. Federal investment is computed as one-third of the first cost of each improvement (See Paragraph 54). Interest has been computed at the rate of 3 percent on Federal funds and 3.5 percent on non-Federal funds. A useful life of 50 years has been assumed in computing amortization charges. An item for maintenance costs is included in the non-Federal annual charges. Detailed computations are included in Appendix G.

Project	Federal	Non-Federal	Total
Hammonasset Beach	$ 4,935	$ 16,405	$ 21,340
Middle Beach			
Recommended Plan of Improvement	430	1,140	1,570
Alternate Plan of Improvement	660	4,860	5,520

JUSTIFICATION OF IMPROVEMENTS

57. Ratio of Benefits to Costs. - The estimated annual benefits and charges for the improvements are summarized and compared in the following table, and the ratios of benefits to costs are given below:

Project	Estimated Annual Benefits	Estimated Annual Costs	Ratio of Benefits to Costs
Hammonasset Beach	$ 157,500	$ 21,340	7.4
Middle Beach			
Recommended Plan of Improvement	4,200	1,570	2.7
Alternate Plan of Improvement	14,900	5,520	2.7

COORDINATION WITH OTHER AGENCIES

58. General Coordination. - 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. The Connecticut Beach Erosion Advisory Committee appointed by the Governor to report to the State Legislature has in like manner been advised and consulted. The Selectmen 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 as to aspects of the study pertaining to their interests. In addition, widespread personal contact has been made with the shore residents to ascertain data concerning the problem.

59. Comments by Local Interests. - Preliminary sketch plans of improvements being considered have been furnished to the Connecticut State Flood Control and Water Policy Commission and to the Connecticut Beach Erosion Advisory Commission. Discussion with these agencies as to the final findings and recommendations of the study have met with their general approval and concurrence.

60. Responsibilities of Local Interests. - The State of Connecticut through the Connecticut State Flood Control and Water Policy Commission has furnished assurances that any requirements of local cooperation which may be imposed by Congress in authorizing any such project will be met. It is understood that Congress may require local interests to:

a. Adopt the projects recommended in the reports.

b. Assure maintenance of the improvements during their useful life as may be required to serve their intended purpose.

c. Provide, at their own expense, all necessary lands, easements, and rights-of-way.

d. Hold and save the United States free from all claims for damages that may arise either before, during or after prosecution of the work.

e. Assure continued public ownership of the beach and its administration for public use only.

f. Assure that water pollution that would endanger the health of bathers will not be permitted.

g. Agree to approval by the Chief of Engineers, prior to commencement of work, of detailed plans, specifications, arrangements for prosecuting the work, adequacy of the proposed work, and the assurances as listed above.

VII. DISCUSSION

61. General. - Discussion of the proposed plans of protection and improvement is limited to those areas for which adoption of a Federal project has been considered. The discussions for the specific proposed projects are included in the following paragraphs.

62. Hammonasset Beach. - The plan of improvement considered most suitable for Hammonasset Beach consists of (1) widening the beach for widths varying from 100 feet on the west end to 50 feet on the east end by artificial placement of sand, (2) construction of two impermeable training walls at Toms Creek inlet, and (3) construction of an impermeable groin at Hammonasset Point. Consideration of necessity for a barrier to landward movement of the dune has led to the conclusion that the additional beach width afforded by the recommended improvement will lessen the problem of migrating sand, thereby making it possible to maintain the existing dunes by planting of grass or periodic handling of small amounts of material. The plan of improvement will afford sufficient additional recreational beach area to relieve the existing beach congestion and encourage additional attendance at the beach. The present danger of damage to shore structures will be eliminated or decreased by the protective beach and the bathing hazards due to the rip currents off the east end of the beach, and the steep foreshore along the entire beach will be eliminated. Comparison of estimated benefits and costs indicates a favorable ratio of 7.4 to 1 despite limited evaluation of benefits.

63. Middle Beach - Recommended Plan of Improvement. - The plan of improvement considered most suitable for Middle Beach consists of revetment of the seaward toe of the existing sea-wall by placement of heavy riprap. Comparison of estimated benefits and costs indicates a favorable ratio of 2.7 to 1.

64. Middle Beach - Alternate Plan of Improvement. - An alternate plan of improvement considered for Middle Beach consists of construction of a beach 100 feet wide by artificial placement of sand, and construction of an impermeable groin at the west end of the improvement. This plan of improvement offers recreational benefits in addition to shore protection equivalent to that offered under the recommended plan of improvement. The costs of the alternate plan of improvement run higher than for the recommended plan of improvement, largely because of allowance for heavy annual sand fill requirements to be expected in this area. The comparison of estimated benefits to costs is 2.7 to 1, about equally as favorable as that for the recommended plan. The additional cost entailed in the alternate plan of improvement, and the apparent lack of space requirements for facilities necessary at a public beach led to selection of the revetment protection as the recommended plan of improvement.

VIII. CONCLUSIONS

65. General. - The purpose of this study was to determine the most suitable methods of stabilizing and improving the shore line between Hammonasset River and East River. One of the items of the study was to determine the source of littoral material within the area. Another item of the study was to determine which sections of the shore line are desirable locations for beach improvements, and the most effective measures for accomplishing the desired improvements. The study reveals that the entire area constitutes a resort development, that no source of littoral material exists within the area itself, and therefore no proposed improvements can be based on use of such littoral material which presupposes continuance of deterioration of other points within this shore area. The inevitable conclusion is that improvement of the shore requires artificial replenishment of the sand beaches from outside the area itself. The logical source of this sand is the offshore depths where the sand from the shores now rests. Feasibility of pumping this sand back on the shore has been proved by projects of that nature in Westport, Bridgeport, West Haven and New London. The study further reveals that major extents of the entire shore constitute desirable locations for beach improvements, and that areas not now so considered may become so with future development. It is not considered advisable for the United States at this time to adopt projects authorizing Federal participation in the cost of improvement of shores except at public beach areas as described in Paragraphs 62 and 63.

66. East River Sand Spit. - The study includes East River Sand Spit at the west limit of Area 2. This sand spit now has summer residences along 1800 feet of its base, west of Hogshead Point. For an additional

400 feet along that part of the spit running west, and for 2600 feet of the remainder of the spit, running north, there is no present development. The existing development already extends some 250 feet past the weakest part of the spit, where breaching may occur. This study would be incomplete if it failed to point out that this entire area is a weak shore area, that rapid changes may be expected, and that residential development of the spit appears to be unwarranted.

67. Public Beach Areas. - The study reveals that beach areas available to the public are insufficient for the demand, and that the beaches are operating at substandard recreational beach space allowances. The conclusion naturally follows that increased public beach area is justified to relieve the existing congestion and to encourage and allow additional use of this recreational area now and in the future. The study further reveals that at present two small public beach areas at East Wharf and West Wharf are impracticable of improvement because of space and location limitations. The interest involved in Hammonasset Beach and Middle Beach for which Federal projects have been considered is 100 percent public interest. Therefore, the share of expense to be borne by the United States is considered to be justified at the maximum limit of one-third of the costs of the improvements, exclusive of costs of lands, easements or rights-of-way. It is considered advisable that the United States adopt projects for Hammonasset Beach and Middle Beach as described in Paragraphs 62 and 63.

It is finally concluded that no cases of pollution exist to prohibit any of the improvements considered for Federal projects.

IX. RECOMMENDATIONS

68. General. - It is recommended that the most suitable methods of stabilizing and improving the shore line between Hammonasset River and East River consist of general restoration of the shore by hydraulic pumping of sand from offshore depths, and that retention of the sand so placed be effected in so far as possible by construction of impermeable groins, all in accordance with specific plans of improvement discussed in Paragraphs 31 to 49 inclusive, and as shown on Plates 15 to 18 inclusive, herewith. It is further recommended that future development and use of the shore be planned and controlled on the basis of the fullest knowledge of shore processes and probable changes, and probable costs and benefits to be incurred thereby.

69. Public Beaches. - The following public beaches are recommended for adoption of separate projects by the United States authorizing Federal participation by the contribution of Federal funds in an amount equal to one-third of the costs of the proposed improvements, generally as shown on Plates 16 and 17, the projects to be accomplished in their entirety or such integral part thereof as may be approved by the Chief of Engineers upon application therefore by local interests:

a. Hammonasset Beach. - Widening of 50 feet at the east end increasing to 100 feet at the west end, 10,000 feet of beach by direct placement of sand; construction of two impermeable training walls at Toms Creek, 320 and 400 feet long; and an impermeable groin at Hammonasset Point, 800 feet long.

b. Middle Beach. - Revetment of 700 feet of sea-wall by placement of riprap for a width of 20 feet.

c. Middle Beach. - Contingent upon evidence satisfactory to the Chief of Engineers that facilities for public use will be provided

by local interests, substitution in place of sea-wall revetment, widening to a 100-foot width 700 feet of beach by the direct placement of sand and construction of an impermeable groin 300 feet long.

The recommendations are subject to the conditions that local interests will:

a. Adopt the projects named herein;

b. Assure maintenance of the improvement for their useful life as may be required to serve their intended purpose;

c. Provide, at their own expense, all necessary lands, easements, and rights-of-way;

d. Hold and save the United States free from all claims for damages that may arise either before, during, or after prosecution of the work;

e. Assure that water pollution that would endanger the health of bathers will not be permitted;

f. Assure continued public ownership of the beach and its administration for public use only.

The recommendations are further subject to the conditions that the adequacy of the work proposed by local authorities, detailed plans, specifications, assurances that the requirements of local cooperation will be met and arrangements for prosecuting the work be approved by the Chief of Engineers prior to commencement of work.

The estimated amounts of Federal participation, in accordance with the foregoing recommendations, are as follows:

Hammonasset Beach.....	$ 128,000
Middle Beach (Revetment).....	11,000
Total.....	$ 139,000

In case local interests desire to adopt the alternate plan of

improvement for Middle Beach, and furnish the required evidence of arrangements for public facilities, the estimated amounts of Federal participation are as follows:

Hammonasset Beach.....	$ 128,000
Middle Beach (Beach Construction).....	17,000
Total.....	$ 145,000

JAMES H. STRATTON
Colonel, Corps of Engineers
Division Engineer

38 Inclosures:
11 Appendices
27 Plates

BEACH EROSION CONTROL REPORT ON COOPERATIVE STUDY OF CONNECTICUT

AREA 2

Hammonasset River to East River

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APPENDIX A

DESCRIPTION AND COMPOSITION OF BEACHES

1. General. - Detailed descriptive data for the entire shore line of Area 2 was obtained by field inspections. The shore line was then divided consecutively from Hammonasset River to East River generally in accordance with the physical character of the shore features. Descriptions of these subdivisions are presented below. In addition to visual inspection, samples of beach material were obtained at selected locations throughout the area and a mechanical analysis of these samples was made to determine median diameter and classification. Beach sample analysis results and locations are shown on Plates 11 to 13. A complete photographic record was made of the shore. Selected photographs are shown on Plates 19 to 27.

CLINTON

A. Cedar Island

1. Location: Head of Clinton Harbor.
2. Extent: 2800 feet (5600 feet of shore).
3. Width - above H.W.: 100 feet.
   - L.W. to H.W.: 150 feet on south side
     700 feet on north side
4. Ownership: Private
5. Use: Private summer cottages
6. Public Facilities: None
7. Composition: Above H.W.: Coarse sand.
   Below H.W.: Fine sand.

CLINTON - MADISON

B. East Shore Hammonasset State Park

1. Location: Cedar Island to Hammonasset Point.

2. Extent: 7200 feet.

3. Width - above H.W.: 100 to 150 feet except at Meigs Point and Hammonasset Point where width is 0 to 20 feet.

   - L.W.toH.W.: 150 to 500 feet.

4. Ownership: Public

5. Use: This part of park not developed for public use - largely inaccessible.

6. Public Facilities: None at site - full park facilities at developed portion of park.

7. Composition: Above H.W.: Coarse sand and gravel, ranging to massive boulders at Meigs and Hammonasset Points.

   Below H.W.: Fine sand and large boulders.

MADISON

C. Hammonasset Beach

1. Location: Hammonasset Point to Toms Creek, (Webster Point).

2. Extent: 10,000 feet.

3. Width - Above H.W.: 50 feet

   - L.W.to H.W.: 25 to 50 feet

4. Ownership: Public

5. Use: Public

6. Public Facilities: Full State Park facilities, including parking, bathhouses, life-guards, sanitary, refreshments, camping.

7. Composition: Above H.W.: Coarse sand.

Below H.W.: Fine sand, some shingle.

D. Toms Creek to Seaview Beach

1. Location: West of Hammonasset State Park.

2. Extent: 2900 feet.

3. Width - above H.W.: 0 to 50 feet

- L.W. to H.W.: 50 to 100 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium to coarse sand.

E. Seaview Beach

1. Location: 2900 to 4500 feet west of Hammonasset State Park.

2. Extent: 1600 feet.

3. Width - Above H.W.: 50 to 150 feet

L.W. to H.W.: 150 to 300 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Above H.W.: Medium to coarse sand.

Below H.W.: Medium sand.

F. Seaview Inlet to East Wharf

1. Location: East of East Wharf.

2. Extent: 1500 feet.

3. Width - Above H.W.: 25 feet

- L.W. to H.W.: 50 to 100 feet

4. Ownership: Private

5. Use: Private residences.

6. Public Facilities: None

7. Composition: Medium sand.

G. East Wharf

1. Location: Town of Madison.

2. Extent: 400 feet.

3. Width - Above H.W.: 20 to 150 feet

- L.W. to H.W.: 150 feet

4. Ownership: Public

5. Use: Restricted to town residents.

6. Public Facilities: Bathhouses, parking.

7. Composition: Medium sand.

H. East Wharf to Middle Beach

1. Location: West of East Wharf.

2. Extent: 1900 feet.

3. Width - Above H.W.: 0 to 75 feet

- L.W. to H.W.: 50 to 75 feet

4. Ownership: Private

5. Use: Private residences.

6. Public Facilities: None

7. Composition: Coarse sand to gravel.

I. Middle Beach

1. Location: 1900 to 2500 feet west of East Wharf.

2. Extent: 550 feet.

3. Width - Above H.W.: 0 feet.

- L.W. to H.W.: 50 feet.

4. Ownership: Public

5. Use: Restricted to town residents.

6. Public Facilities: None

7. Composition: Coarse sand
Gravel

J. Middle Beach to Madison Beach Club

1. Location: 2500 - 3000 feet west of East Wharf.

2. Extent: 500 feet.

3. Width - Above H.W.: 0 feet.

- L.W. to H.W.: 70 to 110 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium to coarse sand.

K. Madison Beach Club to West Wharf

1. Location: East of West Wharf.

2. Extent: 1800 feet.

3. Width - Above H.W.: 0 to 75 feet

L.W. to H.W.: 25 to 100 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Coarse sand to gravel.

L. West Wharf

1. Location: Town of Madison.

2. Extent: 850 feet.

3. Width - Above H.W.: 25 to 100 feet

- L.W. to H.W.: 100 feet

4. Ownership: Public

5. Use: Restricted to town residents.

6. Public Facilities: Bathhouses, parking.

7. Composition: Medium to coarse sand.

M. West Wharf to Garvin Estate

1. Location: West of West Wharf.

2. Extent: 2150 feet.

3. Width - Above H.W.: 40 to 150 feet

- L.W. to H.W.: 70 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium to coarse sand.

N. Garvin, Hotchkiss & Gunther Estates

1. Location: 2000 to 4500 feet west of West Wharf.

2. Extent: 2300 feet.

3. Width - Above H.W.: 0 to 50 feet

- L.W. to H.W.: 30 to 150 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Coarse sand.

O. Overshores to Lee Manor

1. Location: 4500 to 5200 feet west of West Wharf.

2. Extent: 750 feet.

3. Width - Above H.W.: 10 to 50 feet

   - L.W. to H.W.: 50 to 100 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Coarse sand.

P. Canoe Harbor

1. Location: East of Chipman Point.

2. Extent: 2300 feet.

3. Width - Above H.W.: 10 to 50 feet

   - L.W. to H.W.: 20 to 130 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Coarse sand.

Q. Seafield Beach through Highlands

1. Location: Chipman Point, west 4300 feet.

2. Extent: 4300 feet.

3. Width - Above H.W.: 0 to 50 feet

   - L.W. to H.W.: 20 to 100 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium to coarse sand to gravel.

R. Highlands to Hogshead Point

1. Location: Hogshead Point, east 1100 feet.

2. Extent: 1100 feet.

3. Width - Above H.W.: 0 feet.

   - L.W. to H.W.: 20 to 70 feet.

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Gravel, to riprap.

S. Circle Beach

1. Location: West of Hogshead Point

2. Extent: 1500 feet.

3. Width - Above H.W.: 20 to 50 feet

   - L.W. to H.W.: 140 to 180 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium to coarse sand.

GUILFORD

T. Circle Beach to End Half Mile Road

1. Location: 1500 to 2500 feet west of Hogshead Point.

2. Extent: 1000 feet.

3. Width - Above H.W.: 0 to 50 feet

   - L.W. to H.W.: 200 to 300 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Medium sand, gravel, marsh.

U. East River Sand Spit

1. Location: East shore of Guilford Harbor.

2. Extent: 3400 feet.

3. Width - Above H.W.: 50 feet

   - L.W. to H.W.: 100 to 300 feet

4. Ownership: Private

5. Use: Private residences

6. Public Facilities: None

7. Composition: Coarse sand and gravel above high water.
   Fine sand and silt below high water.

APPENDIX B

GEOLOGY

1. General. - The coastal formation in Connecticut is the result of a complicated series of geological changes. That portion of the geological history which is significant in explaining the physiography of the area is discussed briefly in chronological sequence.

2. Pre-Cambrian and Paleozoic Period. - During this period, through endless ages, series after series of sediments were deposited, injected by liquid magmas and under the influence of heat and mountain making pressures, were folded, broken and profoundly altered so that their original character can no longer be recognized. The only semblance of unity in the rocks underlying the New England Province seems to be the general presence of a north, northeast trend in the direction of the rock structure.

3. Triassic Period. - At the end of the Paleozoic Period, this complex structure was worn down at least in part to a peneplane and deposits of Triassic clastic sediments were laid down. Simultaneously with this deposition of great thicknesses of Upper Triassic shales and limestones, the intrusion and extrusion of massive layers of trap occurred. Faulting took place throughout this period and was pretty well distributed over the area. By means of great north-south boundary faults, which to this day separate the sediments from the crystallines on the east, the net result in Connecticut was to lower all strata differentially and give them a regional dip of 5 to 20 degrees east.

4. Fall Zone Cycle. - After this period of disturbance an era of great quiet prevailed during which for countless centuries erosion worked on the highlands, reducing them to a low and rolling country just a few feet above sea level. Regardless of geologic structure and differences in rock hardness, a peneplane was formed across the great faults which separate the

sediments from the harder crystallines. Great thicknesses of Triassic rock were removed. That which is still preserved in the Connecticut Valley lowland owes its existence to the faulting which dropped it below the base level of erosion. The extensive surface formed at this time is called the Fall Zone peneplane.

5. Burial of the Fall Zone Peneplane. - The long period of quiet drew to a close and the great peneplane was slowly covered by a thick series of deposits derived from the waste of the land. In Connecticut these deposits were apparently of Upper Cretaceous age, probably largely marine in origin. Earth movements resulted in uplift in the north and northwest, while seaward the surface was depressed to near or below sea level. In Connecticut the depression carried the peneplane below sea level. Thus toward the north a new cycle of erosion was started by the streams rejuvenated by uplift and the Fall Zone surface began to be destroyed, while the wastes from this destruction with the aid of marine sediments buried the lower surface in the south. When the submergence in the Connecticut area had reached its greatest extent, the streams once emptying into the ocean considerably to the south found that their mouths had moved to the north with the advancing shore line. This shore line was probably even more irregular than that of today.

6. The New England Upland Cycle. - At or near the end of the tilting which started the destruction of the Fall Zone peneplane, a new movement of the earth's surface occurred, resulting in uplift. Coincident with the movement raising the land above sea level, the shore line retreated toward the southeast and the streams extended their lower courses across the young coastal plain thus exposed. At this early date the Connecticut River left its course across the soft Triassic rocks in the vicinity of Middletown and made a sharp bend to the southeast over the newly uncovered sediments of the coastal plain, assuming the course which, with few exceptions, it follows to this day. The

uplift initiated a new cycle of erosion which wore down the land mass and a peneplane, the most extensive of any in New England, was formed. Today the remnants of this surface are known as the New England Upland peneplane.

7. The Connecticut Valley Lowland Cycle. - Another uplift accompanied by tilting terminated the Upland cycle of erosion. This tilting appears to have been to the southeast about 15 feet per mile. The uplift started another cycle of erosion, during which the Coastal Plain deposits were removed most rapidly, while the Triassic shales and limestones, being more resistant, remained somewhat longer. The Upland, underlain by the more resistant crystalline rocks, were still far from total destruction when the Coastal Plain and Triassic areas were reduced almost to sea level. It was during this period that the Connecticut Valley lowland was formed by the erosion of the Triassic rocks. This lowland, which now follows the Connecticut River to about Middletown and enters Long Island Sound at New Haven, is essentially the same as when originally formed.

8. The Sound Valley Cycle. - The Lowland cycle was terminated by another uplift, by which the land was raised in reference to the sea. This uplift raised the surface of the Connecticut Lowland peneplane, which continued as a Coastal Plain along the entire southern edge of the State in a belt about as wide as the present Long Island Sound. The forces of erosion renewed their work and cut a valley in the inner lowland, called the Sound Valley, which was eventually to become the present Long Island Sound.

9. Formation of Long Island Sound. - The cutting of the inner lowland was interrupted by a climatic change which resulted in the formation of a great ice sheet covering the northeastern United States and Canada. This glacier, moving under the impulse of gravity, carried a tremendous amount of debris gathered from the country over which it passed. In passing over Connecticut, the glacier scraped away practically every bit of the thick

mantle of soil and decomposed rock in its path. All the material was not carried to its terminal moraine, which followed a line from the northern fluke of Long Island, through Fishers Island to Watch Hill and the southern coast of Rhode Island. Much of the material was strewn over the surface of Connecticut as the glacier advanced and retreated, and forms the present unevenly distributed soil of Connecticut which varies in depth from 0 to 20 or more feet. In addition to eroding and depositing of materials, a sinking of this region occurred which might have been due to the enormous weight of the ice sheet. The exact amount of submergence occurring is not known but when the ice disappeared, the inner lowland or Sound Valley was below sea level. These waters are what now constitute Long Island Sound, while Long Island is that part of the cuesta and glacial drift which remained above sea level.

10. Postglacial Changes of Level. - Since the withdrawal of the glacier from Connecticut, one small diastrophic movement has occurred. This resulted in the submergence of land masses for a depth generally determined and accepted to be 20 feet. After this movement, authorities generally agree that movements of the land and sea ceased and the relation of the elevation of the waters in Long Island Sound and Connecticut have remained constant. Minor local changes in water elevation may have occurred in restricted areas due to localized conditions. This last lowering of the land masses resulted in the present day shore line of Connecticut being a shore line of submergence, having all the irregularities of such a shore line due to the drowning of coastal valleys.

11. Present Day Trends. - Connecticut at present is in the period of sub-aerial erosion which follows a diastrophic change. During this period erosional forces will work to the reduction of land masses to another penelane with the streams transporting materials from the uplands to the lowlands.

Along the coast, waves attacking the shore line will tend to cut back all headlands, building and rebuilding bars and spits of materials from eroded headlands until a regular, even shore line is produced. This regular shore line will be landward of the present day shore line since the beaches, bars and spits will recede landward as the headlands are lost.

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, Atlantic Ocean," 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 R. 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

Location	Mean Range	Spring Range	Reference Station	Time Interval
Greens Ledge	7.2	8.5	Bridgeport	-0 05
Stamford	7.2	8.5	"	0 00
Coscob Harbor	7.2	8.5	"	+0 05
Greenwich Harbor	7.4	8.7	"	0 00

3. Tidal Observations - New London. - A primary tide station is maintained by the United States Coast and Geodetic Survey at New London, Connecticut. A summary of the highest tide observed at this station during each month for the period from June 1938 to April 1948 is tabulated below. When the highest monthly tide occurred on more than one day in any month, it has been included in the tabulation for each day of its occurrence.

Height and Frequency of Highest Monthly Tides
New London, Connecticut. June 1938 - April 1948

Month	Height of Tide (feet)							
	3.6-3.9	4.0-4.4	4.5-4.9	5.0-5.4	5.5-5.9	6.0-6.4	Over 6.5	Total
January		3	6					
February		9	2					
March	1	6	1	1	1	1		
April	2	6	4					
May	2	4	3					
June	6	8						
July	11	5						
August	11	4						
September	3	9					2	
October	1	5	3	1	1			
November	1	3	3	1	1	2		
December		5	4	3	2			
TOTAL	38	67	26	6	5	3	2	147

The two tides listed in the tabulation as being in excess of 6.5 feet occurred during the hurricanes of September 21, 1938 and September 14-15, 1944.

In September 1938 the recorded height of tide at New London was 11.1 feet and in September 1944 the height was 7.6 feet.

