

U. S. ARMY ENGINEER DISTRICT, JACKSONVILLE
OFFICE OF THE DISTRICT ENGINEER
CORPS OF ENGINEERS
JACKSONVILLE, FLA.

SAKWR

September 29, 1961

SUBJECT: Beach Erosion Control Report on Cooperative Study of Virginia
and Biscayne Keys, Florida

THROUGH: Division Engineer
U. S. Army Engineer Division, South Atlantic
Atlanta, Georgia

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

I. INTRODUCTION

1. Authority.--This report was prepared in cooperation with the City of Miami, representing itself and Dade County as cosponsors, under authority of section 2 of the River and Harbor Act of July 3, 1930, as amended and supplemented. The cooperative study was initiated by application of the city dated October 15, 1958. The application was approved by the Chief of Engineers January 14, 1959.

2. Scope and purpose.--The cooperative study is of survey scope. The problem area extends from the northerly end of Virginia Key southerly along the entire easterly shore and from the northerly end of Key Biscayne southerly about 1-3/4 miles to the south side of the Dade County public beach, thence southerly about 1-1/2 miles to the south end of Key Biscayne. The study area extends from Government Cut on the north to the south end of Key Biscayne. Total length of the problem area is about 5-1/4 miles; total length of the study area is about 8 miles. The purpose of the study, as defined by the application, is to determine the best method of preventing further erosion and of maintaining and restoring the ocean beaches where practicable along the publicly owned frontage of Virginia Key and Key Biscayne.

3. The study includes an economic analysis of the problem and a determination of the extent to which local interests are qualified for Federal aid under the terms of Public Law 826, 84th Congress.

4. Prior reports and studies.--There have been no previous investigations directly related to the erosion problems in the study area. However, field data obtained about 1940 in connection with a considered Navy harbor on the ocean side of Key Biscayne provide subsurface information in Biscayne Bay and in the Atlantic Ocean. In addition, previous cooperative beach erosion studies of Miami Beach (H. Doc. 169, 75th Cong., 1st sess.), and Bakers Haulover Inlet (H. Doc. 527, 79th Cong., 2d sess.), as well as the navigation studies of Bakers Haulover Inlet (H. Doc. 189, 86th Cong., 1st sess.), and Miami Harbor (H. Doc. 71, 85th Cong., 2d sess.), provide background information for the general area.

II. DESCRIPTION

5. General.--The study area fronts the Atlantic Ocean at the south end of the barrier islands reaching from Miami Beach to Key Biscayne. It is separated from the mainland by Biscayne Bay, a body of water about 38 miles long and 3 to 9 miles wide, with natural depths of from 6 to 10 feet*. Virginia Key is connected to the mainland by Rickenbacker Causeway and to Key Biscayne by a highway bridge over Bear Cut. Both Virginia Key and Key Biscayne are low and sandy; heavy mangrove growths are found on the western parts of each key. Average elevation is about 5 feet. The area is one of the primary recreational spots for metropolitan Dade County. It is shown on plate 1 accompanying this report and on United States Coast and Geodetic Survey Chart No. 1248.

6. Principal development on Virginia Key consists of a public recreational beach operated by Dade County, and a \$10 million sewage treatment plant for the City of Miami. The Miami Seaquarium is at the south end of the key. Key Biscayne is more highly developed. In addition to a public recreational beach operated by Dade County, about 1,000 homes of the upper-middle to the luxury class have been built in the last decade. At the present time there is a total of 350 motel and hotel units. Crandon Park, fronting the ocean, is in the central portion of the key. The southern tip of the key is currently being prepared for development by single-residence homes. An abandoned United States Coast Guard light-house is at the south end of Key Biscayne. Virginia Key is about three-fourths mile wide and 2 miles long. It has an area of about 1.5 square miles. Key Biscayne has a maximum width of about 1.3 miles and an average width of about three-fourths mile. The total length of shoreline is about 4.3 miles on the ocean side and about 9.5 miles on the bay side. It has an area of about 3.5 square miles.