4. Extreme Hurricane Tides - September 1938. - Elevations of high water marks referred to the plane of mean low water occurring during the hurricane of 21 September 1938 at selected locations along the shore of Connecticut are tabulated below:

Location	Actual High Water	Predicted High Water
Stonington	11.0	3.2
Mystic	10.8	
Noank	10.3	3.1
New London	11.1	3.0
Saybrook	13.4	4.1
Branford	11.8	6.9
New Haven	13.0	7.2
Bridgeport	13.8	7.8
Southport	13.4	
South Norwalk	11.6	8.1
Rowayton	14.3	
Stamford	15.6	8.2
Greenwich	15.0	8.4

5. Extreme Hurricane Tides - September 1944. - Elevations of high water marks referred to the plane of mean low water occurring during the hurricane of 14-15 September 1944 were reported as follows:

Location	Actual High Water
Stonington	7.7
Saybrook	8.0

APPENDIX D

HURRICANES

1. Characteristics. - 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 than this - 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 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, which accompanied 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 another important factor in the destruction caused by such storms.

2. Severe Hurricanes in New England. - 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 such tropical cyclones as occurring between 1635 and 1944. The paths of some of these are shown on Plate 2. The 1944 hurricane has been described as the most violent in history but it did not cause as much destruction in New England as the one which struck in 1938. A comparison of

these storms indicates certain attendant characteristics which can be expected to result in great damage. The 1938 hurricane 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 later hurricane did not produce the inundation and consequent destruction which occurred during the former. Very little information is available concerning the damage caused by most of the hurricanes which have passed through or near New England. This lack of detailed information makes it difficult, if not impossible, to draw conclusions concerning probable shore damage which can be expected from such storms.

3. Hurricane of 21 September 1938. - On 21 September 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. The hurricane entered the State of Connecticut with its center just west of New Haven at 3:30 p.m. E.S.T. and continued its progress northward at the rate of 50 to 60 miles per hour. The eye of the storm 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 at a distance of about 75 miles to the right of the storm center. Barometric pressures reported indicate the severity of the storm along the Connecticut shore. Minimum 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. Barometric pressures dropped gradually until 12:00 noon, and then dropped rapidly until about 4:00 p.m., when the lowest pressures were reached. Pressures then rose rapidly until 8:00 p.m., when the 12:00 noon pressure was attained; thence

rose gradually. Wind velocities were observed as follows: maximum for a five minute period, 38 miles per hour at New Haven, 46 miles per hour at Hartford, 70 to 90 miles per hour over an area 80 miles wide from Saybrook, Connecticut, to Marthas Vineyard, Massachusetts; maximum gust velocities, 46 miles per hour at New Haven, 59 miles per hour at Hartford, probably in excess of 100 miles per hour in the area from Saybrook to Marthas Vineyard. The amount of precipitation directly attributable to the hurricane is difficult to determine due to the fact that it rained for 2 days prior to the storm. 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. The hurricane increased tidal heights above their predicted ranges. Its approach was manifested in the higher water levels of the preceding low and high water. During these preceding tides, 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 9 feet at New Haven to 22 feet at Saybrook Light and 30 feet at Bridgeport.

4. Hurricane of 14-15 September 1944. - On 14 September 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, thence swerved north, northeast across Long Island, reaching the mainland in the vicinity of Westerly, Rhode

Island. 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 hurricane reached Westerly, Rhode Island, about 11:00 p.m. E.W.T. The greatest wind intensities occurred to the east of the storm center. The calm during the passage of the "eye" of the storm, with the shift in the wind direction after its passage, was clearly noted at Westerly and Providence, Rhode Island. The following minimum barometric pressures were reported in the Connecticut area on 14 September; at New Haven, Connecticut, 28.86 inches at 9:50 p.m.; at Hartford, Connecticut, 28.94 inches at 10:50 p.m.; at Fishers Island, New York, 28.41 inches at 10:45 p.m.; at Groton, Connecticut, 28.40 inches at 11:00 p.m.; at Westerly, Rhode Island, 28.30 inches at 11:00 p.m.; at Block Island, Rhode Island, 28.34 inches at 11:09 p.m. Wind velocities reported for the Connecticut area are as follows: New Haven, maximum five minute wind, N 33 m.p.h. and extreme wind NE 38 m.p.h.; Hartford, maximum five minute wind, N 50 m.p.h. and extreme wind, N 62 m.p.h.; New London, extreme wind 70 m.p.h.; Westerly, Rhode Island, extreme wind, 75 m.p.h.; Block Island, Rhode Island, maximum five minute wind, SE 82 m.p.h. and extreme wind, SE 88 m.p.h. Extreme winds 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. The following elevations of high water in feet above mean high water were reported: Saybrook, Connecticut, 4.5; New London, Connecticut, 5.0; Stonington, Connecticut, 5.0; Watch Hill, Rhode Island, 6.9; Providence, Rhode Island, 8.0. The hurricane effect occurred on the ebb tide from about 3 to 5 hours after predicted gravitational high water in the area from Watch Hill, Rhode Island, to Wood's Hole, Massachusetts.

APPENDIX E

SHORE LINE AND OFFSHORE DEPTH CHANGES

1. Basic Data. - Plans showing the locations of the shore line and the 6, 12 and 18-foot depths have been prepared by the Beach Erosion Board covering the period from 1838 to 1933. These plans were made from United States Coast and Geodetic Survey data. For this study a survey was run during 1948, locating the entire shore line and offshore depths on selected profiles spaced about 400 to 1800 feet apart. Shore line changes are shown on Plate 7 and offshore depth changes are shown on Plates 8, 9, 10 and 14. The principal shore line and offshore depth changes are described below. Due to the scale (1:10000) used on these plans it is obviously difficult to measure small changes with accuracy. Change descriptions are therefore limited to those which are large enough to permit reliable reading. Amounts of accretion, erosion or movement of inlets when given in feet are necessarily scaled distances, and therefore approximate. The changes described can be considered accurate in so far as they indicate the trend in the area described and approximate only in indicating the actual quantitative change.

2. Cedar Island. - Cedar Island is located at the east limit of Area 2. It is in Clinton Harbor at the mouth of the Hammonasset River. In 1840, this island, previously connected to the mainland, became separated by a break through the marshes at its west end. A dike was built across this opening in 1883. In 1838 the island was smaller than at present. Between 1838 and 1884 the eastern end of the island grew eastward about 75 feet and became about 100 feet wider through accretion along its north shore. During this period small changes occurred at the west end of the island, but except for the previously mentioned break, there was no appreciable change. From 1884 to 1933 the island grew an additional 75 feet eastward and about

100 feet westward. The north shore at the east end of the island eroded about 50 feet. Between 1933 and 1948 there was little change at the east end; the south shore along the center of the island moved back about 100 feet, while the west end swung northward and eroded 100 feet.

3. Hammonasset State Park. - The shore of Hammonasset State Park runs generally south and southwest for about 6500 feet along the west side of Clinton Harbor, from Cedar Island to Hammonasset Point, thence northwest about 10,000 feet to Toms Creek. The shore line opposite Cedar Island along the break which separated Cedar Island from the mainland eroded as much as 200 feet since 1884. The next 1500 feet of shore, running southwest, built seaward up to 200 feet from 1838 to 1933. Since 1933, erosion not exceeding 50 feet in width occurred here. Along the next 2000 feet the shore bends from southwest to south to the inlet of a creek. From 1838 to 1884 this shore line moved generally landward. Some accretion appears to have occurred here between 1884 and 1933. From 1933 to 1948 only small changes are apparent except at the mouth of the creek. The shore line at the mouth of the creek shows large irregular changes through the past century, the net result of these changes up to 1933 being erosion. Since 1933 the shore along the west side of the mouth of the creek has built seaward about 150 feet, little change occurring along the east bank. The next 1200 feet of shore south of the creek has changed very little since 1838. The remaining stretch of shore, about 1600 feet long, extending to Hammonasset Point, has moved seaward up to 150 feet since 1838. This growth continued between 1933 and 1948. From Hammonasset Point to Toms Creek a regular pattern of change occurred in the position of the high water line since 1838. This can best be described as a clockwise rotation of the beach about a point at its center, resulting in accretion of over 100 feet at Hammonasset Point and erosion of a similar amount east of Toms Creek,

the central portion of Hammonasset Beach remaining in its original position.

Offshore depth changes along the west side of Clinton Harbor from 1838 to 1894 were generally as follows: shoaling in the vicinity of the 6-foot depths and deepening in the vicinity of the 12 and 18-foot depths. Profiles run during 1948 indicate that since 1894 the 6 and 12-foot depth curves have moved shoreward. From Hammonasset Point to Toms Creek offshore depths generally increased between 1838 and 1884. Since 1884 there has been little apparent change in offshore depths.

4. Webster Point to Seaview Beach. - This stretch of shore about 2500 feet long is located west of and adjacent to Toms Creek. The shore line here moved landward continuously from 1838 to 1933 for a distance generally of 100 feet. During this period Toms Creek inlet moved continuously eastward about 150 feet. Since 1933 this inlet has moved westward about 200 feet and the shore west of the inlet, now protected by walls and groins, moved generally 50 feet seaward.

Offshore depths increased between 1838 and 1884, moving the 12 and 18-foot depth curves hundreds of feet shoreward. Profiles run in 1948 show that since 1884 the 6-foot depth curve moved about 200 feet landward, little change occurred in the position of the 12-foot curve, and some shoaling has probably occurred in the vicinity of the 18-foot depth.

5. Seaview Beach. - This section of shore, about 2000 feet long, is located east of and adjacent to an inlet at the west end of Seaview Beach. Between 1838 and 1933 the shore line moved landward about 100 feet. Between 1933 and 1948 the eastern half of this beach moved seaward, probably not more than 25 feet, and the western half of the beach eroded a similar amount. The inlet at the west end of the section has been comparatively stable through the years.

Offshore the 12 and 18-foot depth curves moved hundreds of feet

landward between 1838 and 1884. Since 1884, opposite the eastern portion of the beach the 6-foot depth curve continued to move landward while shoaling occurred nearer to the inlet.

6. Seaview Inlet to East Wharf. - This section of shore line, about 1500 feet long, extends from the inlet at the west end of Seaview Beach to East Wharf. Between 1838 and 1948 there was very little change in the position of the shore line.

Offshore, between 1838 and 1884, little change is apparent in the location of the 18-foot depth curve, while the 12-foot depth curve moved over 500 feet shoreward. A profile run in 1948 indicates that there has been no change in depths since 1884.

7. East Wharf to Middle Beach. - This section of shore, about 1500 feet long, is adjacent to and west of East Wharf. It includes part of Middle Beach. Between 1838 and 1933 the shore line changed as follows: accretion, generally less than 50 feet, along the easterly 1000 feet and a small amount of erosion along the westerly 500 feet. From 1933 to 1948 the shore line advance seaward about 50 feet.

Offshore, between 1838 and 1884, deepening occurred at the locations of the 12 and 18-foot depth curves. Profiles run in 1948 indicate no apparent change in depths since 1884.

8. Middle Beach to Madison Beach Yacht Club. - This area consists of the shore line, about 1600 feet in length, from the Madison Beach Yacht Club to and including part of Middle Beach. Extensive erosion occurred along this shore from 1838 to 1933. The greatest shore movement took place about 300 feet east of the Madison Yacht Club pier where the shore receded about 250 feet. The area is now protected continuously by walls and groins. There has been no change in the position of the high water line since 1933.

Offshore the 12 and 18-foot depth curves have moved in a landward direction, but the presence of two small islands 600 and 1200 feet offshore has interfered with any general movement. Some deepening has continued up to 1948 between and seaward of these two islands.

9. Madison Beach Yacht Club to West Wharf. - This section of shore is about 2000 feet long and extends from the pier at the Madison Beach Yacht Club to West Wharf. Along the easterly two-thirds of this area, the shore line eroded about 200 feet between 1838 and 1933. This erosion continued to 1948. Along the westerly third of the area there has been little change since 1838.

Offshore the 12 and 18-foot depth curves moved generally landward between 1838 and 1884. During this period shoaling occurred opposite the easterly half of this area near Tuxis Island, and deepening opposite the westerly half in the vicinity of the 6-foot depth curve. A profile run during 1948 west of Tuxis Island shows that offshore deepening is continuing.

10. West Wharf to the Garvin Estate. - This area extends about 2600 feet between West Wharf and a point of land in front of the Garvin Estate. Between 1838 and 1933 erosion moved the shore line back along this entire area for a width generally of 50 feet. Since 1933 there has been little apparent change in the shore except at the east and west limits. At the east limit along 300 feet of shore west of West Wharf there was accretion up to 75 or 100 feet. At the west limit along the east side of the point of land in front of the Garvin Estate a small amount of erosion took place.

Offshore, between 1838 and 1884, the 6, 12 and 18-foot depth curves moved landward, resulting in deepening of the entire shore front area. Profiles run in 1948 indicate that little change in depth has occurred since 1884.

11. Garvin Estate to Lee Manor. - This shore, about 2500 feet long, extends from a point of land in front of the Garvin Estate to Lee Manor. The easterly 1000 feet of shore belonging to the Garvin and Hotchkiss Estates moved almost continuously landward from 1838 to 1948, resulting in a total change in position of about 50 feet. West of a point of land which terminates this area and extending about 500 feet westward to an inlet, the shore has built out generally less than 50 feet. Between the inlet and Lee Manor the shore has alternately built seaward and landward. Its present position is about the same as in 1838.

Offshore the 6-foot depth curve moved seaward between 1838 and 1884, and the 18-foot depth curve moved landward. Since 1884 there appears to have been little change in offshore depths.

12. Canoe Harbor. - This portion of the shore is adjacent to and extends about 2000 feet west of Lee Manor. There was little change in the position of this shore between 1838 and 1884. From 1884 to 1933 the high water line moved landward generally about 50 to 75 feet. Between 1933 and 1948 the shore line advanced seaward between 25 and 50 feet, except along the western 600 feet of the area where erosion appears to have pushed the high water line back from 0 to 50 feet.

Offshore, between 1838 and 1884, the 6-foot depth curve moved seaward and the 12 and 18-foot depth curves moved landward. Since 1884, there appears to have been little noticeable change in offshore depths.

13. Canoe Harbor to Hartford Bay. - This area extends about 2000 feet west from the point of land at the west end of Canoe Harbor and includes Seafield Beach and Buffalo Bay. Some accretion occurred along this entire shore between 1838 and 1884, varying in amount from 50 to 100 feet. From 1884 to 1933 the high water line moved landward so that the net effect since 1838 was a change in position seaward along the easterly 1000 feet

comprising Seafield Beach and a movement slightly landward along the westerly 500 feet known as Buffalo Bay. Between 1933 and 1948 the shore line moved about 40 feet seaward along Seafield Beach and little change is apparent in Buffalo Bay.

Offshore, between 1838 and 1884, shoaling occurred in the vicinity of the 6-foot depth curve opposite Seafield Beach, while little change occurred opposite Buffalo Bay. The 12 and 18-foot depth curves moved shoreward during this period. There was little change in offshore depths between 1884 and 1948.

14. Hartford Bay. - This stretch of shore, about 1500 feet long, is located between Buffalo Bay on the east and the Highlands on the west. From 1838 to 1933 there was little change in the position of the shore line except at the east end where the point separating Hartford Bay from Buffalo Bay moved landward about 100 feet. Between 1933 and 1948 the shore shifted seaward between 25 and 75 feet.

Offshore, between 1838 and 1884, shoaling occurred in the vicinity of the 6-foot depth and deepening occurred in the vicinity of the 12-foot depth. Since 1884 there has been little apparent change in offshore depths.

15. The Highlands. - This stretch of shore, about 800 feet long, is located west of and adjacent to Hartford Bay. Between 1884 and 1933 some erosion, generally less than 50 feet, occurred along the east end of the area. At present the shore is protected by sea-walls, riprap and groins, and the high water line is at the foot of the walls. There has been no apparent change in the location of the high water line since 1933.

Offshore depths increased between 1838 and 1884. There has been no apparent change in offshore depths since 1884.

16. Hogshead Point. - There was little change at this point between

1838 and 1884. Between 1884 and 1933 the land was eroded back, generally less than 50 feet. At present the entire point is protected by sea-walls and riprap and the high water line is at the foot of the walls. There has been no change in the location of the high water line since 1933.

Offshore depth changes have been irregular. Generally, the offshore area deepened between 1838 and 1884. Profiles run in 1948 indicate no apparent change in depths have occurred since 1884.

17. Circle Beach. - Circle Beach is about 1000 feet long and is adjacent to and west of Hogshead Point. The shore along this area eroded about 100 feet between 1838 and 1933, the greater part of this erosion having occurred up to 1884. Between 1933 and 1948 little change occurred in the position of the high water line.

Offshore depths increased between 1838 and 1884.. There has been no apparent change in offshore depths since 1884.

18. East River Spit. - The shore along this area extends about 4000 feet between a point of land at the west end of Circle Beach and East River. Between 1838 and 1933 extensive erosion occurred along the easterly 2500 feet of this shore. This erosion moved the high water line landward as much as 300 feet at the point where the spit recurves from a southwesterly to a northwesterly direction. The only other major change along this spit during this period occurred at its western end where the tip of the spit shifted its position about 100 feet landward and grew westward about 250 feet. Between 1933 and 1948, accretion, generally 100 feet in width, occurred along the 600 feet of shore immediately west of the above mentioned point of the recurved spit. Further west to the end of the spit, irregular changes - sometimes landward, sometimes seaward - occurred. These changes in places were as much as 100 feet. The tip of the spit continued to grow between 1933 and 1948, adding about 75 feet at its western end.

A profile run in 1948 at the point of the recurved spit shows that since 1884 shoaling occurred offshore at the 6-foot depth, deepening at the 12-foot depth, and no apparent change occurred at the 18-foot depth.

APPENDIX F

EXISTING PROTECTIVE STRUCTURES

1. Significant Shore Structures. - In this area, as is generally true of the Connecticut shore, much of the shore line has been under the influence of artificial structures. A description of each structure in detail would be of doubtful value. Therefore, typical structures have been selected for analysis. The existence of shore structures has destroyed, diminished or interrupted natural processes of supply of beach material obtained from erosion of undeveloped areas and transmission alongshore by littoral currents. An important effect of the shore structures has been to diminish effectiveness of the numerous groins along the Connecticut shores, as groins are designed primarily to improve a shore area by interception of littoral drift. Groins in such an area have been found effective only in holding existing beach material rather than in improving the area. Structures affecting a shore are (1) sea walls or bulkheads, (2) revetments, (3) groins, (4) jetties and offshore breakwaters, and (5) artificial fill. There are no offshore breakwaters or artificially filled shore areas along this part of the Connecticut shore. Examples of shore structures are described below in geographic order of occurrence from east to west.

2. Dardanelles Dike. - Dardanelles Dike was built by the Federal Government in 1883 to close a breach between Cedar Island and the Hammonasset shore. The dike was built 375 feet long, 8 feet wide, with a top elevation of 5 feet above mean low water, and consisted of about 1600 tons of riprap. Settlement of the dike foundation necessitated repairs in 1892 to restore the top elevation as originally built. The dike does not at present completely close the breach, the Hammonasset shore having

cut back about 75 feet. The original purpose of the dike was to reduce shoaling in the Clinton Harbor channel by preventing dispersion of the tidal flow through the breach. The quantitative effect of the structure would be difficult to determine. The dike at present is failing to accomplish its function, and will require extension or modification to restore its full effect.

3. Groin at Toms Creek. - At Webster Point, at the present west bank of Toms Creek Inlet, there is a steel sheet pile groin 110 feet long. The top of the groin slopes from an elevation of 9 feet above mean low water at the inshore end to an elevation of 5 feet above mean low water at the outer end. On a southwest wind the littoral drift passes right over and around this groin, depositing sand to the east and forcing the inlet eastward. The groin, although of good construction, is neither long enough nor high enough to fulfill its purpose completely.

4. East and West Wharves. - East and West Wharves are solid masonry L-shaped wharves, with the lee to the east. The direction of these wharves indicates the prevalence of southwesterly winds in this area. These wharves are not used for shipping, and extend merely to about the low water line. Sand has been deposited on the west face of each of the wharves. A rather unusual formation of sand in a semi-circular berm or bar is found east of each of these wharves. That part of the wharves parallel to the shore evidently tends to produce a still water area encouraging this deposit or preventing the erosion of sand east of the wharves.

5. Tuxis Island Breakwater. - The so-called Tuxis Island Breakwater is a steel sheet pile breakwater about 520 feet long, with a top elevation just above high water. The breakwater extends from shore to a ledge rock island about 800 feet northeast of Tuxis Island. The breakwater was built in 1937,

evidently to afford a lee for small boats and to protect the shore from storms. There is little, if any, indication that it has served to build up the shore by trapping littoral drift.

6. Lee Manor Groin. - A groin generally of rock crib construction was built in 1947 at Lee Manor, extending by about 40 feet an existing timber groin 100 feet long. The top of this groin is approximately at mean high water level. The outer end of the groin is about 30 feet inshore of a large ledge rock outcrop. After construction of this groin the beach at Lee Manor, immediately to the east, built up in elevation about 4 feet in one year. It cannot yet be stated with certainty that this accretion is permanent.

7. Highlands Groin System. - There is a series of eight timber groins at the Highlands, spaced about 75 feet apart, each 75 feet in length except the most westerly one which is about 130 feet long. The top elevation of these groins is about one foot above high water. The beach at the wall is at this time one foot below high water, and is about 70 feet wide at low water. These groins were built or rebuilt in 1948. Sufficient time has not elapsed to determine the effect of the groins.

APPENDIX G

ESTIMATES OF COSTS OF IMPROVEMENTS CONSIDERED FOR FEDERAL PROJECTS

The estimated life of the considered projects is 50 years. The rate of interest on Federal investments is computed at 3 percent and on non-Federal investments at 3.5 percent.

Beach fill annual maintenance requirements have been estimated at one percent of initial volumes placed. The basis for this determination is as follows:

a. Present average annual recession of shore line 1 to 2 feet.

b. Based on consideration that hurricanes of 1938 and 1944 caused a large percentage of the above recession, not reasonably to be expected within the assumed 50-year life of the projects, and that recommended groin construction will retard beach losses, estimated future annual recession 0.5 feet.

c. Average recommended widening of beach, 50 feet.

d. Percentage of initial volume lost annually, 1.

1. Hammonasset State Park. - The plan of improvement considered for Hammonasset State Park consists of widening the beach 50 feet beginning at the east limit to 100 feet at the west limit, the construction of a groin 800 feet long at the east limit, the construction at Tams Creek of two sheet pile training walls, 400 and 320 feet long, the latter to be a 210-foot extension of an existing sheet pile groin.

a. First Costs. -

Beach Construction

460,000 cubic yards sand at $0.50.....	$ 230,000
Engineering and Contingencies.....	33,000
	$ 263,000

Groin and Training Wall Construction

8400 tons riprap at $10.00.....	$ 84,000
9600 square feet steel sheet piling at $2.25.....	21,600
Engineering and Contingencies.....	15,400
	$ 121,000
Total Cost.....	$ 384,000

b. Annual Charges. - First costs are allocated as follows:

Federal cost - one-third of total cost.....	$ 128,000
Non-Federal cost - two-thirds of total cost.....	256,000
	$ 384,000

Federal Annual Charges

Interest.....		$ 3,800
Amortization.....		1,135
		$ 4,935

Non-Federal Annual Charges

Interest.....		$ 8,950
Amortization.....		1,955
Annual Maintenance		
Repairs to groin, 85 tons riprap at $10.00.....	$ 850	
Protective painting of sheet piling, 10 gallons paint at $5.00.....	50	
Replenishment of sand losses, 4,600 cubic yards sand at $1.00.....	4,600	$ 5,500
		$ 16,405
Total Annual Charges.....		$ 21,340

2. Middle Beach (Recommended Plan of Improvement). - The plan of improvement recommended for Middle Beach consists of placing riprap in front of the existing sea-wall.

a. First Costs. -

Revetment

2850 tons riprap at $10.00.....	$ 28,500
Engineering and Contingencies.....	4,500
Total Cost.....	$ 33,000

b. Annual Charges. - First costs are allocated as follows:

Federal cost - one-third of total cost.....	$ 11,000
Non-Federal cost - two-thirds of total cost.....	22,000
	$ 33,000

Federal Annual Charges

Interest.....	$ 330
Amortization.....	100
	$ 430

Non-Federal Annual Charges

Interest.....	$ 770
Amortization.....	170
Annual Maintenance	
Repairs to riprap, 20 tons riprap at $10.00.....	$ 200
	$ 1,140
Total Annual Charges.....	$ 1,570

3. Middle Beach (Alternate Plan of Improvement). - The alternate plan of improvement considered for Middle Beach consists of placing sand fill in front of the sea-wall to provide a beach 100 feet wide at mean high water, and the construction of one impermeable groin 300 feet long at the west limit of the beach.

a. First Costs. -

Beach Construction

32,000 cubic yards sand at $0.65.....	$ 20,800
Engineering and Contingencies.....	3,200
	$ 24,000

Groin Construction

2350 tons riprap at $10.00	$ 23,500
Engineering and Contingencies	3,500
	$ 27,000
Total Cost	$ 51,000

b. Annual Charges. - First costs are allocated as follows:

Federal cost - one-third of total cost	$ 17,000
Non-Federal cost - two-thirds of total cost	34,000
	$ 51,000

Federal Annual Charges

Interest		$ 510
Amortization		150
		$ 660

Non-Federal Annual Charges

Interest		$ 1,200
Amortization		260
Annual Maintenance		
Repairs to groin, 20 tons riprap at $10.00	$ 200	
Replenishment of sand losses, 3200 cubic yards sand at $1.00	3,200	$ 3,400
		$ 4,860
Total Annual Charges		$ 5,520

APPENDIX H

ESTIMATES OF BENEFITS FROM IMPROVEMENTS CONSIDERED FOR FEDERAL PROJECTS

GENERAL

1. Theory. - Public Law 727, 79th Congress, authorizing Federal participation, states that "with the purpose of preventing damage to public property and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States that are owned by States, municipalities, or other political subdivisions * * ". The problem in Connecticut is primarily the loss and deterioration of its beaches, and secondarily the protection of shore structures from direct damage. The benefits computed herein are based primarily on the promotion and encouragement of the healthful recreation of the people by improvement and restoration of the beaches and secondarily on protection of shore structures. Indirect benefits, such as increased earning power or value of adjacent or indirectly affected private lands, have not been estimated, although known to exist. Intangible benefits, such as prevention of loss of life by elimination of hazardous bathing conditions on steeply sloping beaches, similarly have not been estimated.

2. Standards of Public Beach Space. - Established standards of recreational beach area indicate 75 square feet per person as an optimum. In a densely settled section of the country such as Connecticut, attainment of that optimum is not ordinarily to be expected. Present operating standards of peak beach use in Area 2 indicate recreational beach area on existing town public beaches in Madison of 16.7 square feet per

person, and on Hammonasset State Park Beach of 18.5 square feet per person over the entire beach. The improvements recommended for public beaches in Area 2 are expected to raise this operating recreational area standard to 37.5 square feet for Hammonasset State Park Beach and 75 square feet per person for town public beaches in Madison, if the alternate improvement for Middle Beach is adopted.

Hammonasset State Park is available to the public without restriction. This park draws directly on a population reservoir of the eastern half of Connecticut. State parks draw but little on the population reservoir in the immediate vicinity. Hammonasset State Park has a comparative large attendance due to the fairly good condition of the beach, its only drawback being the narrowness of the beach.

Town Public Beaches.-There are three town public beaches in Area 2 for which there is only an alternate recommendation for one, and no improvements recommended for the other two, their size and location precluding any improvement beneficial to the public.

3. Beach Attendance Formulas. - Study of existing beach attendance figures along the Connecticut shore indicate approximate formulae which have been used in this estimate for determination of annual and peak attendance figures. The estimates are based on a summer season of ten weeks, of which only seven are taken as effective weeks, to allow for weather and other factors.

Town or Local Public Beach Formulae

Day of Week	Attendance	No. of Weeks	Annual Attendance	Peak Attendance (1)
Sunday	3X	7	21X	1.5X
Saturdays	2X	7	14X	X
Weekdays	X	7	35X	0.5X
		Total Attendance	70X	

(1) 50% of attendance for that day.

State Park Beach Formula

Day of Week	Attendance	No. of Weeks	Annual Attendance	Peak[1] Attendance
Sunday	5X	7	35X	2.5X
Saturday	3X	7	21X	1.5X
Weekdays	X	7	35X	0.5X
		Total Attendance	91X	

(1) 50% of attendance for that day.

Hammonasset State Park

4. Present Beach Use. -

a. Total beach area - 500,000 square feet

b. Annual Attendance - 1,000,000 persons

c. Peak Attendance - 27,000 persons

d. Operating standard of recreational beach area provided for peak use - 18.5 square feet per person.

5. Expected Increased Beach Use. -

a. Total proposed beach area - 1,250,000 square feet

b. Expected annual attendance - 1,200,000 persons

c. Expected peak attendance - 33,000 persons

d. Proposed standard of recreational beach area provided for peak use - 37.5 square feet per person.

6. Economic Value of Increased Beach Attendance. - The recreational value of beach use per person may be assumed to equal at least the expenditure he makes for it. It may also be assumed he receives added value above the cost to him, which cannot be evaluated. It may be assumed that the average person using the beach at Hammonasset State Park arrives by automobile with three others. The cost of transportation may be estimated at 60 miles (round trip) at $0.05 per mile. This cost of $3.00 divided by four persons equals $0.75 per person. The fee charged for use of beach

facilities would increase this value to $1.00 per person. Assuming that half of this expenditure is for other than the bathing benefit, the total annual benefit from increased attendance is therefore 200,000 x $0.50 = $100,000.

7. Economic Value of Improved Beach Use Standards. - The present beach area under the porposed standard of recreational beach use area permits a peak attendance of 13,300 persons. Any excess above that number of persons results in lower than the proposed standard. This is equivalent to raising the beach use standards for 115,000 of the present 1,000,000 annual attendance. It is considered that this proposed standard, less than optimum standard, is justified as "improvement of the shore to encourage healthful recreation." Using the same value of $0.50 per person for improving the beach area for 115,000 of the present attendance, will yield a benefit of $57,500. Total recreational benefit - $157,500.

TOWN PUBLIC BEACHES

8. Middle Beach (Recommended Plan of Improvement). -

a. Elimination of present annual maintenance costs.....$700

b. Elimination of toe wall construction estimated to be required within 5 years (700' x $25/') divided by 5.....$3,500

Total Annual Benefit.....$4,200

9. Middle Beach (Alternate Plan of Improvement). - The alternate plan of improvement, consisting of construction of a beach 100 feet wide at Middle Beach, is expected to relieve congestion at the only town public beaches, East Wharf and West Wharf, both of which are impracticable of improvement. Elimination of wall maintenance costs as in Paragraph 8 above yield an annual benefit of $4,200.

10. Present Use of Town Beaches. -

a. Total beach area - 25,000 square feet

b. Annual attendance - 70,000 persons

c. Peak attendance - 1,500 persons

d. Operating standard of recreational beach area provided for peak use - 16.5 square feet per person.

11. Expected Increased Beach Use. -

a. Total proposed beach area - 115,000 square feet

b. Expected annual attendance - 70,000 persons.

c. Expected peak attendance - 1,500 persons

d. Proposed standard of recreational beach use area provided for peak use - 75 square feet per person.

12. Economic Value of Improved Beach Use Standards. - The present town public beach area under the proposed standard of recreational beach use area permits a peak attendance of 330 persons. Any excess above that number of persons results in lower than the proposed standard. This is equivalent to raising the beach use standards for 53,500 of the present 70,000 annual attendance. It is considered that this proposed adoption of the optimum beach use standard is justified as "improvement of the shore to encourage healthful recreation." It is assumed the cost to those using the town beaches is $0.20 per person. The total annual benefit would be 53,500 x 0.20 = $10,700

13. Total Annual Benefit Alternate Plan of Improvement for Middle Beach. -

a. Shore protection.....$ 4,200

b. Recreational benefit..... 10,700

$14,900

APPENDIX I

ESTIMATES OF COSTS OF IMPROVEMENTS CONSIDERED FOR NON-FEDERAL PROJECTS

The estimated life of the considered projects is 50 years. The rate of interest on Non-Federal investments is computed at 3.5 percent.

1. Webster Point to Seaview Beach. - The plan of improvement for this area consists of widening the beach to a 100-foot width.

a. First Costs. -

Beach Construction

67,000 cubic yards of sand at $0.50	$ 33,500
Engineering and Contingencies	4,500
Total Costs	$ 38,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest	$ 1,330
Amortization	290
Annual maintenance	
Replenishment of sand losses, 700 cubic yards sand at $1.50	$ 1,050
Total Non-Federal Annual Charges	$ 2,670

2. Seaview Inlet to East Wharf. - The plan of improvement for this area consists of widening the beach to a 100-foot width and the construction of an impermeable groin 400 feet long.

a. First Costs. -

Beach Construction

50,000 cubic yards sand at $0.60	$30,000
Engineering and Contingencies	4,000
	$34,000

Groin Construction

2500 tons riprap at $10.00		$ 25,000
Engineering and Contingencies		3,500
		$ 28,500
Total Costs		$ 62,500

b. Annual Charges. -

Non-Federal Annual Charges

Interest		$ 2,200
Amortization		480
Annual maintenance		
Replenishment of sand losses, 500 cubic yards sand at $1.50	$ 750	
Repair to groins, 25 tons of riprap at $10.00	250	$ 1,000
Total Non-Federal Annual Charges		$ 3,680

3. East Wharf to Middle Beach. - The plan of improvement for this area consists of widening to a 100-foot width, 1000 feet of beach at the west end of the area and the construction of one impermeable groin 370 feet long.

a. First Costs. -

Beach Construction

48,000 cubic yards sand at $0.60	$ 28,800
Engineering and Contingencies	4,200
	$ 33,000

Groin Construction

2250 tons of riprap at $10.00		$ 22,500
Engineering and Contingencies		3,500
		$ 26,000
Total Cost		$ 59,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest		$ 2,065
Amortization		450
Annual maintenance		
Replenishment of sand losses, 480 cubic yards of sand at $1.50	$ 720	
Repairs to groin, 20 tons of riprap at $10.00	$ 200	$ 920
Total Non-Federal Annual Charges		$ 3,435

4. Middle Beach to Madison Beach Club. - The plan of improvement considered for this area consists of placing riprap to a width of 20 feet along the front of the wall. An alternate plan consists of building a beach 100 feet wide and the construction of one impermeable groin 300 feet long at the west limit of the improvement.

a. First Costs. -

Revetment

2200 tons of riprap at $10.00	$ 22,000
Engineering and Contingencies	3,000
	$ 25,000
Total Cost	$ 25,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest	$ 900

Amortization		$ 500
Annual maintenance		
Repairs to riprap, 25 tons of riprap at $10.00		$ 250
Total Non-Federal Annual Charges		$ 1,650

Alternate Plan

a. First Costs.-

Beach Construction

25,000 cubic yards of sand at $0.80		$ 20,000
Engineering and Contingencies		2,500
		$ 22,500

Groin Construction

2400 tons of riprap at $10.00		$ 24,000
Engineering and Contingencies		3,500
		$ 27,500
Total Costs		$ 50,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest		$ 1,750
Amortization		380
Annual maintenance		
Replenishment of sand losses, 250 cubic yards of sand at $2.00	$ 500	
Repairs to groin, 25 tons of riprap at $10.00	$ 250	750
Total Non-Federal Annual Charges		$ 2,880

5. Madison Beach Club to West Wharf. - The plan of improvement for this area consists of widening 1400 feet of beach to a 100-foot width and the construction of one impermeable groin 320 feet long.

a. First Costs. -

Beach Construction

61,000 cubic yards of sand at $0.50.....		$ 30,500
Engineering and Contingencies.....		4,500
		$ 35,000

Groin Construction

2200 tons of riprap at $10.00.....		$ 22,000
Engineering and Contingencies.....		3,000
		$ 25,000
Total Costs.....		$ 60,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest.....		$ 2,100
Amortization.....		460
Annual maintenance		
Replenishment of sand losses, 600 cubic yards of sand at $1.50.....	$ 900	
Repairs to groin, 25 tons of riprap at $10.00.....	$ 250	1,150
Total Non-Federal Annual Charges.....		$ 3,710

6. West Wharf to Garvin Estate. - The plan of improvement for this area consists of the construction of one impermeable groin 370 feet long.

a. First Costs. -

Beach Protection

None

Groin Construction

1400 tons of riprap at $10.00.....	$ 14,000
Engineering and Contingencies.....	2,000
	$ 16,000
Total Cost.....	$ 16,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest	$ 560
Amortization	120
Annual maintenance	
Repairs to groin, 15 tons of riprap at $10.00	150
Total Non-Federal Annual Charges	$ 830

7. Garvin, Hotchkiss and Gunther Estates. - The plan of improvement for this area consists of widening the beach to a 100-foot width; the construction of two impermeable groins, 300 and 400 feet long; and one impermeable jetty 400 feet long.

a. First Costs. -

Beach Construction

68,000 cubic yards sand at $0.50	$ 34,000
Engineering and Contingencies	5,000
	$ 39,000

Groin Construction

5200 tons of riprap at $10.00	$ 52,000
Engineering and Contingencies	8,000
	$ 60,000
Total Costs	$ 99,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest	$ 3,500
Amortization	760
Annual maintenance	
Replenishment of sand losses, 680 cubic yards sand at $1.50	$ 1,020

Repairs to groin and jetty, 50 tons of riprap at $10.00....	$ 500	$ 1,520
Total Non-Federal Annual Charges.....		$ 5,780

8. Overshores to Lee Manor. - The plan of improvement for this area consists of widening the beach to a 100-foot width and the construction of one impermeable jetty 400 feet long. (The groin at the west end of the improvement is included under the Canoe Harbor plan of improvement in Paragraph 9 below).

a. First Costs. -

Beach Construction

14,500 cubic yards sand at $1.00.....	$ 14,500
Engineering and Contingencies.....	2,000
	$ 16,500

Jetty Construction

1700 tons of riprap at $10.00.....	$ 17,000
Engineering and Contingencies.....	2,500
	$ 19,500
Total Costs.....	$ 36,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest.....		$ 1,260
Amortization.....		275
Annual maintenance		
Replenishment of sand losses, 150 cubic yards sand at $2.00.....	$ 300	
Repairs to groin, 15 tons of riprap at $10.00.....	150	450
Total Non-Federal Annual Charges.....		$ 1,985

9. Canoe Harbor. - The plan of improvement for Canoe Harbor consists of widening to a 100-foot width 2050 feet of beach and the construction of

one impermeable groin 460 feet long.

a. First Costs. -

Beach Construction

98,000 cubic yards of sand at $0.50		$ 49,000
Engineering and Contingencies		7,500
		$ 56,500

Groin Construction

1600 tons of riprap at $10.00		$ 16,000
Engineering and Contingencies		2,500
		$ 18,500
Total Costs		$ 75,000

b. Annual Charges. -

Non-Federal Annual Charges		
Interest		$ 2,625
Amortization		575
Annual maintenance		
Replenishment of sand losses, 980 cubic yards of sand at $1.50	$ 1,470	
Repairs to groin, 15 tons of riprap at $10.00	$ 150	1,620
Total Non-Federal Annual Charges		$ 4,820

10. Seafield Beach through Highlands. - The plan of improvement for this area consists of widening the beach to a 100-foot width and the construction of five impermeable groins 200 to 350 feet long.

a. First Costs. -

Beach Construction

170,000 cubic yards of sand at $0.50	$ 85,000
Engineering and Contingencies	12,500
	$ 97,500

Groin Construction

9800 tons of riprap at $10.00		$ 98,000
Engineering and Contingencies		14,500
		$ 112,500
Total Costs		$ 210,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest		$ 7,350
Amortization		1,600
Annual maintenance		
Replenishment of sand losses, 1700 cubic yards of sand at $1.00	$ 1,700	
Repairs to groins, 100 tons of riprap at $10.00	1,000	2,700
Total Non-Federal Annual Charges		$ 11,650

11. Highlands to Hogshead Point. - The plan of improvement for this area consists of placing riprap to a width of 25 feet along the front of the walls.

a. First Costs. -

Revetment

3400 tons of riprap at $10.00	$ 34,000
Engineering and Contingencies	5,000
Total Cost	$ 39,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest	$ 1,360
Amortization	300
Annual maintenance	
Repairs to riprap, 40 tons of riprap at $10.00	400
Total Non-Federal Annual Charges	$ 2,060

12. Circle Beach. - The plan of improvement for Circle Beach consists of widening the beach to a 100-foot width and the construction of one impermeable groin 350 feet long.

a. First Costs. -

Beach Construction

34,000 cubic yards of sand at $0.65		$ 22,100
Engineering and Contingencies		3,400
		$ 25,500

Groin Construction

2300 tons of riprap at $10.00		$ 23,000
Engineering and Contingencies		3,500
		$ 26,500
Total Costs		$ 52,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest		$ 1,820
Amortization		400
Annual maintenance		
Replenishment of sand losses, 230 cubic yards of sand at $2.00	$ 460	
Repairs to groin, 20 tons of riprap at $10.00	$ 200	660
Total Non-Federal Annual Charges		$ 2,880

13. Circle Beach to End of Half-Mile Road. - The plan of improvement for this area consists of widening the beach to a 100-foot width and the construction of one impermeable groin 400 feet long.

a. First Costs. -

Beach Construction

21,000 cubic yards of sand at $0.70	$ 14,700

Engineering and Contingencies..... $ 2,300

$ 17,000

Groin Construction

1400 tons of riprap at $10.00..... $ 14,000

Engineering and Contingencies..... 2,000

$ 16,000

Total Costs..... $ 33,000

b. Annual Charges. -

Non-Federal Annual Charges

Interest..... $ 1,150

Amortization..... 250

Annual maintenance

Replenishment of sand losses, 210 cubic yards sand at $2.00..... $ 420

Repairs to groins, 15 tons of riprap at $10.00..... 150 570

Total Non-Federal Annual Charges..... $ 1,970

14. Summary. -

	Type of Project	Total Cost of Considered Improvement	Total Non-Federal Annual Charges	Total Cost of Alternate Improvements Considered	Total Non-Federal Annual Charges of Alternate Improvements
Webster Point to Seaview Beach	Beach Construction	$ 38,000	$ 2,670	-	-
Seaview Inlet to East Wharf	Beach Construction	62,500	3,680	-	-
East Wharf to Middle Beach	Beach Construction	59,000	3,435	-	-
Middle Beach to Madison Beach Club	Revetment	25,000	1,650	-	-
Middle Beach to Madison Beach Club	Beach Construction	-	-	50,000	2,880
Madison Beach to West Wharf	Beach Construction	60,000	3,710	-	-

	Type of Project	Total Cost of Considered Improvement	Total Non-Federal Annual Charges	Total Cost of Alternate Improvements Considered	Total Non-Federal Annual Charges of Alternate Improvements
West Wharf to Garvin Estate	Beach Protection	$ 16,000	$ 830	-	-
Garvin, Hotchkiss and Gunther Estates	Beach Construction	99,000	5,780	-	-
Overshores to Lee Manor	Beach Construction	36,000	1,985	-	-
Canoe Harbor	Beach Construction	75,000	4,820	-	-
Seafield Beach Through Highlands	Beach Construction	210,000	11,650	-	-
Highlands to Hogshead Point	Revetment	39,000	2,060	-	-
Circle Beach	Beach Construction	52,000	2,880	-	-
Circle Beach to end of Half-Mile Road	Beach Construction	33,000	1,970	-	-
Total Costs and Charges		$804,500	$47,120	$50,000	$2,880

APPENDIX J

ESTIMATES OF BENEFITS FROM IMPROVEMENTS CONSIDERED FOR NON-FEDERAL PROJECTS

1. Estimate of Increased Land Values. -

   a. Assessed value of Madison shore property west of Hammonasset Beach (excluding buildings).....$920,000

   b. Ratio assessed value to real value..... 0.60

   c. Real value of shore property (a/b).....$1,533,000

   d. Length of shore property..... 21,200 feet

   e. Real value per linear foot of shore property (c/d).....$ 72.30

   f. Estimated increase in value per linear foot due to proposed improvements (50% of e).....$ 36.15

   g. Length of shore included in proposed improvements..... 18,200 feet

   h. Total estimated increase in value (f x g).....$ 657,900

   i. Estimated annual benefit (3.5% of h).....$ 23,000

2. Estimate of Savings in Maintenance of Existing Protective Structures. -

Structure	Length in Feet	Estimated Value	Estimated Annual Maintenance Cost
Sea-walls	14,200	$ 570,000	$ 28,500
Bulkheads	3,900	120,000	6,000
Groins	4,700	30,000	1,500

Total Estimated Annual Maintenance Cost.....$ 36,000

The proposed improvements would eliminate this maintenance cost. Therefore,

Total estimated annual benefit.....$ 36,000

3. Estimate of Loss of Property Prevented by Proposed Improvements. -

   a. Value of shore property in danger of destruction (Including buildings).....$ 50,000

   b. Salvage value of buildings (25% of a.)..... 12,500

c. Estimated value of property losses prevented..... $ 37,500

d. Estimated annual charges on losses prevented..... 1,600

e. Estimated annual benefit..... 1,600

4. Estimate of Savings Effected by Elimination of Need for New Construction Required at Other Unprotected or Inadequately Protected Shores. -

a. Estimated cost of new construction..... $150,000

b. Estimated annual charges..... 6,400

c. Estimated annual maintenance..... 3,000

d. Total annual charges = benefits..... 9,400

5. Justification. -

a. Annual charges total proposed improvement costs... $ 47,120

b. Estimated annual benefits..... 70,000

c. Ratio benefits to costs..... 1.5

APPENDIX K

POLLUTION ALONG THE CONNECTICUT SHORE

1. Pollution Study. - A sanitary study of shore bathing waters was carried out by the State of Connecticut, Department of Health, during the summers of 1945, 1946 and 1948. The purpose of the study was to obtain specific information concerning the sanitary condition of bathing areas and to notify local authorities and interested persons about "danger spots" along the shore which are seriously affected by sewage pollution. The entire shore line of the State of Connecticut, including a number of small coves and the lower part of some tidal streams, was examined during this period.

2. Bacterial Survey. - A bacterial survey was made consisting of water samples taken at approximately 1000-foot intervals along the shore at over 1000 stations in water depths of from 2 to 6 feet, such depths covering most of the areas used for bathing. These samples were taken at four stages of the tide; namely, high, low, mean ebb and mean flood. Wind direction at the time of sampling was recorded. No attempt was made to take samples under different wind conditions as it was believed that the run of the tide was the principal factor influencing the travel of pollution along the shore. A laboratory analysis in each of three dilutions of 10 ml., 1.0 ml. and 0.1 ml. was made for each sample obtained. From this analysis the most probable number of coliform organisms per 100 ml. was computed. The final result for each sampling station was obtained by averaging the computed most probable numbers for the four samples at each station.

3. Sanitary Survey. - In addition to the bacterial survey described above, a sanitary survey of shore areas was conducted. This included the location of sewer outlets, with data as to flows and character of untreated

and treated sewage. Much of this data was already available from previous detailed studies. 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.

4. Comparison of Bacterial and Sanitary Surveys. - The entire shore area was divided into sections varying in length from 1000 feet to one or more miles for the purpose of classification. The shore was classified as A, B, C or D, representing good, fair, doubtful to poor, and poor conditions, respectively. From the bacterial survey, Class A was considered to include samples containing from 0 to 50 coliform organisms per 100 ml.; Class B, 51 to 500; Class C, 501 to 1000; and Class D, over 1000. From the sanitary survey data the shore sections were also classified into the four groups described above. A tabulation of the results of these two classifications is given below.

	Bacterial Analysis Classification		Sanitary Survey Classification	
	Mileage	Percentage	Mileage	Percentage
Class A	90.7	35.9	65.1	25.8
Class B	103.6	41.1	75.9	30.1
Class C	15.1	6.0	65.7	26.0
Class D	42.9	17.0	45.6	18.1
	252.3	100.0	252.3	100.0

A comparison of the bacterial analysis and sanitary survey classifications shows that 61.1 percent of the shore was graded the same in both classifications; 34.3 percent of the shore falls into one grade lower according to the sanitary survey classification than according to the bacterial analysis classification; 3.6 percent of the shore falls into one

grade higher and 1.0 percent of the shore falls into two grades lower according to the sanitary survey classification. In general, then, it can be said that with minor exceptions the bacterial analysis classification grades the shore the same as or one class higher than the sanitary survey classification.

5. Spread of Disease at Bathing Places. - The Joint Committee on Bathing Places of the American Public Health Association and the Conference of State Sanitary Engineers published a comprehensive report in which is reviewed the possibilities of the spread of disease through the use of bathing places. This review was prepared after a comprehensive survey of reported cases of illness attributed to such waters. Although recognizing the possibilites of transmission of disease at bathing places, the Joint Committee concludes that there is little known evidence that this has occurred. They point out that careful surveillance and proper sanitary control should be exercised and recommend against bathing in grossly polluted waters.

6. Polluted Shore Areas in Connecticut. - In general, from the Connecticut study it was found that pollution existed principally in harbor waters and in waters in close proximity to harbors. This pollution is rapidly dissipated by dilution in Long Island Sound so that many miles of Connecticut shore line are in excellent condition. Considerable progress has been made in the improvement of conditions in harbors through sewage treatment plant installations. Due to a tendency toward extensive use of bathing beaches near urban centers, a few bathing places are located in areas close to the border line of safety. Although this condition is undesirable and indicates a need for improvement, no alarm is felt at present in view of the absence of reported cases of illness acquired at these localities. Many individual cases of local pollution have been disclosed by the

survey. These sources though small in magnitude are considered more dangerous due to their proximity to bathing areas than larger sources of pollution at a greater distance. The two principal rivers entering Long Island Sound, the Connecticut and the Housatonic, receive a large amount of pollution. Due to self-purification and later dilution in Long Island Sound, these rivers cause very little pollution load on the Sound. Within a distance of 1000 feet on either side of the Housatonic River no pollution effect was noted. The bacteria counts of samples along the mouth of the Connecticut River were all relatively low. The following areas in Connecticut were classified as being in poor condition:

a. Vicinity of sewer outlets at New London and Groton

b. Localized areas at Bridgeport, Norwalk and New Haven

c. Byram River between Portchester, N. Y., and Greenwich

d. The upper part of Cos Cob Harbor in Greenwich

e. The Saugatuck River section of Westport

f. The Mill River section of Fairfield

g. The mouth of the Branford River

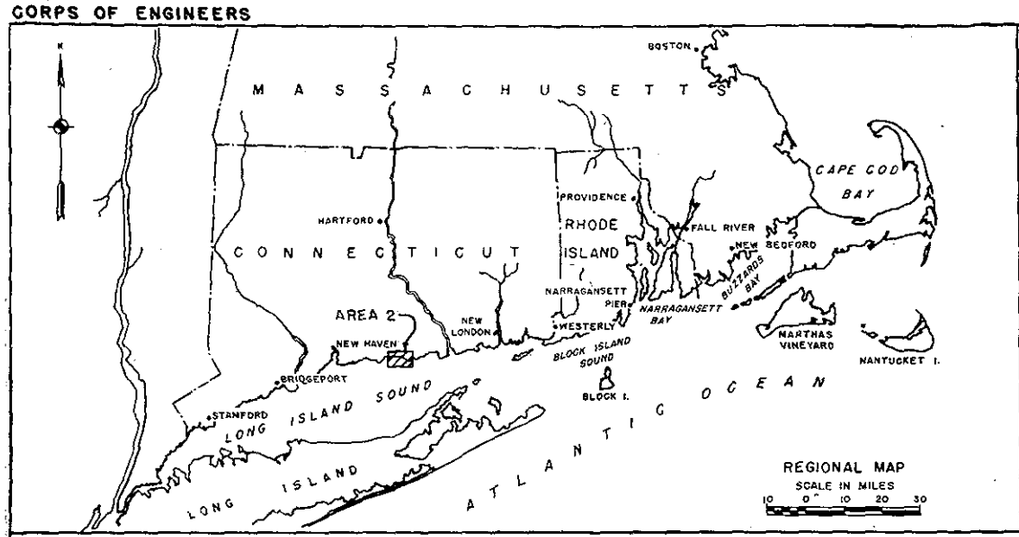
h. The vicinity of Grove Beach in Westbrook

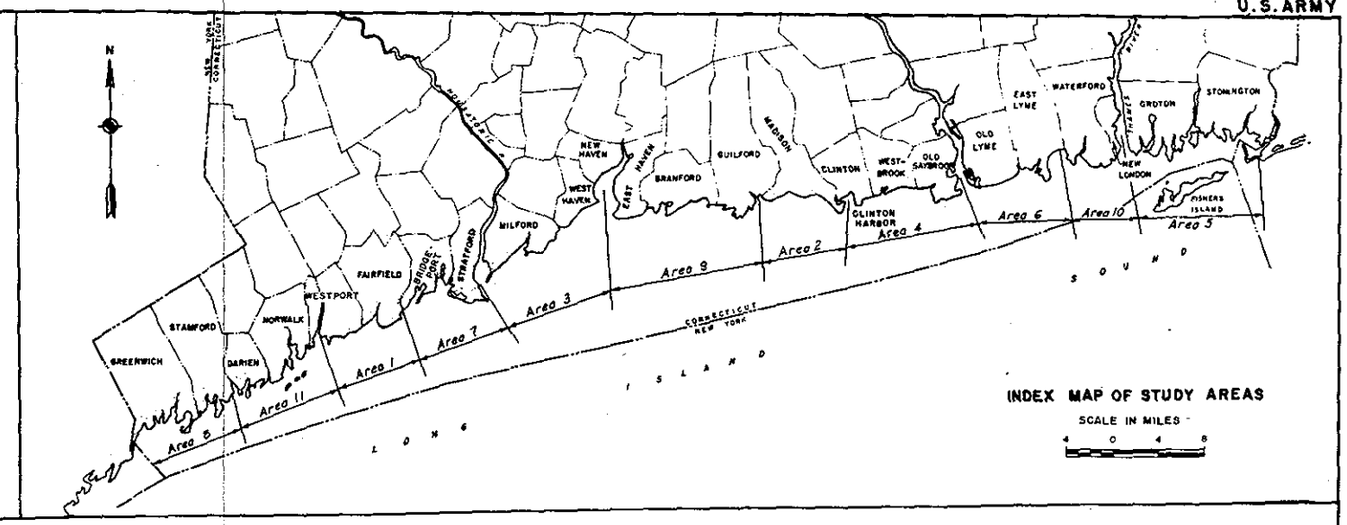
i. Stonington Harbor

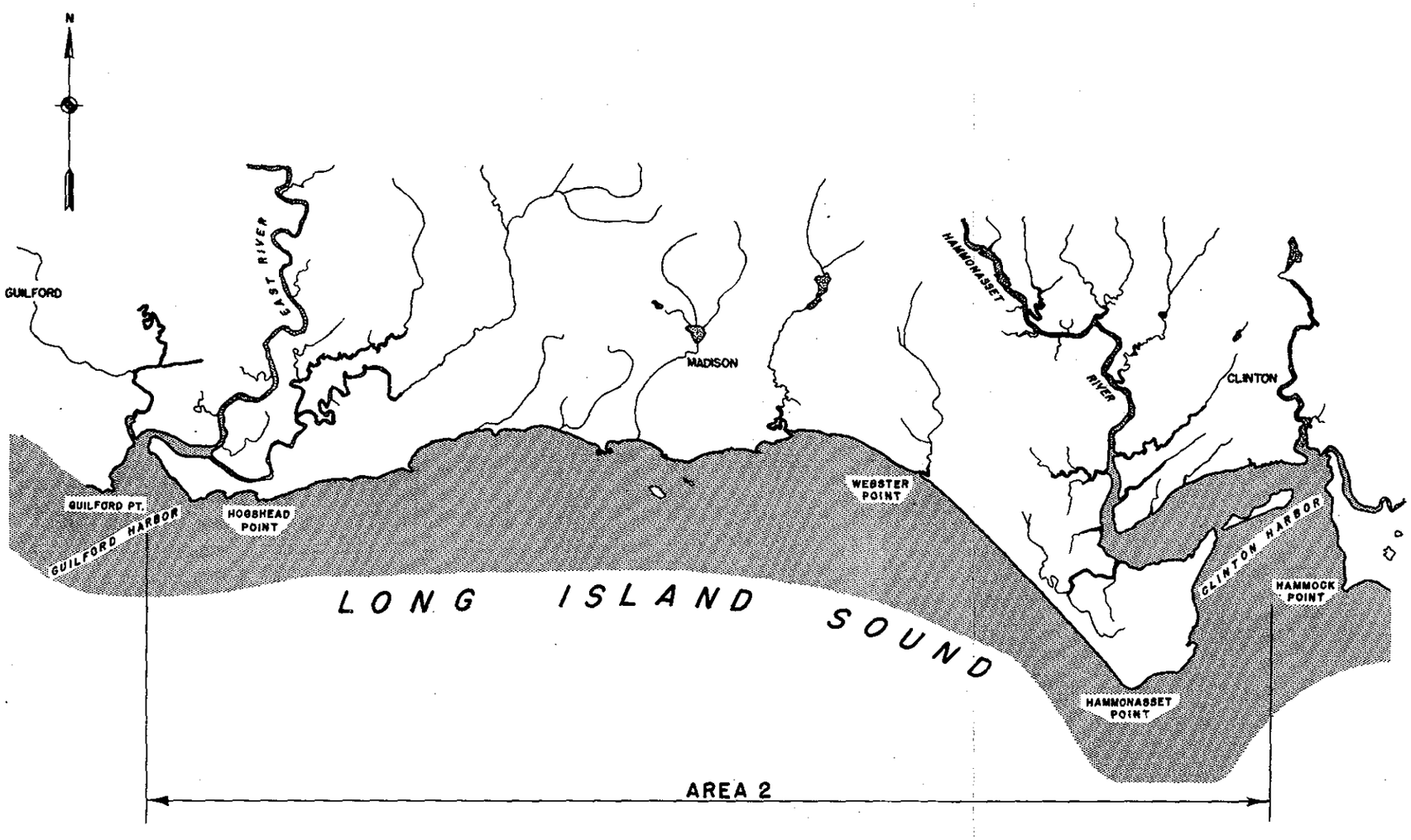
j. The easterly section of Stonington, particularly the vicinity of the mouth of the Pawcatuck River

k. Many sewer outlets in Mystic

The pollution in the above areas is very local with little pollution effect noticeable at relatively short distances away, with the exception of the Pawcatuck River area where the pollution carries for a considerable distance.







TRACED FROM U.S.C. & G.S. CHARTS 216 & 217

CONNECTICUT BEACH EROSION CONTROL STUDY

LOCATION MAP AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 1 SHEET SCALE IN FEET

2000 0 2000 4000

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

APPROVAL RECOMMENDED: H. A. Whitcomb, CHIEF, B & H OPERATIONS DIVISION

SUBMITTED: B & H PROJECTS AND REPORTS BRANCH

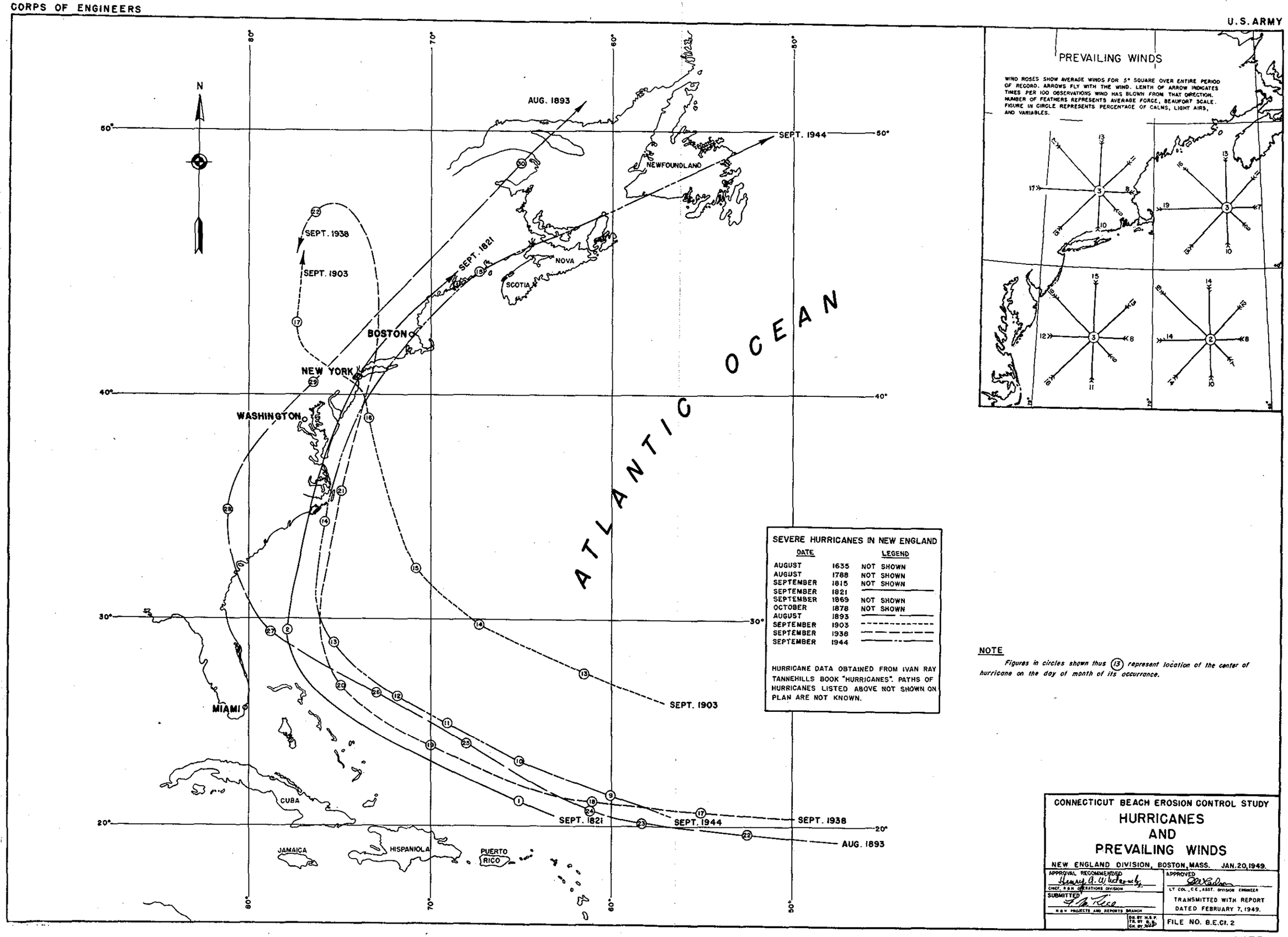
APPROVED: LT. COL. C.E., ASST. DIVISION ENGINEER

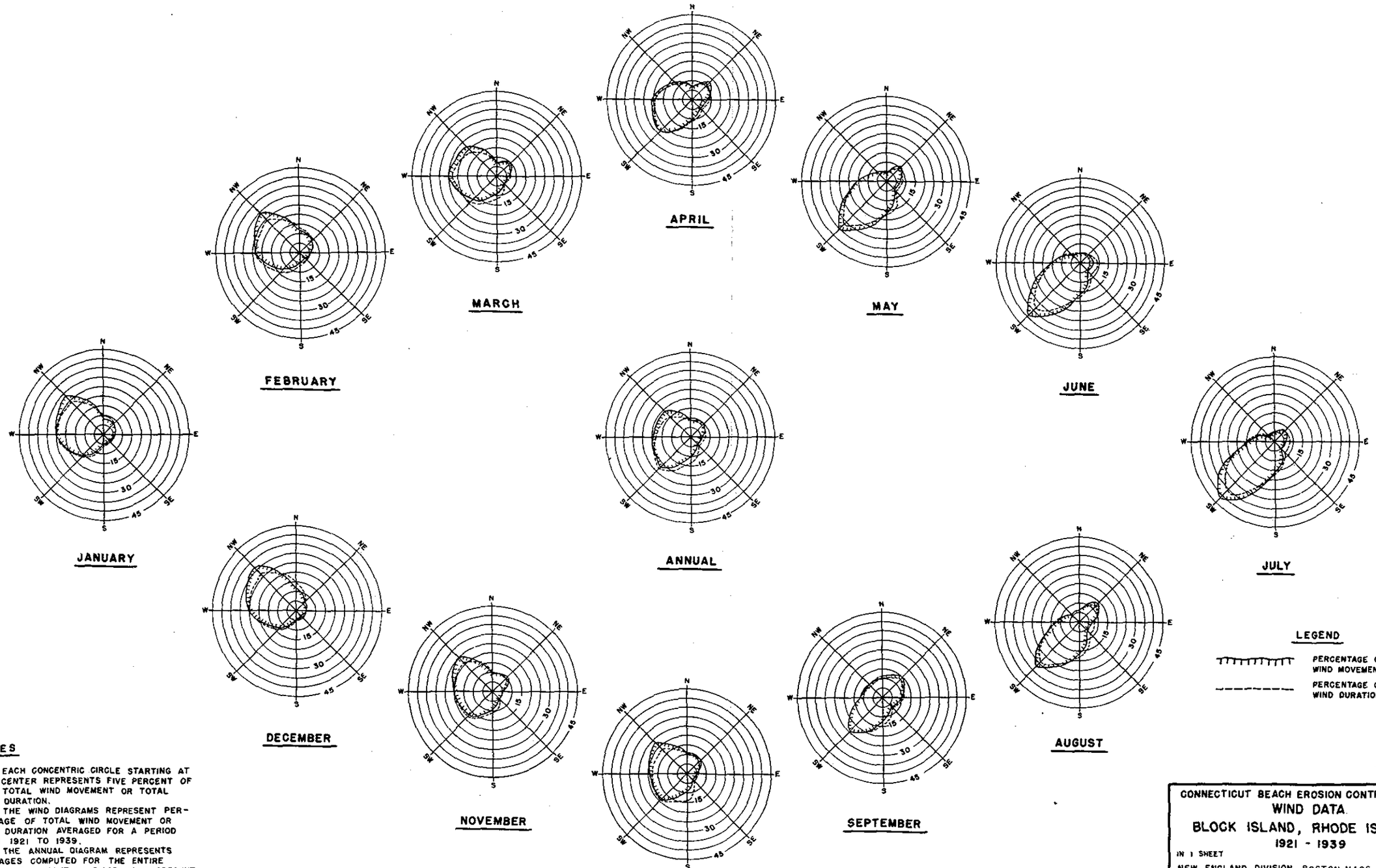
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.

DR. BY H.S.P. TR. BY R.S.P. CK. BY RJP

FILE NO. B.E. Ct. 15

PLATE 1


N
80°
70°
60°
50°
40°
30°
20°
AUG. 1893
SEPT. 1944
NEWFOUNDLAND
SEPT. 1938
SEPT. 1903
SEPT. 1821
NOVA
SCOTIA
BOSTON
NEW YORK
WASHINGTON
MIAMI
CUBA
JAMAICA
HISPANIOLA
PUERTO RICO
ATLANTIC OCEAN
SEPT. 1903
SEPT. 1821
SEPT. 1944
SEPT. 1938
AUG. 1893
PREVAILING WINDS
WIND ROSES SHOW AVERAGE WINDS FOR 5° SQUARE OVER ENTIRE PERIOD OF RECORD. ARROWS FLY WITH THE WIND. LENTH 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.
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.
CONNECTICUT BEACH EROSION CONTROL STUDY
HURRICANES AND PREVAILING WINDS
NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 20, 1949.
APPROVAL RECOMMENDED
CHIEF, R&H OPERATIONS DIVISION
SUBMITTED
R&H PROJECTS AND REPORTS BRANCH
APPROVED
LT. COL., C.E., ASST. DIVISION ENGINEER
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
FILE NO. B.E.Ct. 2



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

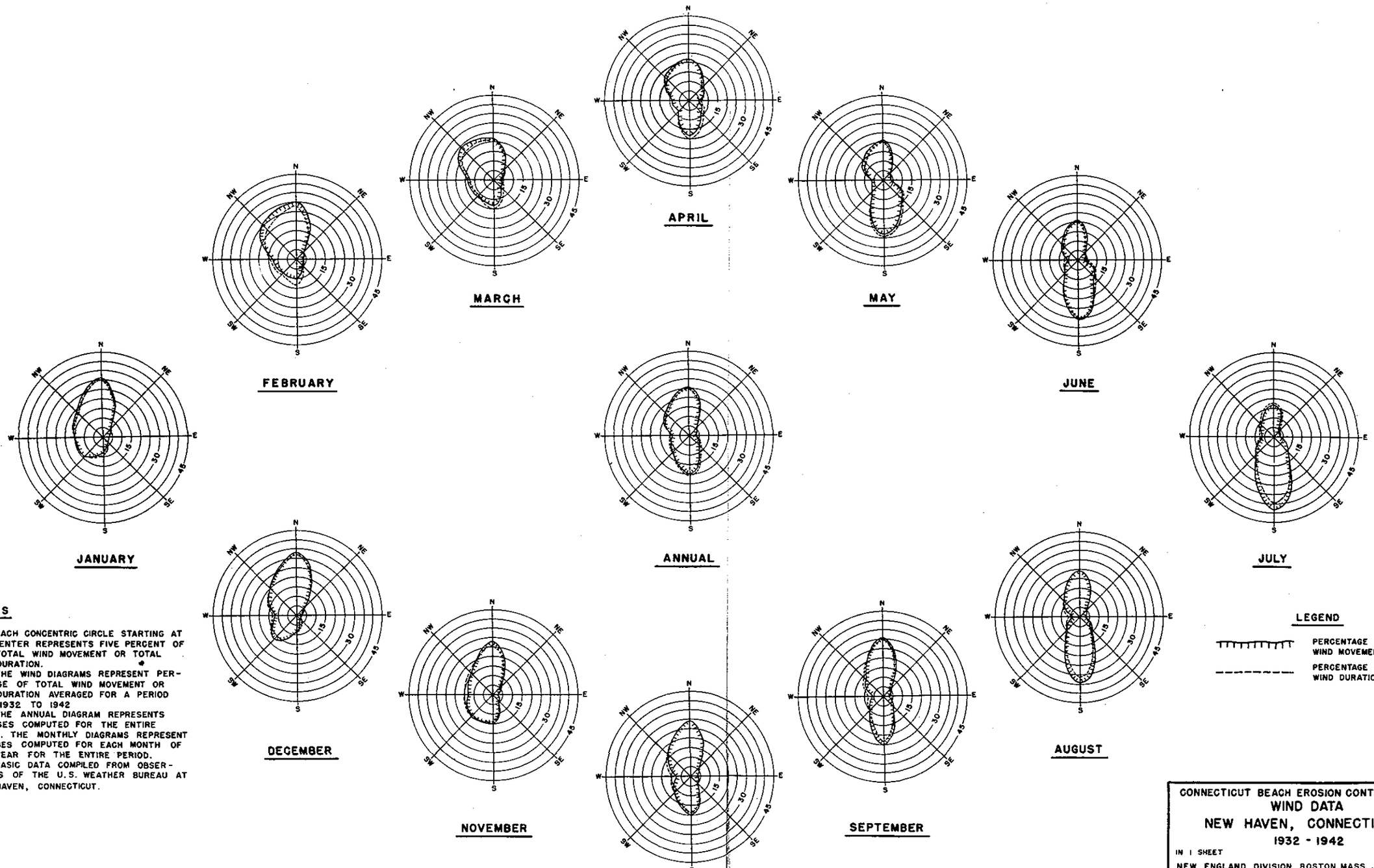
BLOCK ISLAND, RHODE ISLAND

1921 - 1939

IN 1 SHEET

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

APPROVAL RECOMMENDED CHIEF, R & H OPERATIONS DIVISION	APPROVED LT COL, C.E., ASST DIVISION ENGINEER
SUBMITTED R & H PROJECTS AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR BY H.S.P. TR BY R.S. CH BY	FILE NO. B.E.CI.3



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

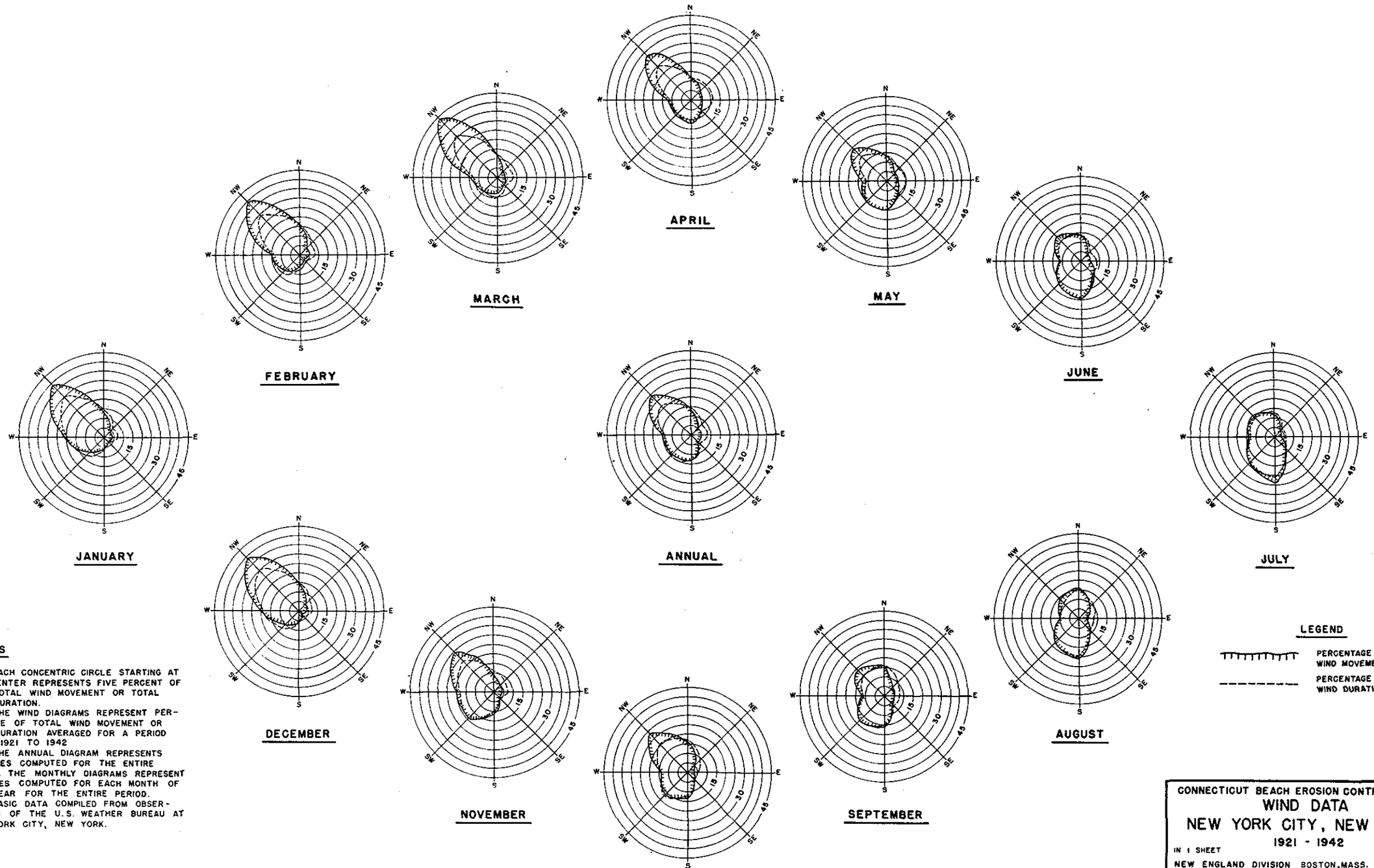
CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA
NEW HAVEN, CONNECTICUT
1932 - 1942

IN 1 SHEET

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

APPROVAL RECOMMENDED	APPROVED
Henry A. Whitcomb, CHIEF, A & H OPERATIONS DIVISION	LT COL., C.E., ASST. DIVISION ENGINEER
SUBMITTED, A & H PROJECTS AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY H.S.P. TR. BY M.N. CH. BY	FILE NO. S.E.C1.4



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 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 YORK CITY, NEW YORK.

LEGEND

PERCENTAGE OF TOTAL WIND MOVEMENT

PERCENTAGE OF TOTAL WIND DURATION

CONNECTICUT BEACH EROSION CONTROL STUDY

WIND DATA

NEW YORK CITY, NEW YORK

1921 - 1942

IN 1 SHEET

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

APPROVAL RECOMMENDED: Henry A. Whitcomb, Jr. — CHIEF, R & H OPERATIONS DIVISION	APPROVED: [illegible] — LT COL, C.E., ASST DIVISION ENGINEER
SUBMITTED: [illegible] — R & H PROJECTS AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY H.S.R. TR. BY D.A. CH. BY [illegible]	FILE NO. B.E.C1.5

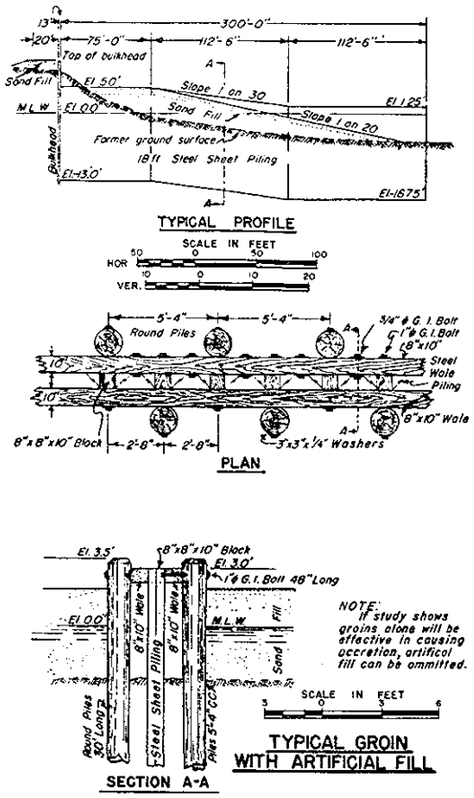


FIGURE 1

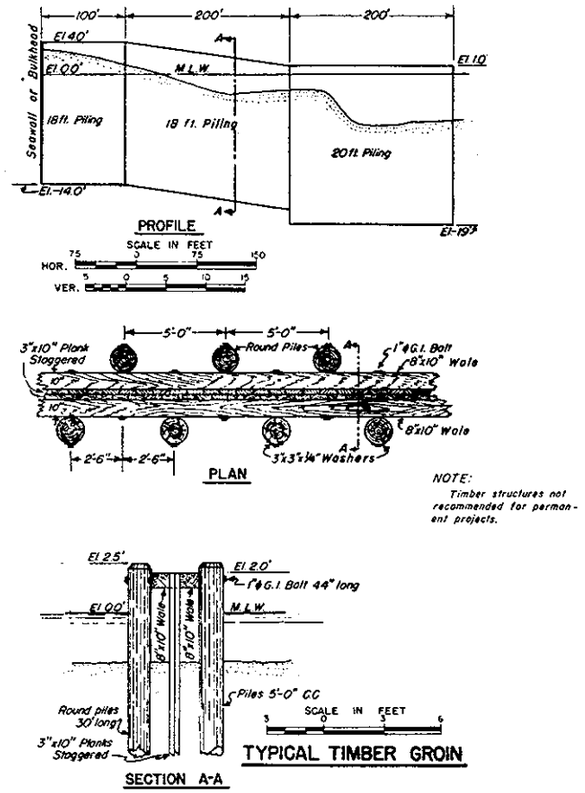


FIGURE 2

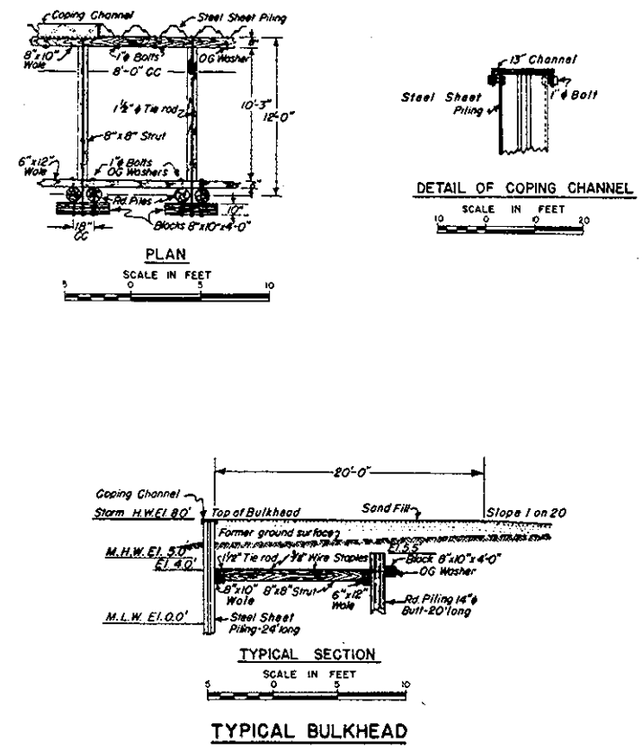


FIGURE 3

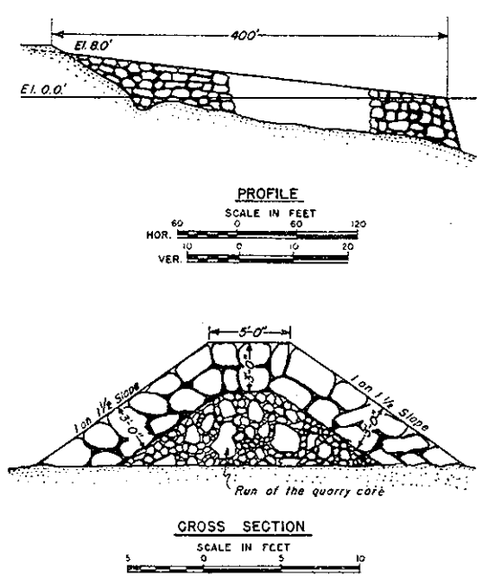


FIGURE 4

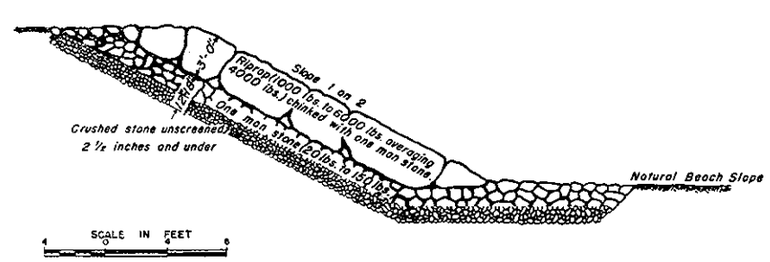


FIGURE 5

NOTE

Typical construction details reproduced from "Engineering Manual for Civil Works, Beach Erosion Studies," Part CXXXIII dated April 1947.

CONNECTICUT BEACH EROSION CONTROL STUDY

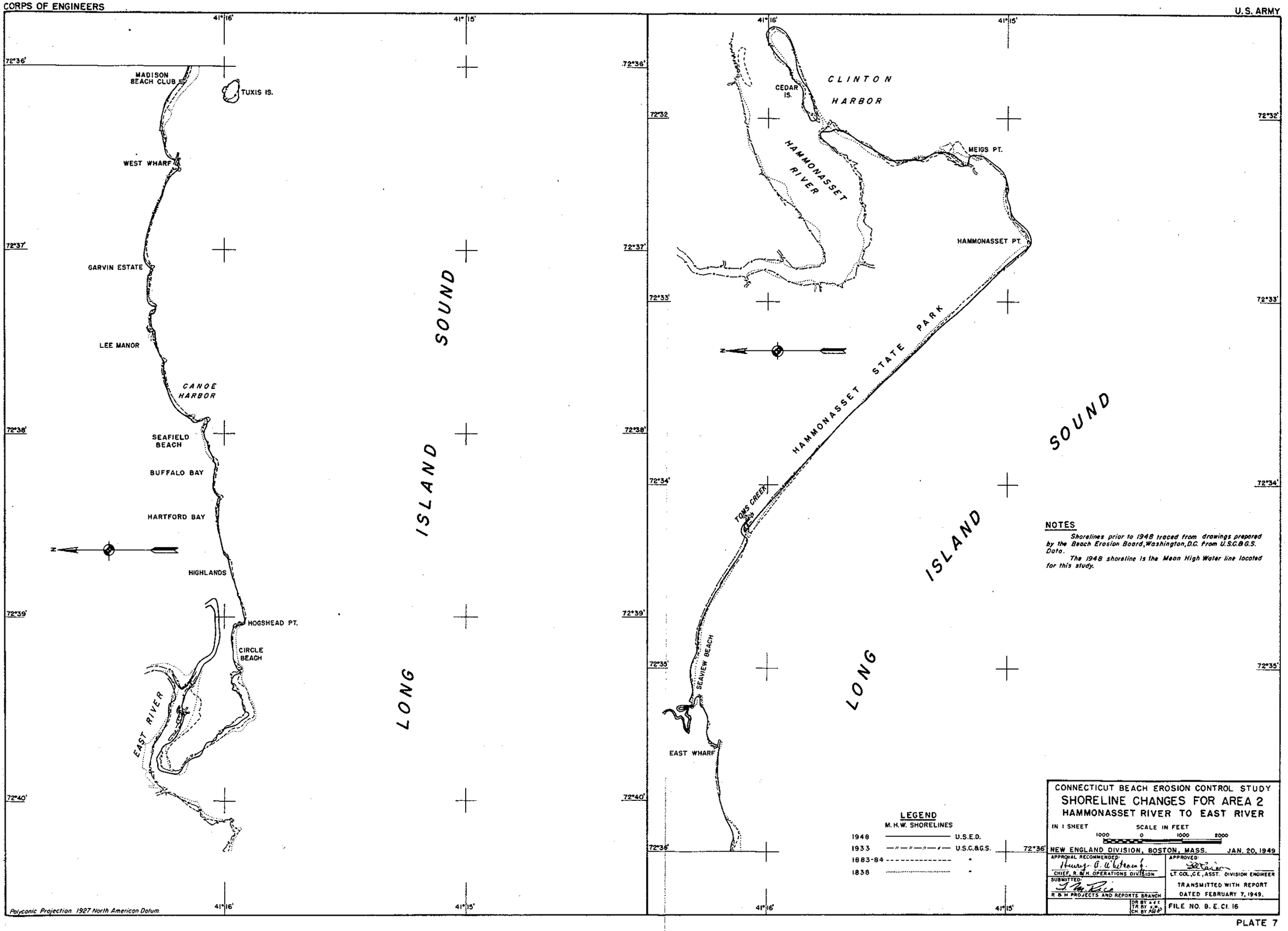
SHORE STRUCTURES

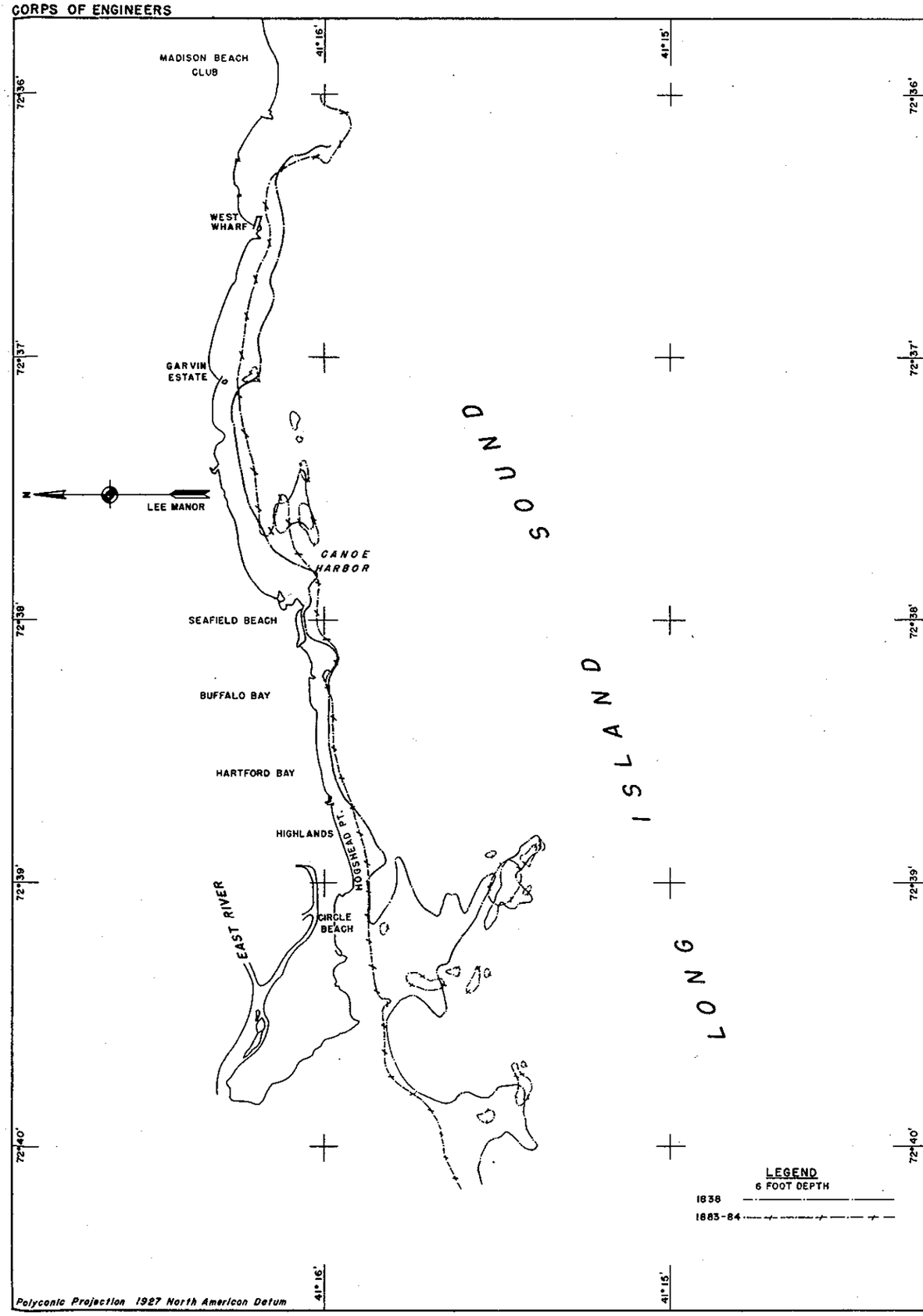
TYPICAL CONSTRUCTION DETAILS

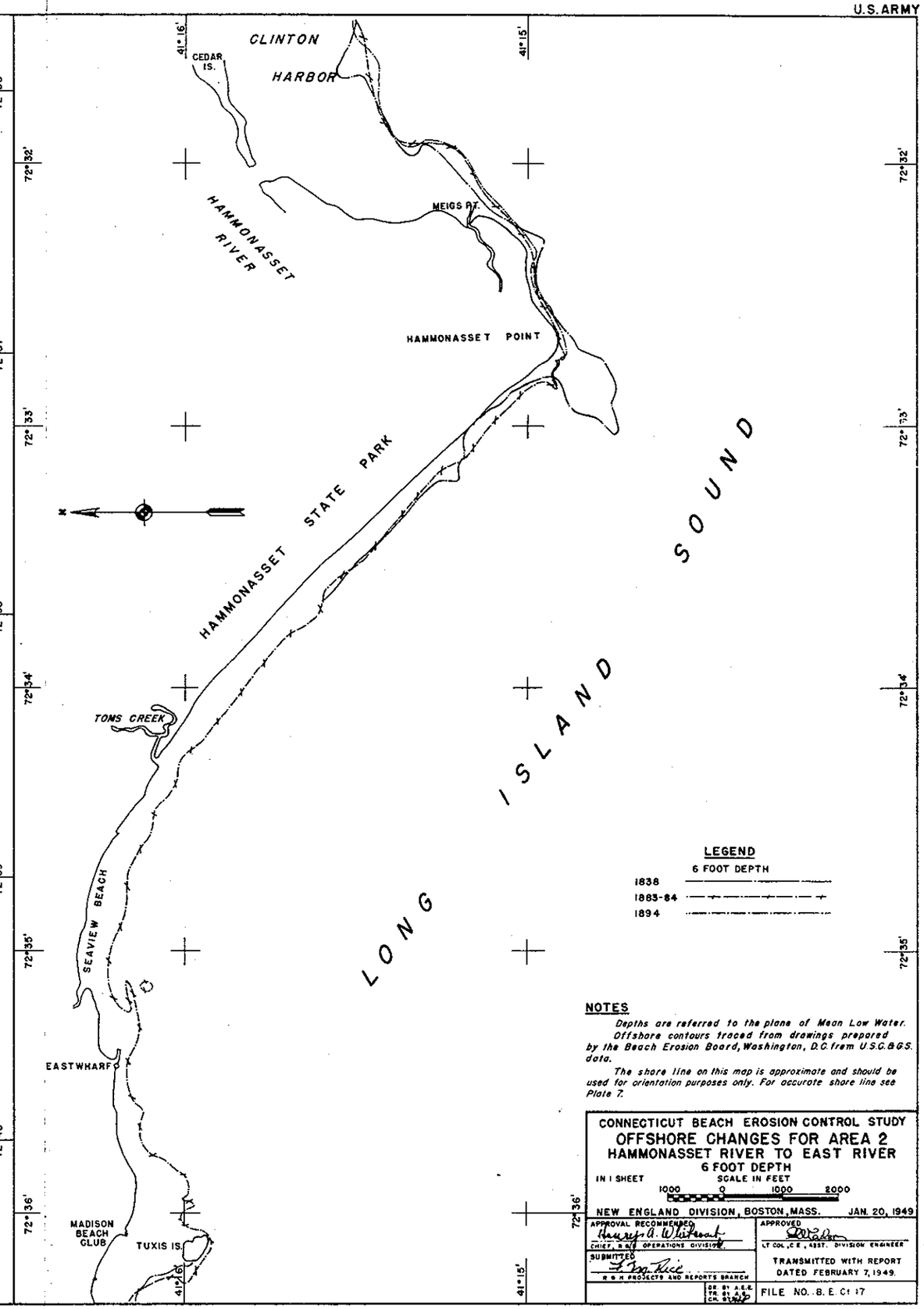
IN 1 SHEET — SCALE AS SHOWN

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	TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY H.S.P. TR. BY H.S. CH. BY H.S.P.	FILE NO. B.E.Cl. 6


41°16'
41°15'
72°36'
72°37'
72°38'
72°39'
72°40'
MADISON BEACH CLUB
TUXIS IS.
WEST WHARF
GARVIN ESTATE
LEE MANOR
CANOE HARBOR
SEAFIELD BEACH
BUFFALO BAY
HARTFORD BAY
HIGHLANDS
HOGSHEAD PT.
CIRCLE BEACH
EAST RIVER
LONG ISLAND SOUND
CLINTON HARBOR
CEDAR IS.
HAMMONASSET RIVER
MEIGS PT.
HAMMONASSET PT.
HAMMONASSET STATE PARK
TOMS CREEK
SEAVIEW BEACH
EAST WHARF
72°32'
72°33'
72°34'
72°35'
Polyconic Projection 1927 North American Datum
LEGEND
M. H. W. SHORELINES
1948 U.S.E.D.
1933 U.S.C.&G.S.
1883-84 "
1838 "
NOTES
Shorelines prior to 1948 traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. Data.
The 1948 shoreline is the Mean High Water line located for this study.
CONNECTICUT BEACH EROSION CONTROL STUDY
SHORELINE CHANGES FOR AREA 2
HAMMONASSET RIVER TO EAST RIVER
IN 1 SHEET
SCALE IN FEET
1000 0 1000 2000
NEW ENGLAND DIVISION, BOSTON, MASS.
JAN. 20, 1949
APPROVAL RECOMMENDED:
CHIEF, R. & H. OPERATIONS DIVISION
SUBMITTED:
R & H PROJECTS AND REPORTS BRANCH
DR BY
TR BY
CH. BY
APPROVED:
LT. COL., C.E., ASST. DIVISION ENGINEER
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
FILE NO. B. E. C. I. 16





NOTES

Depths are referred to the plane of Mean Low Water. Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.

The shore line on this map is approximate and should be used for orientation purposes only. For accurate shore line see Plate 7.

Polyconic Projection 1927 North American Datum

CONNECTICUT BEACH EROSION CONTROL STUDY

OFFSHORE CHANGES FOR AREA 2
HAMMONASSET RIVER TO EAST RIVER
6 FOOT DEPTH

IN 1 SHEET — SCALE IN FEET 1000 0 1000 2000

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

APPROVAL RECOMMENDED: Harry A. Whitcomb, CHIEF, N.E.D. OPERATIONS DIVISION

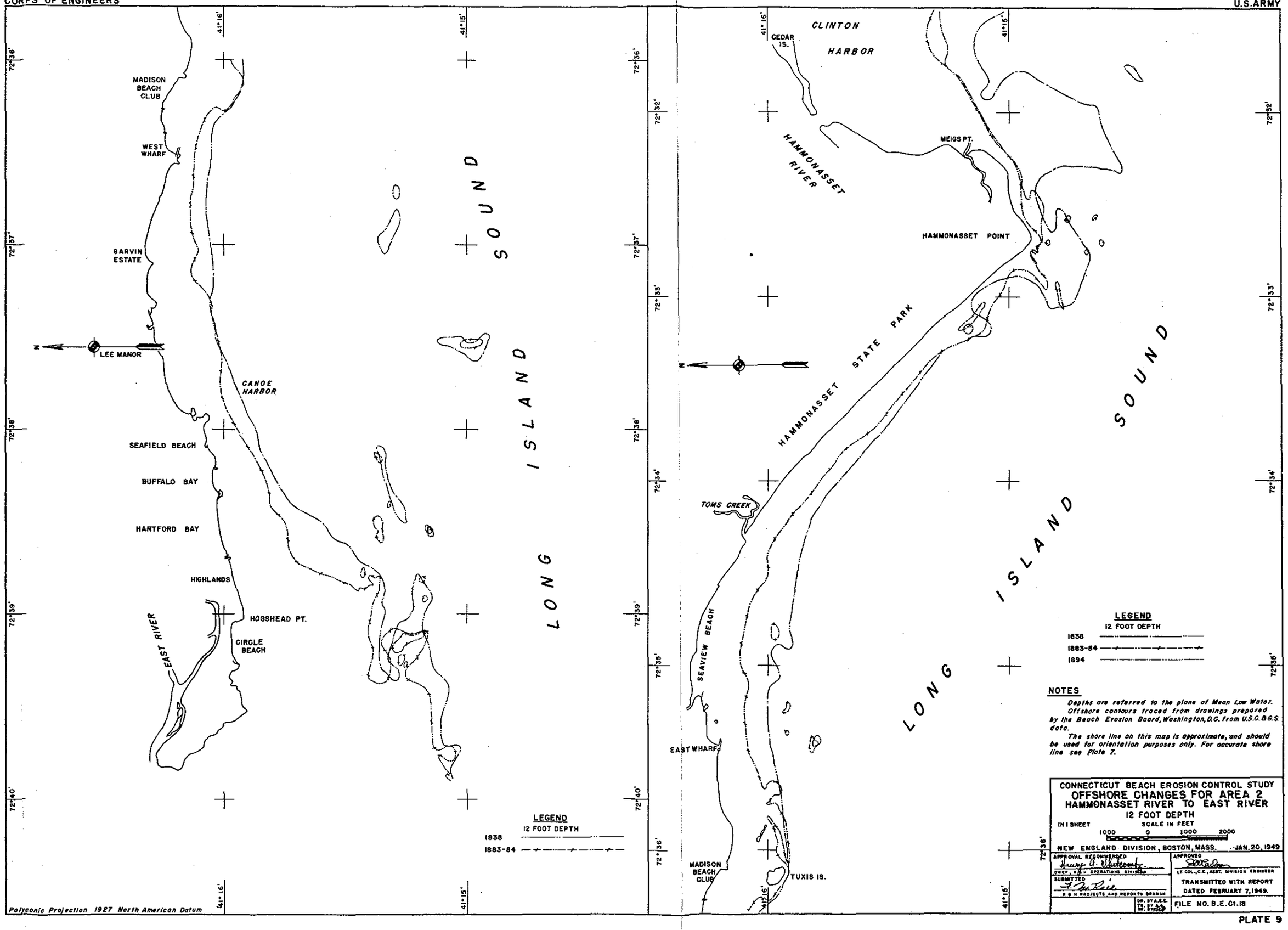
APPROVED: LT COL., C.E., ASST. DIVISION ENGINEER

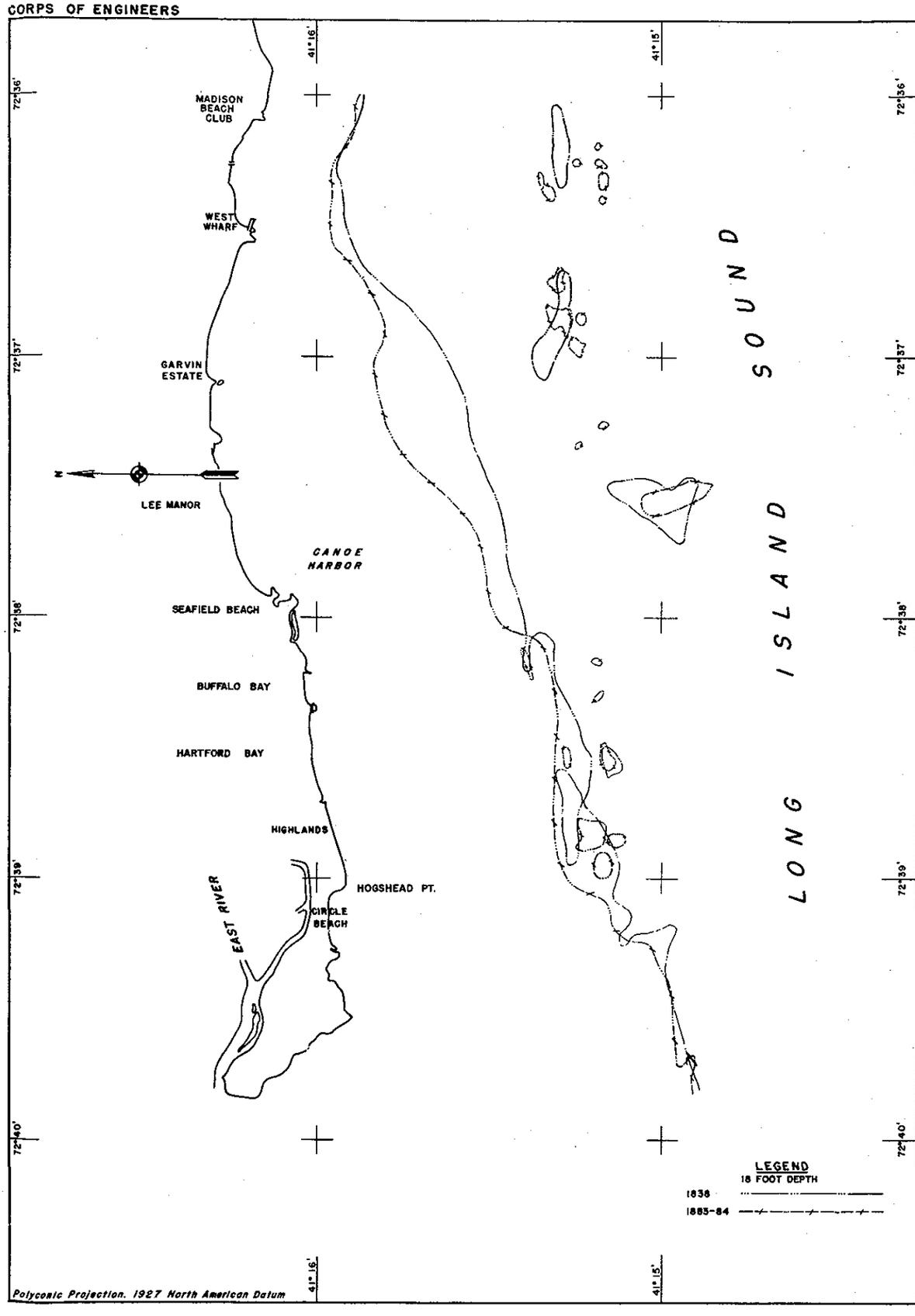
SUBMITTED: E. Jon Rice, N.E.D. PROJECTS AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.

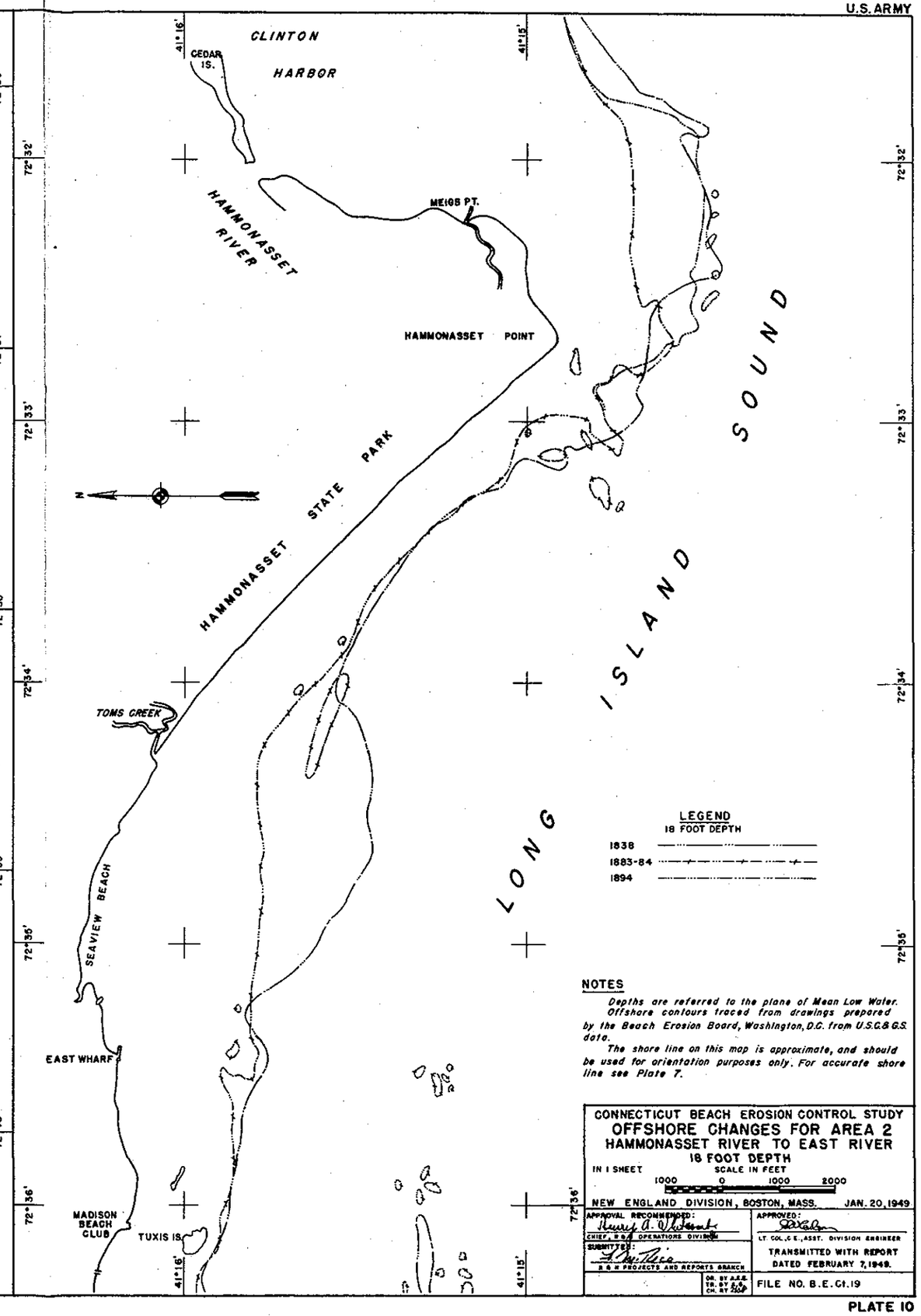
DR. BY A.E.R. TR. BY A.J. CK. BY

FILE NO. B.E. C1 17


MADISON BEACH CLUB
WEST WHARF
GARVIN ESTATE
LEE MANOR
CANOE HARBOR
SEAFIELD BEACH
BUFFALO BAY
HARTFORD BAY
HIGHLANDS
HOGSHEAD PT.
CIRCLE BEACH
EAST RIVER
LONG ISLAND SOUND
LEGEND
12 FOOT DEPTH
1838
1883-84
CLINTON HARBOR
CEDAR IS.
HAMMONASSET RIVER
MEIGS PT.
HAMMONASSET POINT
HAMMONASSET STATE PARK
TOMS CREEK
SEAVIEW BEACH
EAST WHARF
MADISON BEACH CLUB
TUXIS IS.
LEGEND
12 FOOT DEPTH
1838
1883-84
1894
NOTES
Depths are referred to the plane of Mean Low Water.
Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.&G.S. data.
The shore line on this map is approximate, and should be used for orientation purposes only. For accurate shore line see Plate 7.
CONNECTICUT BEACH EROSION CONTROL STUDY
OFFSHORE CHANGES FOR AREA 2
HAMMONASSET RIVER TO EAST RIVER
12 FOOT DEPTH
IN 1 SHEET
SCALE IN FEET
1000 0 1000 2000
NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 20, 1949
APPROVAL RECOMMENDED
CHIEF, R&H OPERATIONS DIVISION
SUBMITTED
R&H PROJECTS AND REPORTS BRANCH
APPROVED
LT. COL., C.E., ASST. DIVISION ENGINEER
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
FILE NO. B.E.CT.18
Polyconic Projection 1927 North American Datum



Polyconic Projection. 1927 North American Datum



NOTES

Depths are referred to the plane of Mean Low Water. Offshore contours traced from drawings prepared by the Beach Erosion Board, Washington, D.C. from U.S.C.& G.S. data.

The shore line on this map is approximate, and should be used for orientation purposes only. For accurate shore line see Plate 7.

CONNECTICUT BEACH EROSION CONTROL STUDY
OFFSHORE CHANGES FOR AREA 2
HAMMONASSET RIVER TO EAST RIVER
18 FOOT DEPTH

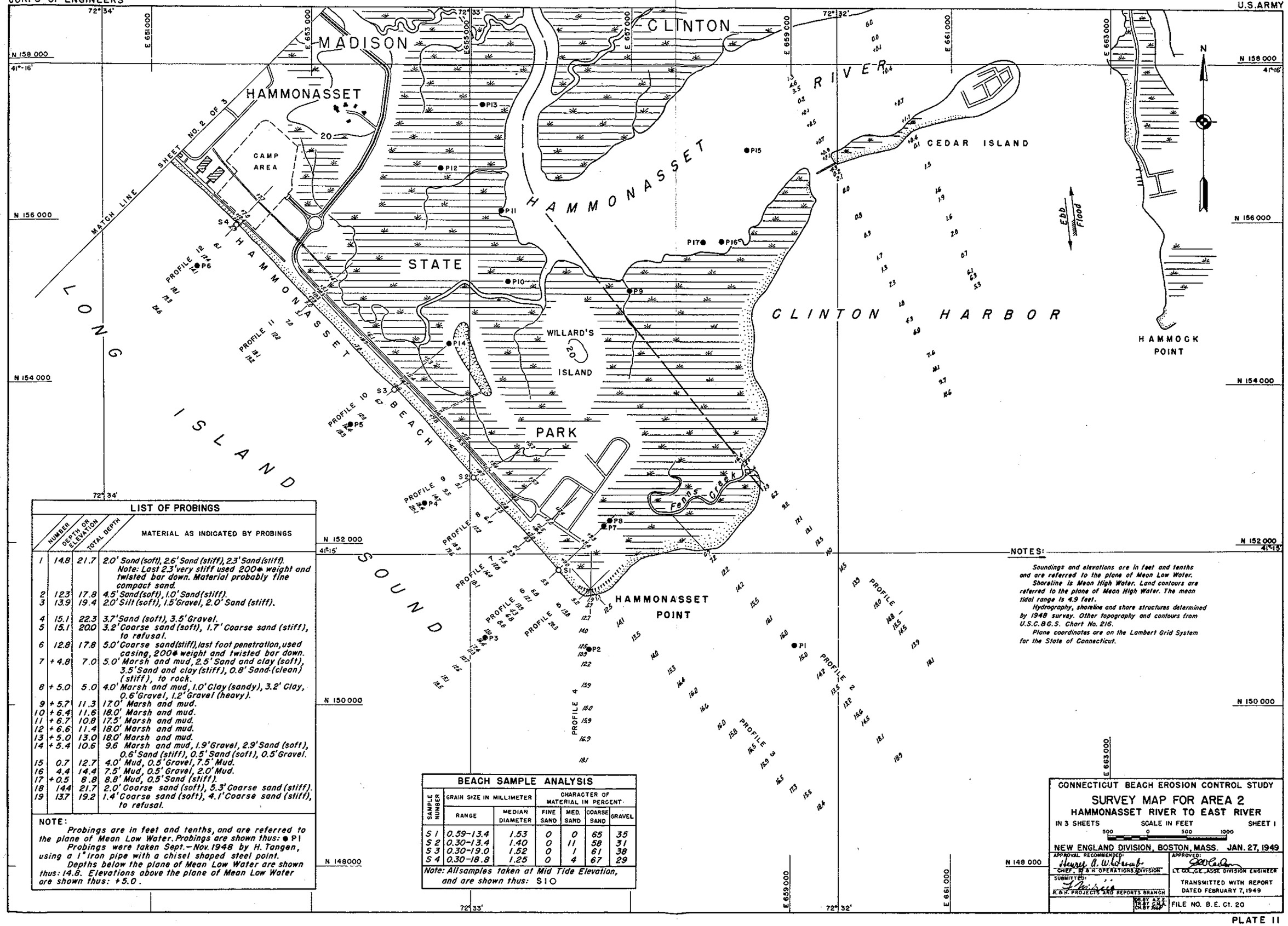
IN 1 SHEET — SCALE IN FEET 1000 0 1000 2000

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

APPROVAL RECOMMENDED: Henry A. Wisser — CHIEF, B & H OPERATIONS DIVISION
SUBMITTED: — B & H PROJECTS AND REPORTS BRANCH
APPROVED: — LT. COL., C.E., ASST. DIVISION ENGINEER
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY A.E.E. TR. BY E.G. CH. BY
FILE NO. B.E.C1.19

CORPS OF ENGINEERS

U.S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
1	14.8	21.7	2.0' Sand (soft), 2.6' Sand (stiff), 2.3' Sand (stiff). Note: Last 2.3' very stiff used 200# weight and twisted bar down. Material probably fine compact sand.
2	12.3	17.8	4.5' Sand (soft), 1.0' Sand (stiff).
3	13.9	19.4	2.0' Silt (soft), 1.5' Gravel, 2.0' Sand (stiff).
4	15.1	22.3	3.7' Sand (soft), 3.5' Gravel.
5	15.1	20.0	3.2' Coarse sand (soft), 1.7' Coarse sand (stiff), to refusal.
6	12.8	17.8	5.0' Coarse sand (stiff), last foot penetration, used casing, 200# weight and twisted bar down.
7	+4.8	7.0	5.0' Marsh and mud, 2.5' Sand and clay (soft), 3.5' Sand and clay (stiff), 0.8' Sand (clean) (stiff), to rock.
8	+5.0	5.0	4.0' Marsh and mud, 1.0' Clay (sandy), 3.2' Clay, 0.6' Gravel, 1.2' Gravel (heavy).
9	+5.7	11.3	17.0' Marsh and mud.
10	+6.4	11.6	18.0' Marsh and mud.
11	+6.7	10.8	17.5' Marsh and mud.
12	+6.6	11.4	18.0' Marsh and mud.
13	+5.0	13.0	18.0' Marsh and mud.
14	+5.4	10.6	9.6 Marsh and mud, 1.9' Gravel, 2.9' Sand (soft), 0.6' Sand (stiff), 0.5' Sand (soft), 0.5' Gravel.
15	0.7	12.7	4.0' Mud, 0.5' Gravel, 7.5' Mud.
16	4.4	14.4	7.5' Mud, 0.5' Gravel, 2.0' Mud.
17	+0.5	8.8	8.8' Mud, 0.5' Sand (stiff).
18	14.4	21.7	2.0' Coarse sand (soft), 5.3' Coarse sand (stiff).
19	13.7	19.2	1.4' Coarse sand (soft), 4.1' Coarse sand (stiff), to refusal.

NOTE:

Probings are in feet and tenths, and are referred to the plane of Mean Low Water. Probings are shown thus: ● P1

Probings were taken Sept.–Nov. 1948 by H. Tangen, using a 1" iron pipe with a chisel shaped steel point.

Depths below the plane of Mean Low Water are shown thus: 14.8. Elevations above the plane of Mean Low Water are shown thus: +5.0.

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S1	0.59–13.4	1.53	0	0	65	35
S2	0.30–13.4	1.40	0	11	58	31
S3	0.30–19.0	1.52	0	1	61	38
S4	0.30–18.8	1.25	0	4	67	29

Note: All samples taken at Mid Tide Elevation, and are shown thus: S1O

NOTES:

Soundings and elevations 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 4.9 feet.

Hydrography, shoreline and shore structures determined by 1948 survey. Other topography and contours from U.S.C.&G.S. Chart No. 216.

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

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 3 SHEETS — SCALE IN FEET (500 0 500 1000) — SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 27, 1949

APPROVAL RECOMMENDED: Henry A. Wilcox — CHIEF, R. & H. OPERATIONS DIVISION

APPROVED: Geo. Cadwalader — LT. COL., C.E., ASST. DIVISION ENGINEER

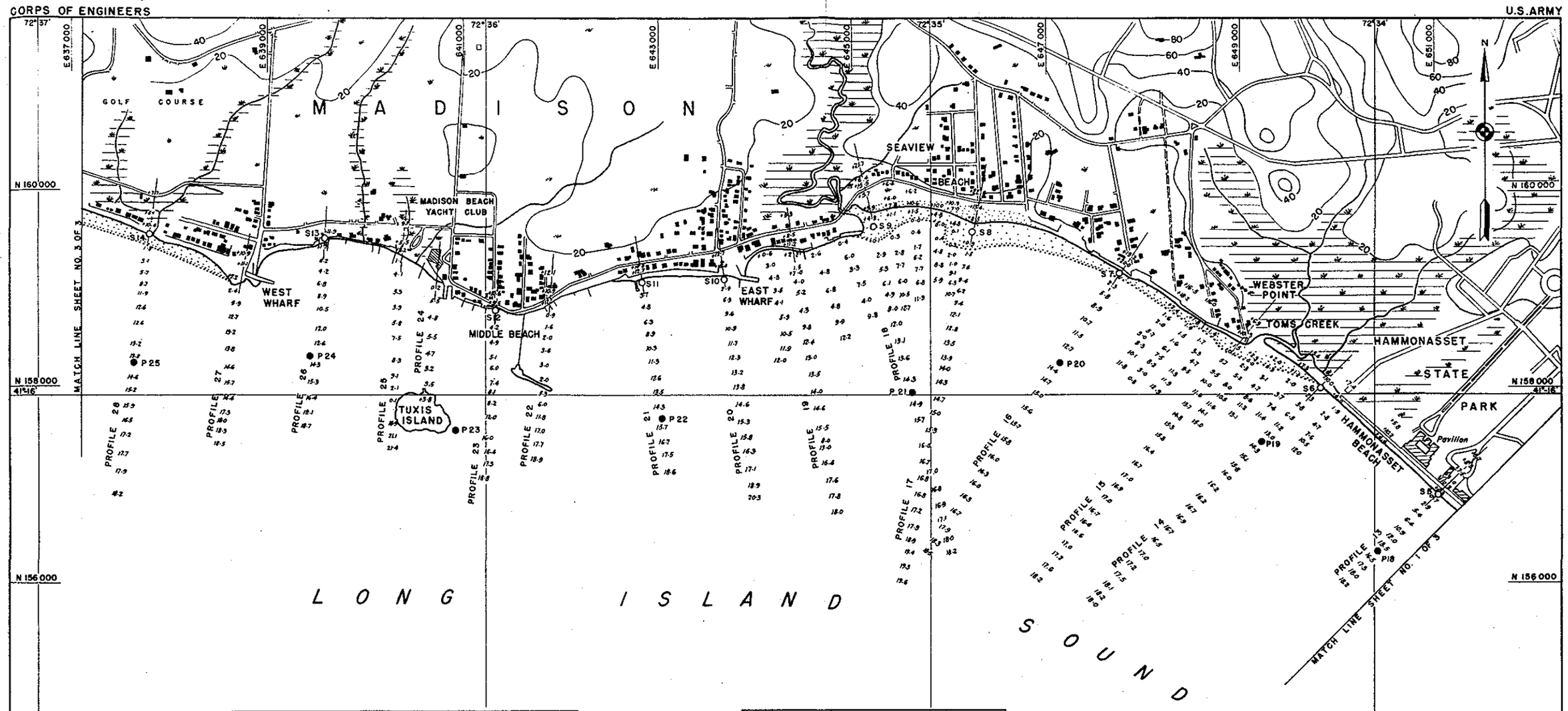
SUBMITTED: F. W. Geer — R. & H. PROJECTS AND REPORTS BRANCH

DR. BY A.S.C. TR. BY A.S.C. CH. BY F.W.G.

TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949

FILE NO. B.E. Ct. 20

PLATE 11



LIST OF PROBINGS

NUMBER	DEPTH	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
18	14.4	21.7	2.0' Coarse sand (soft), 5.3' Coarse sand (stiff).
19	13.7	19.2	1.4' Coarse sand (soft), 4.1' Coarse sand (stiff), to refusal.
20	13.0	22.9	0.8' Silt, 9.1' Sand soft.
21	13.7	21.9	1.4' Silt, 0.5' Gravel (soft), 6.3' Sand soft.
22	14.5	20.7	0.8' Silt, 1.8' Sand, 0.5' Gravel, 1.0' Sand, 1.0' Clay (soft), 1.1' Gravel.
23	14.1	27.4	13.3' Fine sand (soft).
24	13.4	22.9	4.7' Silt & sand, 4.8' Fine sand.
25	13.8	21.9	5.8' Silt & mud, 1.7' Silt & sand, 0.6' Sand (stiff).

NOTE:
Probings are in feet and tenths and are referred to the plane of Mean Low Water. Probings are shown thus ● P18.
Probings were taken Oct., Nov., 1948, by H. Tangen and G. Fuchs, using a 1" iron pipe with a chisel shaped steel point.
Depth's shown are below the plane of Mean Low Water.

BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S5	0.30 - 9.4	1.18	0	7	64	29
S6	0.30 - 13.4	1.38	0	14	42	44
S7	0.15 - 13.2	1.65	0	19	33	48
S8	0.30 - 9.4	0.81	0	21	53	26
S9	0.15 - 4.7	0.57	3	46	47	4
S10	0.59 - 13.4	1.60	0	0	55	45
S11	0.30 - 13.4	1.55	0	19	37	44
S12	0.074 - 9.4	0.61	8	39	35	18
S13	0.15 - 30.8	11.9	0	4	21	75
S14	0.30 - 9.4	2.09	0	1	44	55

Note: All samples taken at Mid Tide Elevation. and are shown thus ○ S5.

NOTES

Soundings and elevations 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 5.0 feet.
Hydrography, shoreline and shore structures determined by 1948 survey. Other topography and contours from U.S.C.&G.S. Chart No. 216.
Plane coordinates are on the Lambert Grid System for the State of Connecticut.

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 2
HAMMONASSET RIVER TO EAST RIVER

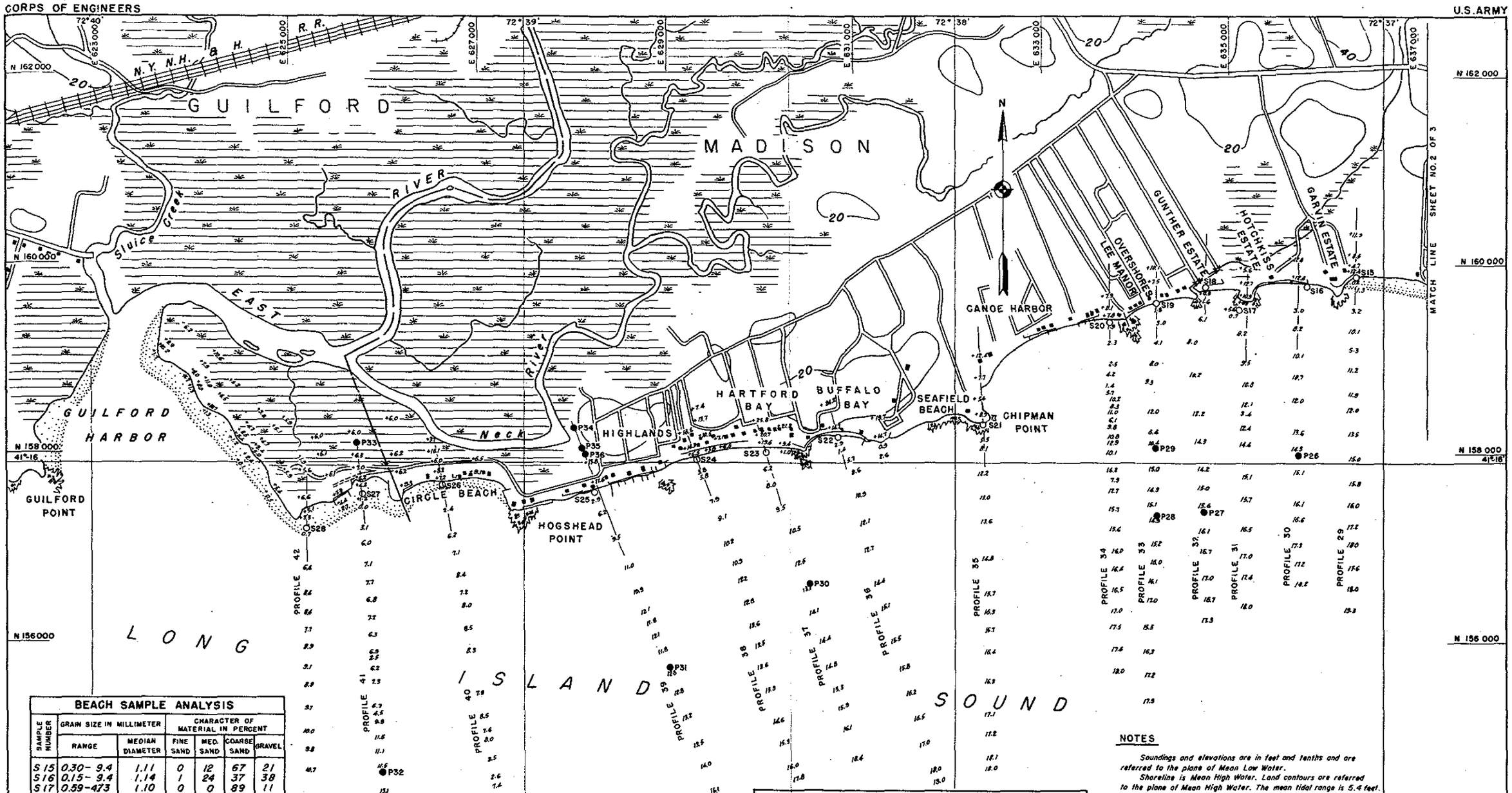
IN 3 SHEETS — SCALE IN FEET (500 0 500 1000) — SHEET 2

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 26, 1949

APPROVAL RECOMMENDED: Henry A. Whitcomb — CHIEF, R. & H. OPERATIONS DIVISION
APPROVED: LT. COL., C.E., ASST. DIVISION ENGINEER
SUBMITTED: J. W. Rice — R. & H. PROJECTS AND REPORTS BRANCH
DR. BY A.E.E. TR. BY H.W.L. CH. BY
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949
FILE NO. B.E. Ct. 20

CORPS OF ENGINEERS

U.S. ARMY



BEACH SAMPLE ANALYSIS

SAMPLE NUMBER	GRAIN SIZE IN MILLIMETER		CHARACTER OF MATERIAL IN PERCENT			
	RANGE	MEDIAN DIAMETER	FINE SAND	MED. SAND	COARSE SAND	GRAVEL
S 15	0.30 - 9.4	1.11	0	12	67	21
S 16	0.15 - 9.4	1.14	1	24	37	38
S 17	0.59 - 4.73	1.10	0	0	89	11
S 18	0.30 - 4.73	0.77	0	6	86	8
S 19	0.30 - 4.73	1.09	0	11	60	29
S 20	0.59 - 4.73	0.99	0	0	88	12
S 21	0.074 - 9.4	0.92	14	16	48	22
S 22	0.15 - 9.4	1.03	1	18	69	12
S 23	1.18 - 6.80	2.50	0	0	30	70
S 24	0.30 - 13.4	1.02	0	18	63	19
S 25	0.074 - 19.0	3.27	1	4	28	67
S 26	0.30 - 9.4	0.94	0	33	39	28
S 27	0.15 - 19.0	0.27	14	79	1	6
S 28	0.00042 - 0.035	0.0057	Silt and clay			

Note: All samples taken at Mid Tide Elevation, and are shown thus: OS15 .

LIST OF PROBINGS

NUMBER	DEPTH OR ELEVATION	TOTAL DEPTH	MATERIAL AS INDICATED BY PROBINGS
26	14.0	24.3	8.8' Mud and sand, 1.5' Compact hard sand.
27	15.7	30.8	15.1' Mud and sand.
28	14.4	14.9	0.5' Rock.
29	15.5	29.3	13.8' Mud and sand.
30	12.2	28.2	16.0' Mud and sand.
31	12.3	27.6	15.3' Mud and sand.
32	11.5	26.6	15.1' Mud and sand, Soft clay and shells.
33	+ 6.0	4.5	9.0' Soft mud, 1.5' Compact mud and sand.
34	+ 6.7	+ 1.7	3.4' Soft mud, 1.6' Mixed clay and sand.
35	+ 15.4	+ 13.5	1.9' Topsoil to ledge rock.
36	+ 17.3	+ 14.5	2.8' Topsoil to ledge rock.

NOTE: Probings are in feet and tenths, and are referred to the plane of Mean Low Water. Probings are shown thus: ● P 26 . Probings were taken Nov., Dec., 1948, by G. Fuchs, using a 1" iron pipe with a chisel shaped steel point. Depths below the plane of Mean Low Water are shown thus: 14.0. Elevations above the plane of Mean Low Water are shown thus: + 6.0 .

NOTES

Soundings and elevations 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 5.4 feet.

Hydrography, shoreline and shore structures determined by 1948 survey. Other topography and contours from U.S.C. & G.S. Chart Nos. 216 & 217.

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

CONNECTICUT BEACH EROSION CONTROL STUDY

SURVEY MAP FOR AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 3 SHEETS — SCALE IN FEET (500 0 500 1000) — SHEET 3

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 27, 1949

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

SUBMITTED: J. W. Rice, R. & H. PROJECTS AND REPORTS BRANCH

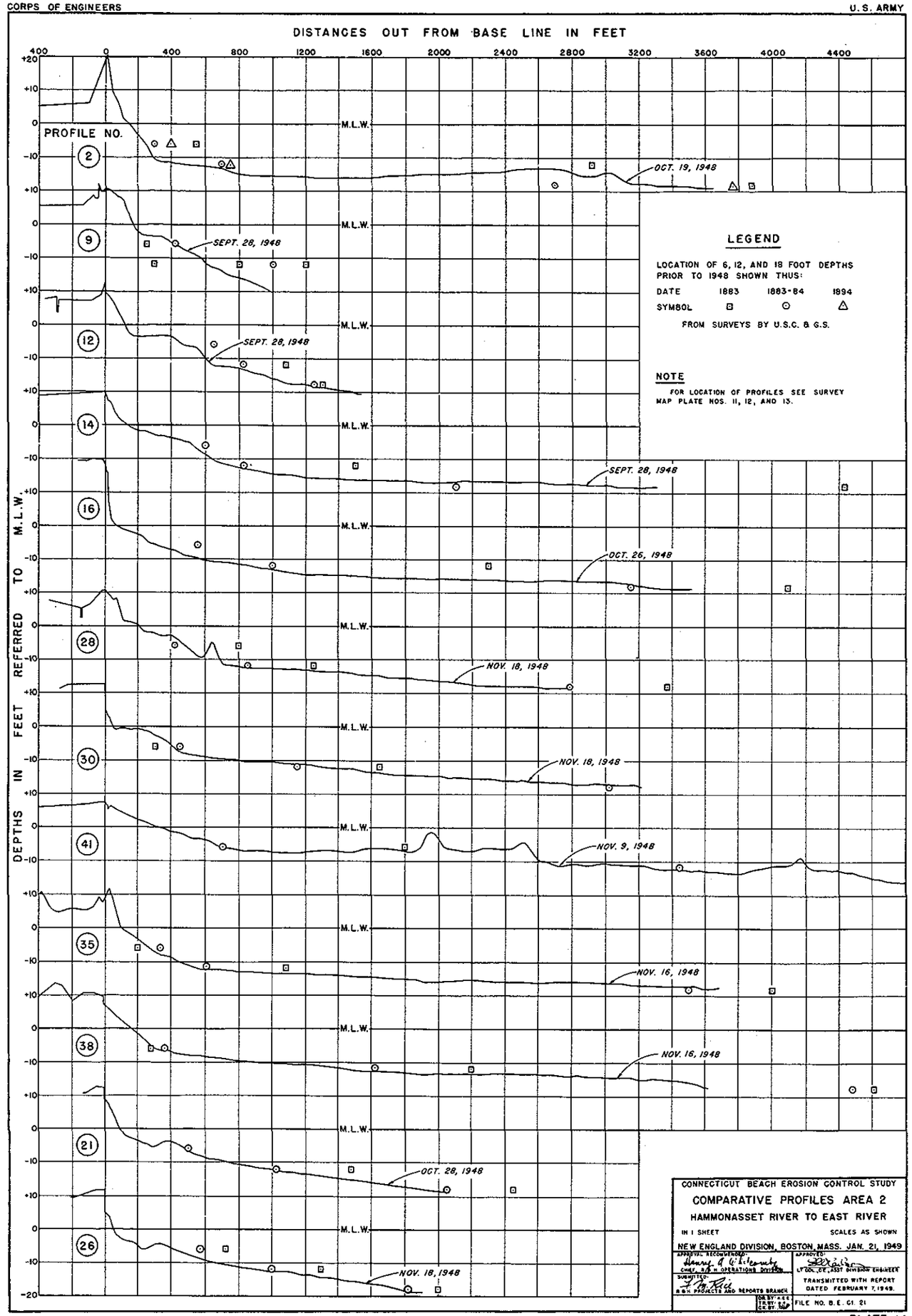
DR. BY A.K.E. TR. BY K.S. CH. BY JCW

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

TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949

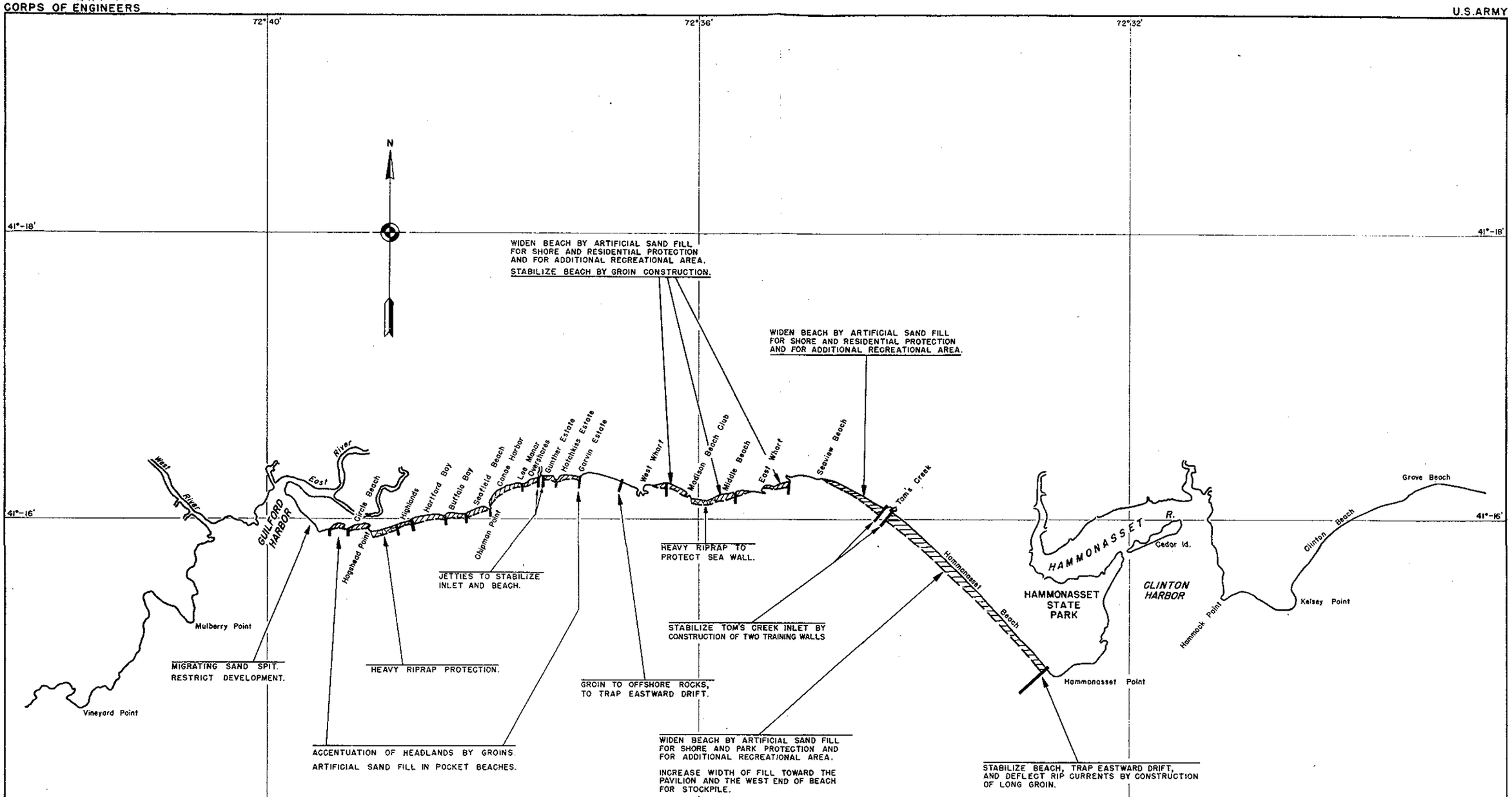
FILE NO. B.E. Ct. 20

PLATE 13


DISTANCES OUT FROM BASE LINE IN FEET
400 0 400 800 1200 1600 2000 2400 2800 3200 3600 4000 4400
DEPTHS IN FEET REFERRED TO M.L.W.
+20 +10 0 -10 -20
PROFILE NO.
2
9
12
14
16
28
30
41
35
38
21
26
M.L.W.
OCT. 19, 1948
SEPT. 28, 1948
SEPT. 28, 1948
SEPT. 28, 1948
OCT. 26, 1948
NOV. 18, 1948
NOV. 18, 1948
NOV. 9, 1948
NOV. 16, 1948
NOV. 16, 1948
OCT. 28, 1948
NOV. 18, 1948
LEGEND
LOCATION OF 6, 12, AND 18 FOOT DEPTHS PRIOR TO 1948 SHOWN THUS:
DATE 1883 1883-84 1894
SYMBOL
FROM SURVEYS BY U.S.C. & G.S.
NOTE
FOR LOCATION OF PROFILES SEE SURVEY MAP PLATE NOS. 11, 12, AND 13.
CONNECTICUT BEACH EROSION CONTROL STUDY
COMPARATIVE PROFILES AREA 2
HAMMONASSET RIVER TO EAST RIVER
IN 1 SHEET
SCALES AS SHOWN
NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 21, 1949
APPROVAL RECOMMENDED:
CHIEF, R&H OPERATIONS DIVISION
SUBMITTED:
R&H PROJECTS AND REPORTS BRANCH
APPROVED:
LT. COL., C.E., ASST DIVISION ENGINEER
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY: A.E.S.
TR. BY: S.J.
CK. BY: S.J.
FILE NO. B.E. C1. 21

CORPS OF ENGINEERS

U.S. ARMY



NOTE:
Construction plans not to scale.
Shoreline and grids from U.S.C.&G.S. Charts 216 and 217.
Only recommended plans of improvement shown on this drawing.

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 2
(SCHEMATIC)

HAMMONASSET RIVER TO EAST RIVER

IN 1 SHEET — SCALE IN FEET: 2000 0 2000 4000

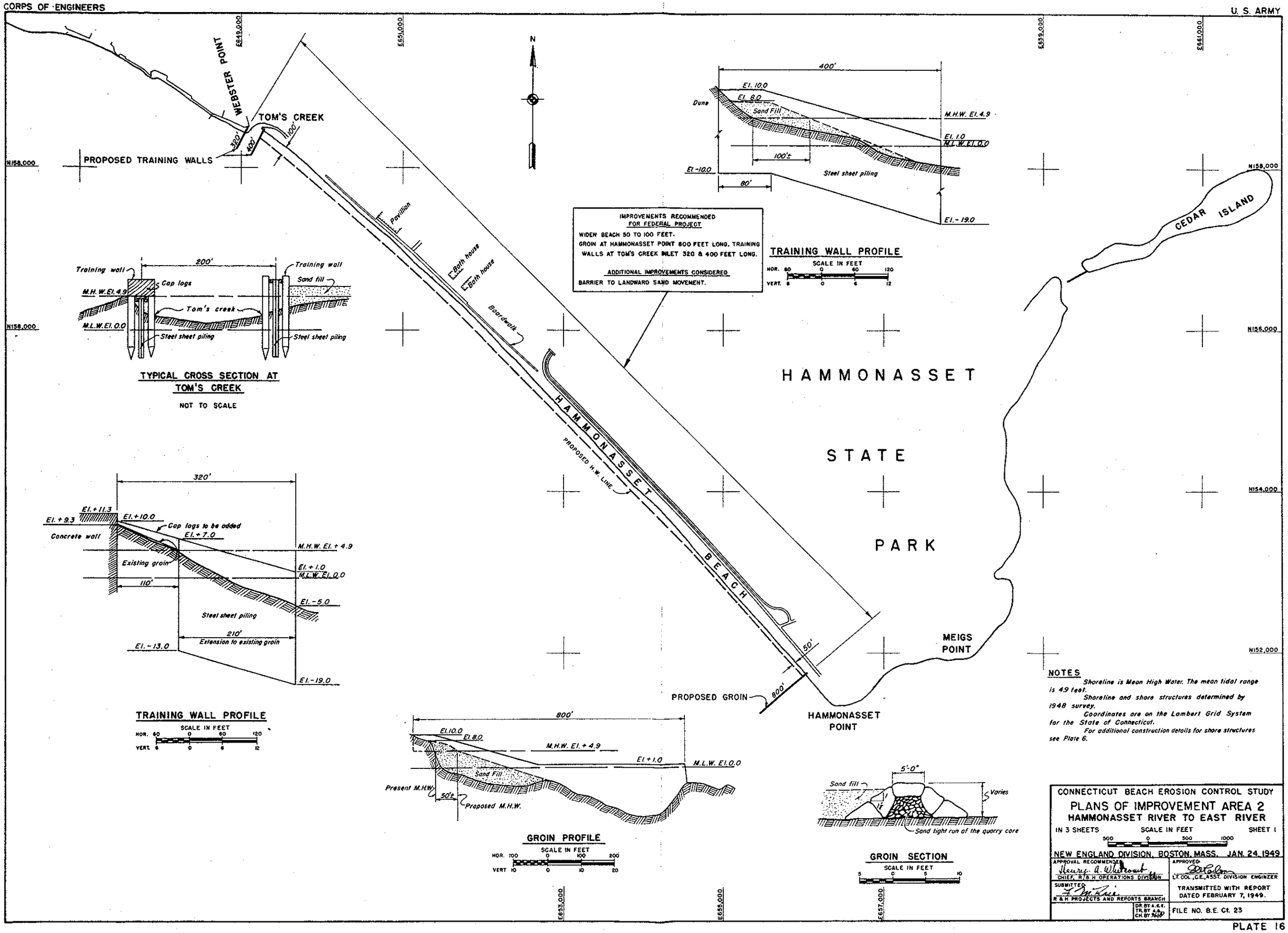
NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 24, 1949

APPROVAL RECOMMENDED: Henry A. Whiteomb, CHIEF, R.&H. OPERATIONS DIVISION	APPROVED: LT. COL., C.E., ASST. DIVISION ENGINEER
SUBMITTED: F. M. Rice, R.&H. PROJECTS AND REPORTS BRANCH	TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.
DR. BY A.E.E. TR. BY E.J.B. CH. BY	FILE NO. B.E.Ct. 22

PLATE 15

CORPS OF ENGINEERS

U. S. ARMY



NOTES

Shoreline is Mean High Water. The mean tidal range is 4.9 feet.

Shoreline and shore structures determined by 1948 survey.

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

For additional construction details for shore structures see Plate 6.

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 3 SHEETS — SCALE IN FEET (500 0 500 1000) — SHEET 1

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 24, 1949

APPROVAL RECOMMENDED: Henry A. Whitcomb — CHIEF, R & H OPERATIONS DIVISION

APPROVED: [signature] — LT. COL., C.E., ASST. DIVISION ENGINEER

SUBMITTED: [signature] — R & H PROJECTS AND REPORTS BRANCH

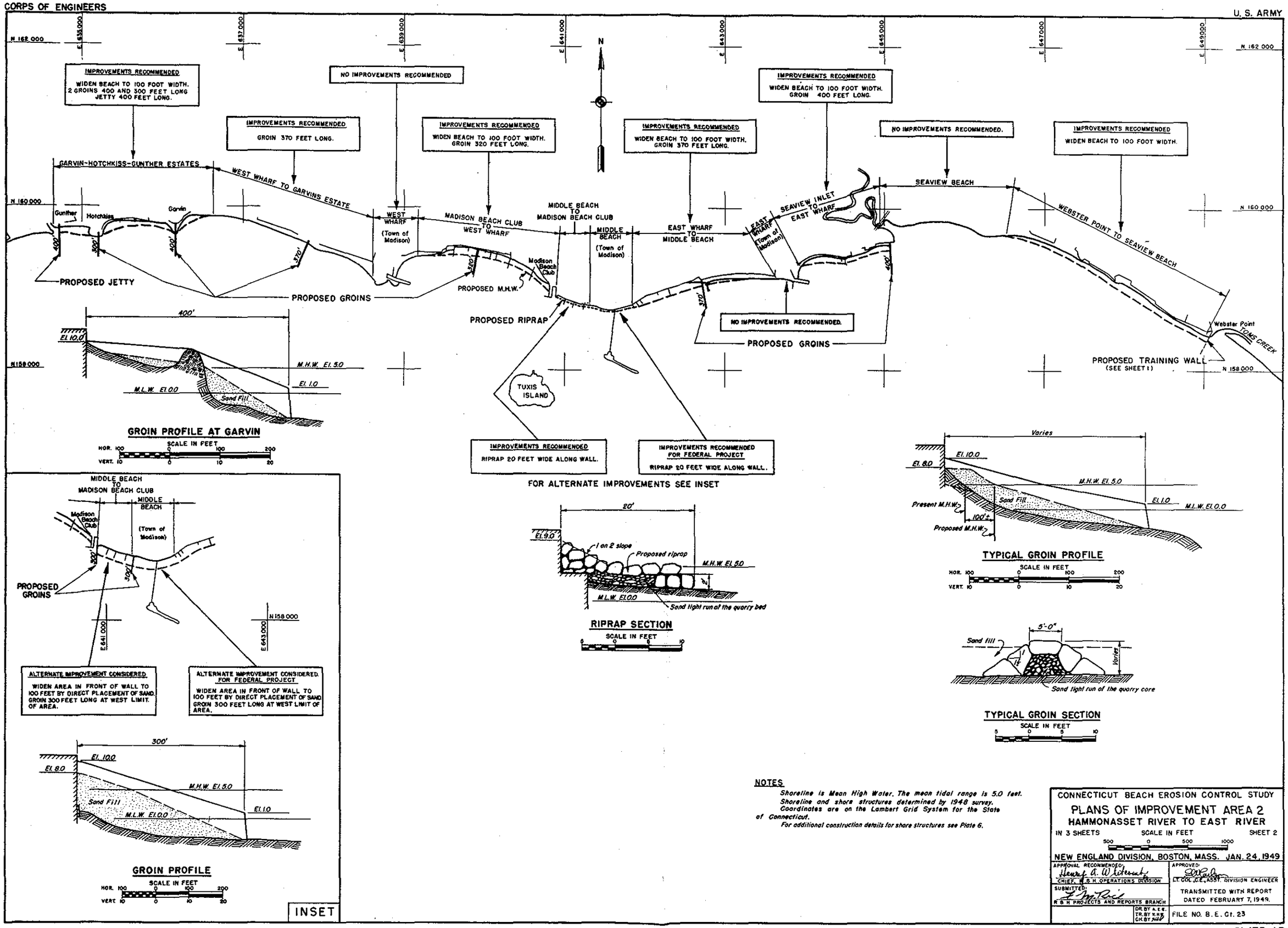
DR. BY A.E.E. TR. BY A.E. CH. BY [illegible]

TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.

FILE NO. B.E. Ct. 23

CORPS OF ENGINEERS

U. S. ARMY



NOTES

Shoreline is Mean High Water. The mean tidal range is 5.0 feet.
Shoreline and shore structures determined by 1948 survey.
Coordinates are on the Lambert Grid System for the State of Connecticut.
For additional construction details for shore structures see Plate 6.

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 3 SHEETS — SCALE IN FEET 500 0 500 1000 — SHEET 2

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 24, 1949

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

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

SUBMITTED: R. & H. PROJECTS AND REPORTS BRANCH

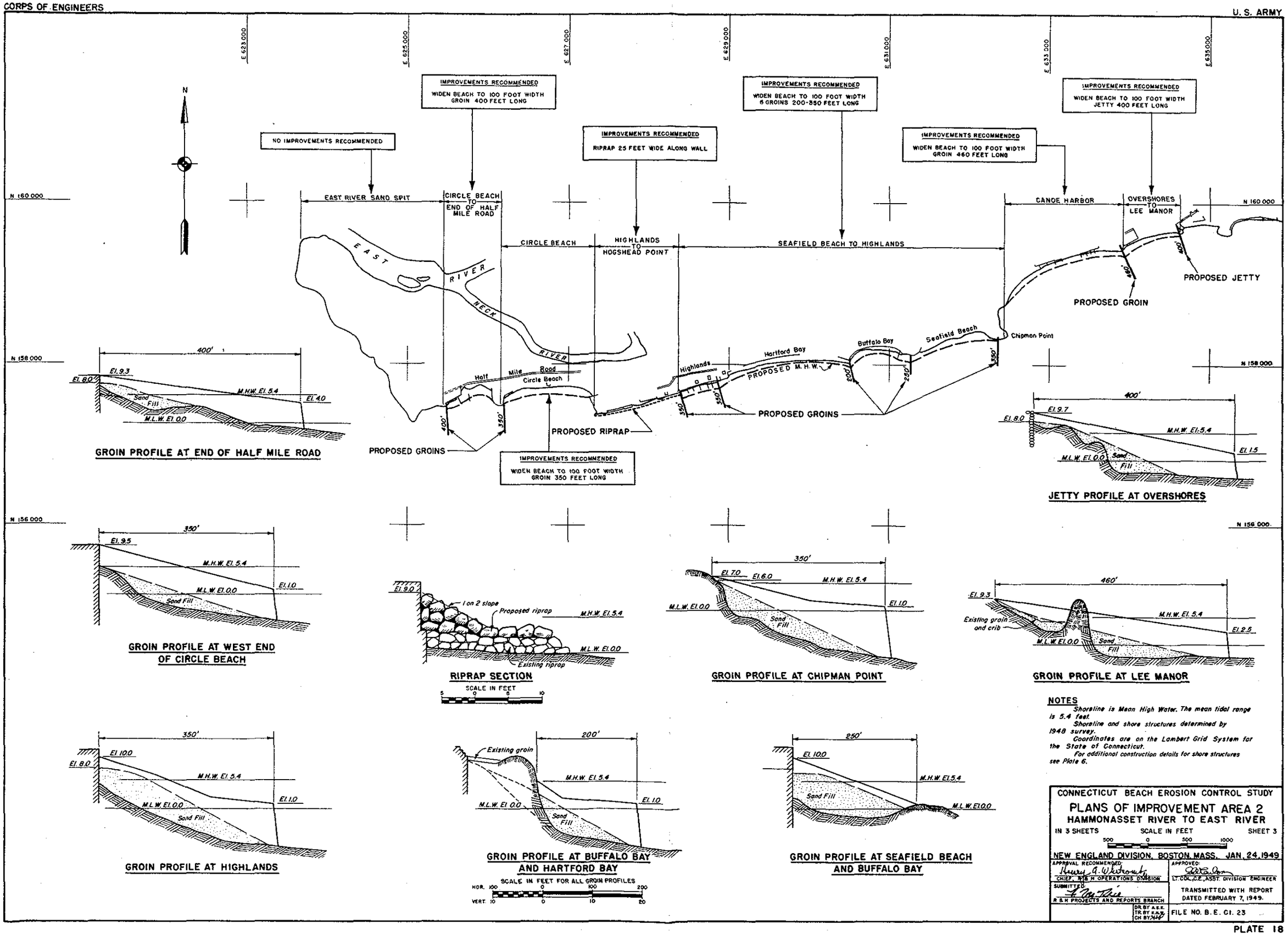
TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.

DR. BY A.E.E. TR. BY K.H.S. CK. BY

FILE NO. B.E. Ct. 23

CORPS OF ENGINEERS

U. S. ARMY



NOTES

Shoreline is Mean High Water. The mean tidal range is 5.4 feet.

Shoreline and shore structures determined by 1948 survey.

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

For additional construction details for shore structures see Plate 6.

CONNECTICUT BEACH EROSION CONTROL STUDY

PLANS OF IMPROVEMENT AREA 2

HAMMONASSET RIVER TO EAST RIVER

IN 3 SHEETS — SCALE IN FEET — SHEET 3

500 0 500 1000

NEW ENGLAND DIVISION, BOSTON, MASS. JAN. 24, 1949

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

APPROVED: [illegible] LT. COL., C.E., ASST. DIVISION ENGINEER

SUBMITTED: [illegible] R & H PROJECTS AND REPORTS BRANCH

TRANSMITTED WITH REPORT DATED FEBRUARY 7, 1949.

DR. BY A.E.E. TR. BY R.N.S. CH. BY [illegible]

FILE NO. B. E. Cl. 23

HAMMONASSET BEACH: - One of the longest and most beautiful stretches of sand beach in Connecticut.

FIG. 1. HAMMONASSET BEACH. August 12, 1947. Looking west from Hammonasset Point.

FIG. 2. HAMMONASSET BEACH. August 12, 1947. Looking west along west half of beach.

FIG. 3. HAMMONASSET BEACH. August 12, 1947. Steel sheet pile groin at inlet to Toms Creek at west end of beach.

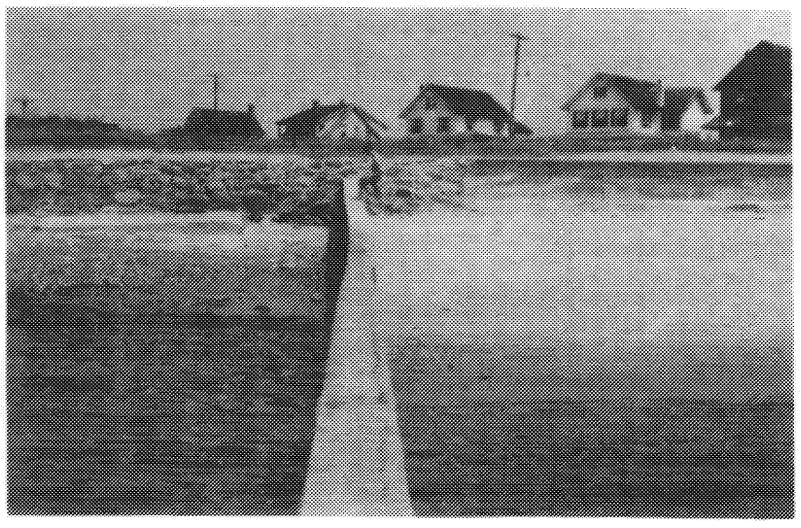


FIG. 1. WEBSTER POINT. August 12, 1947. Groin catching westerly drift material.

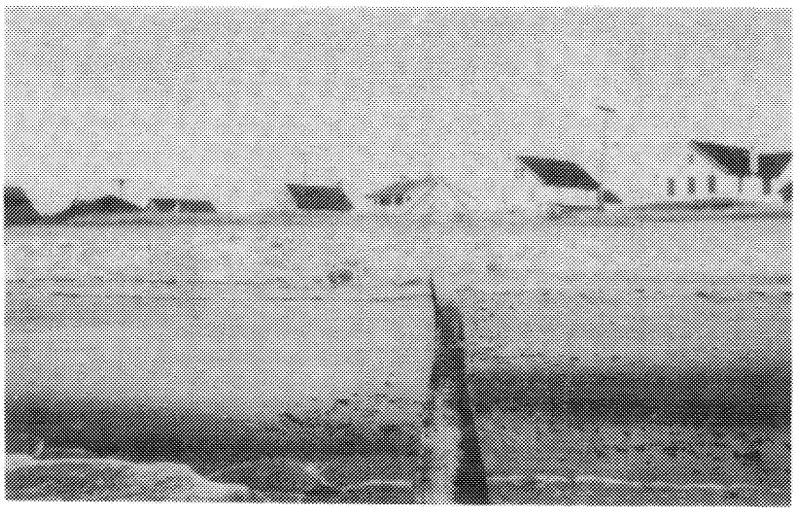


FIG. 2. WEBSTER POINT. December 6, 1948. Same groin as above catching easterly drift material.

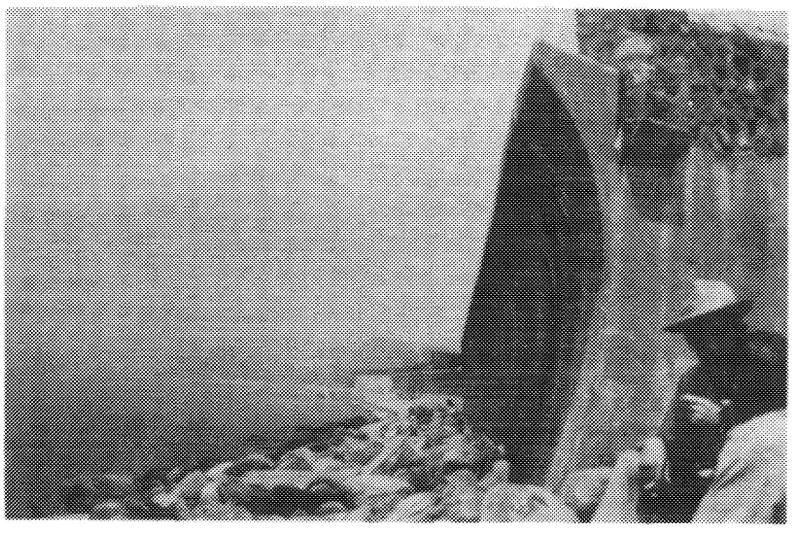


FIG. 3. WEST OF WEBSTER POINT. July 21, 1948. Revetment and narrow beach in front of sea-walls.

FIG. 1. BETWEEN SEAVIEW BEACH AND EAST WHARF. August 12, 1947. Rock outcrop and sand beach.

FIG. 2. EAST WHARF. September 4, 1947. Town beach along east side of East Wharf.

FIG. 3. MIDDLE BEACH. December 8, 1948. Groins catching easterly drift west of East Wharf.

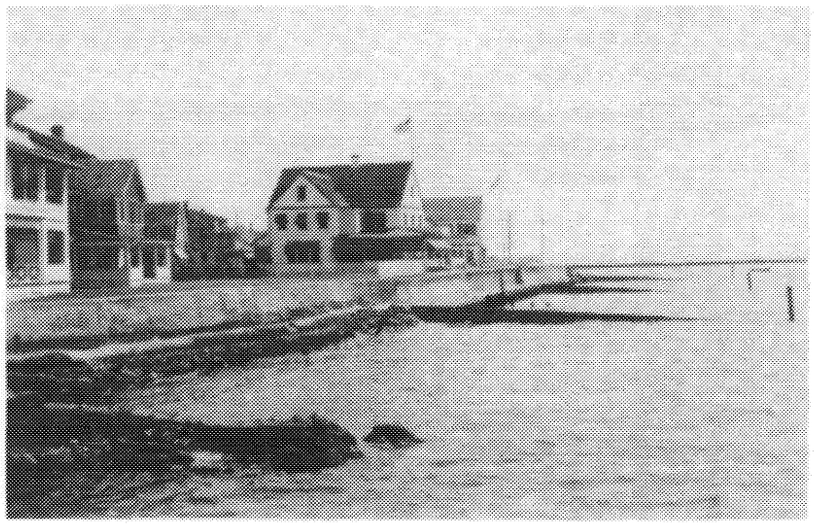


FIG. 1. OPPOSITE TUXIS ISLAND. September 4, 1947. Groins and exposed base of sea-walls.

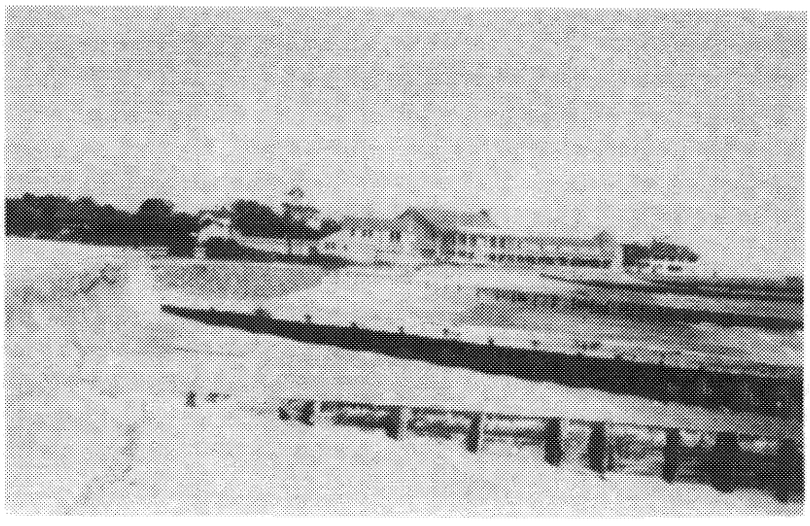


FIG. 2. MADISON BEACH CLUB. June 17, 1948. Groins catching easterly drift material.

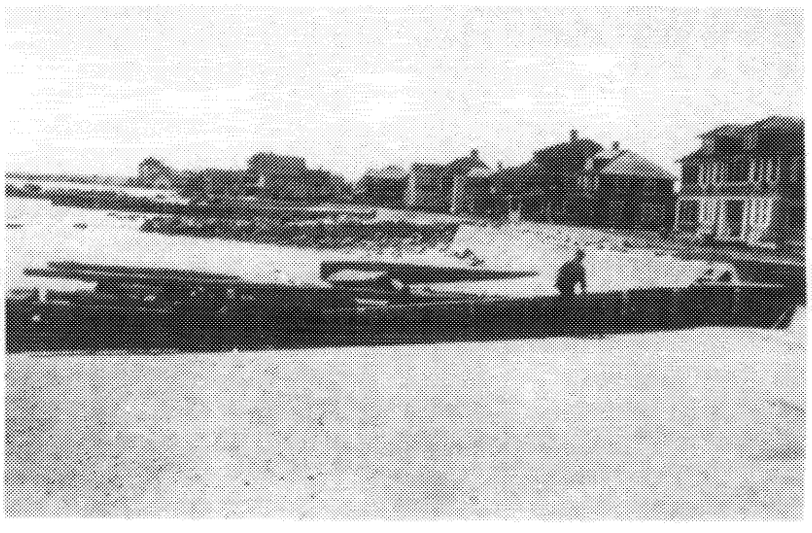


FIG. 3. WEST OF MADISON BEACH CLUB. June 17, 1948. Groins catching westerly drift material.

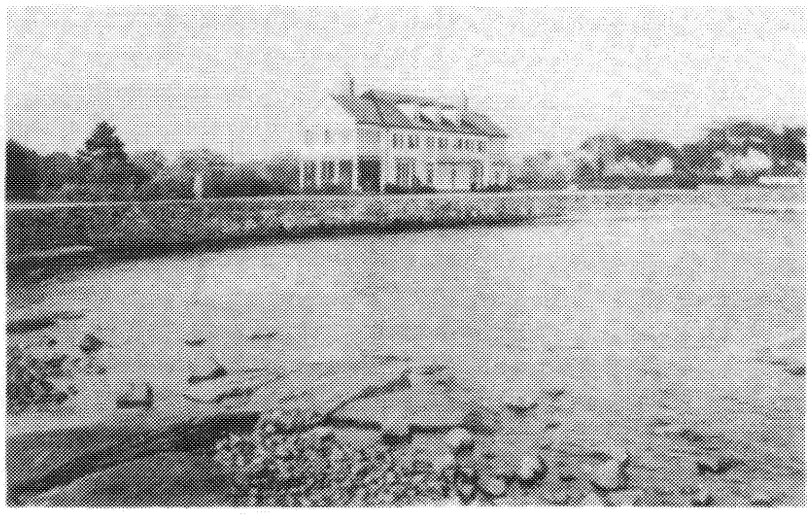


FIG. 1. HOTCHKISS ESTATE. August 12, 1947. Exposed toe of sea-wall.

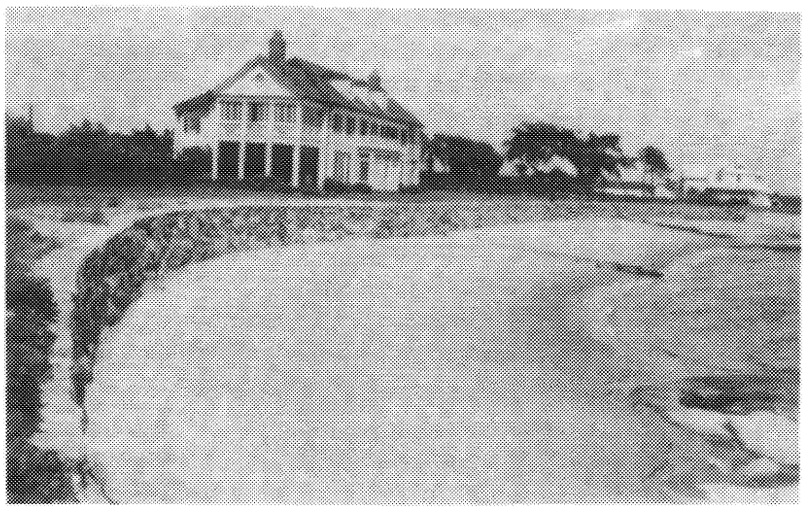


FIG. 2. HOTCHKISS ESTATE. June 17, 1948. Same location as above showing beach built up in front of sea-wall.

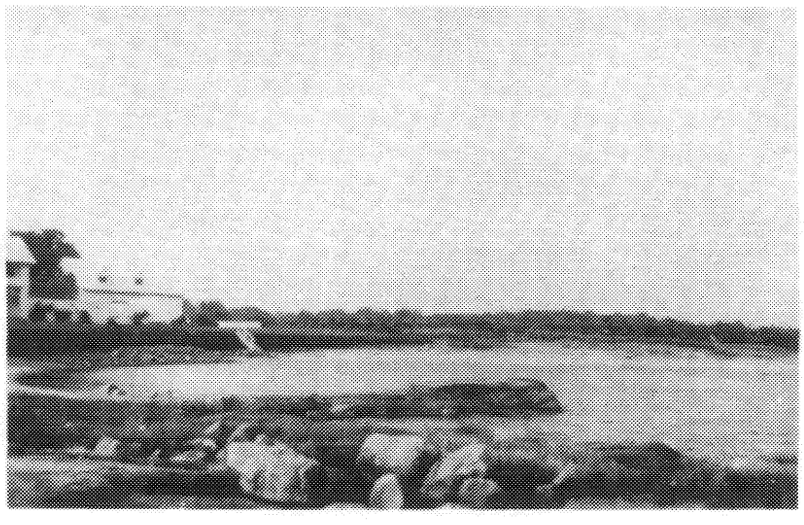


FIG. 3. GARVIN ESTATE. August 12, 1947. Riprap in front of bulkhead. Undeveloped shore area to right of buildings.

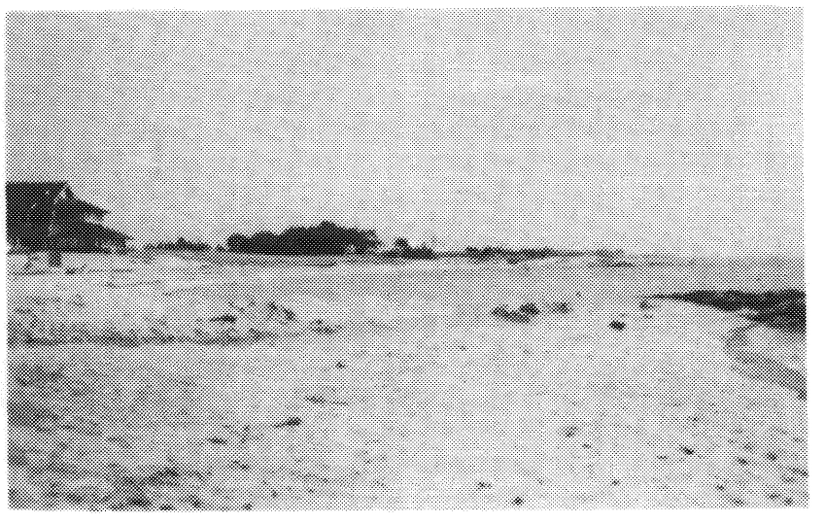


FIG. 1. OVERSHORES. September 4, 1947. Newly opened creek inlet.

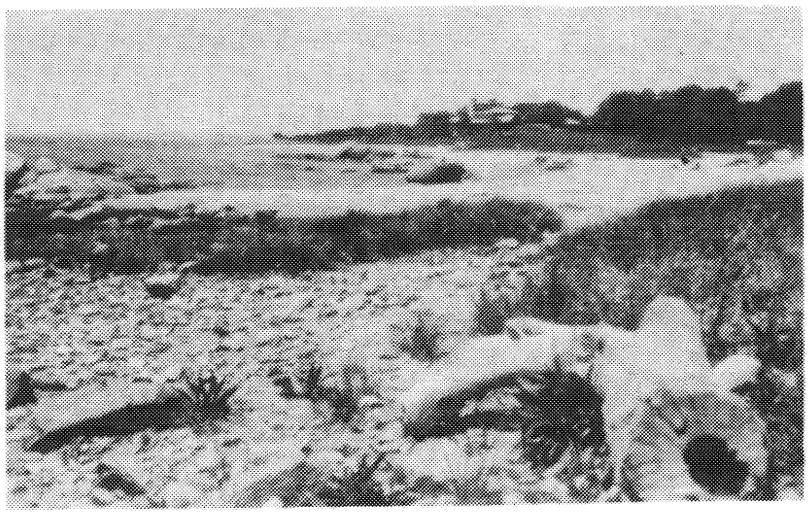


FIG. 2. SEAFIELD BEACH. June 17, 1948. Looking west.

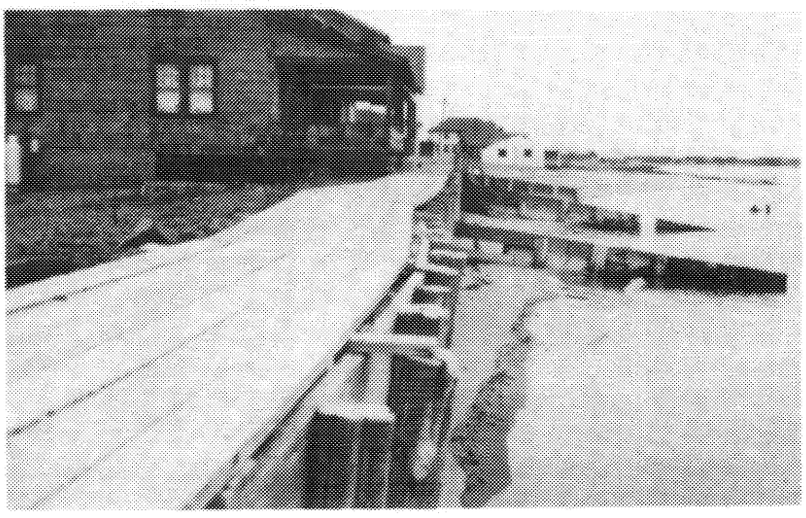


FIG. 3. CANOE HARBOR. December 1948. Groins and eroded shore.

FIG. 1. BUFFALO BAY. June 17, 1948.

FIG. 2. HARTFORD BAY. June 17, 1948.

FIG. 3. HIGHLANDS. June 17, 1948. Groins catching westerly drift material.

FIG. 1. HOGSHEAD POINT. June 17, 1948. Revetment and sea-walls.

FIG. 2. CIRCLE BEACH. August 12, 1947.

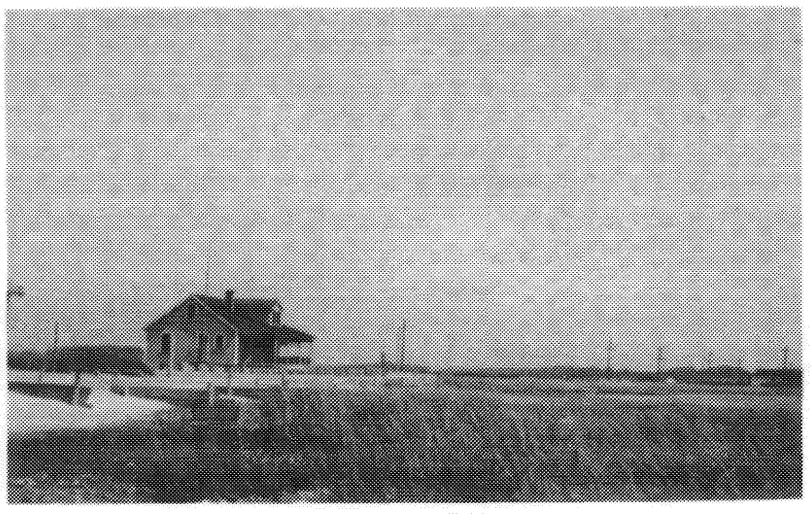


FIG. 3. EAST RIVER SPIT. September 4, 1947. Sand beach has retreated over the marsh. Note groins.