7. The area tributary to Virginia Key and Key Biscayne is densely populated. Greater Miami has an official population of about 570,000 in

*Unless otherwise noted, all stages and elevations throughout this report refer to mean-low-water datum.

1960. That represents a growth of about 50 percent since 1950 and 155 percent since 1940. Population of Dade County in 1960 was 935,047. These figures are based on the United States Censuses of 1940, 1950, and 1960.

8. Miami Harbor.--The Federal project of Miami Harbor extends from the ocean entrance to Government Cut westerly 5-1/2 miles across Biscayne Bay to the mainland. The project provides for the following:

a. A channel 30 feet deep and 500 feet wide from the ocean to near the outer end of the north jetty, thence 30 feet deep and 400 feet wide through the entrance cut and across Biscayne Bay to and including a turning basin in front of the municipal terminals at Miami, 1,700 feet by 1,650 feet and 30 feet deep, and a turning basin along the north side of Fisher Island about 39 acres in extent and 30 feet deep; two parallel rubblestone jetties at the entrance, 1,000 feet apart and 3,000 and 2,750 feet long, and rubblestone revetment on both sides of the 1,000-foot-wide entrance cut. The part of the previous project completed in 1939 was essentially like the existing project except that the 400-foot wide channel was only 300 feet wide, the turning basin at the municipal terminal was 1,400 feet by 1,350 feet, and there was no turning basin along Fisher Island. The additional work authorized by the existing project has not been provided.

b. A channel 15 feet deep and 200 feet wide from the mouth of Miami River to the turning basin at the municipal terminals; channel 8 feet deep and 200 feet wide, from the mouth of Miami River to the Intra-coastal Waterway and thence 100 feet wide easterly to the entrance cut. The authorized work described in this subparagraph has not been accomplished.

9. The Intracoastal Waterway from Jacksonville to Miami enters Biscayne Bay at its northerly end and traverses the bay to the existing Miami Harbor turning basin at the municipal terminals. Existing project dimensions are 8 by 100 feet. Enlargement to 10 by 125 feet has been authorized but not provided. A channel 7 feet deep and 90 feet wide has been authorized from Miami to Key West. Project dimensions along the northerly 63 miles were obtained in 1939. No work has been accomplished on the remaining part of the project.

10. Shorefront property.--a. General.--There is no federally owned shorefront property in the problem area. Non-Federal publicly owned property is shown on plate 5 and described below. The evaluations are on a 1961 price level and are based on appraisals furnished by city and county tax assessors' offices.

b. Virginia Key.--The key is owned in its entirety by the City of Miami and by Dade County. The city owns the approximate northern half of the key and the county the approximate southern half. Most of the county frontage consists of Virginia Beach, a public beach operated by the county. The current market value of all property, exclusive of development, is about \$40,000,000.

c. Key Biscayne.--Dade County owns the approximate northern half of the key; the remainder is privately owned. Public shore frontage totals about 9,900 feet; total length of the ocean shore of the key is about 22,500 feet. Of the county-owned frontage, Crandon Park as now developed occupies 5,500 feet, or about 56 percent of the publicly owned shoreline on the key. Crandon Park is highly developed and offers all the facilities required of a modern recreational area. Current market value of the county property, exclusive of development, is about \$35,000,000; development is evaluated at about \$2,500,000.

11. Privately owned shore property.--There is no privately owned shore property on Virginia Key. The southerly 12,600 feet of the ocean shore of Key Biscayne, about 56 percent of the total ocean shore, is privately owned. The current market value of privately owned shorefront property (a strip 400 feet wide in the east-west dimension and 12,600 feet long in the north-south dimension) is about \$14,500,000 exclusive of development; the current market value of all privately owned property on Key Biscayne is in excess of \$50,000,000, exclusive of development.

12. Access to beaches by the public.--In Florida, title to riparian property extends to the mean or ordinary high-water line. Seaward of that line the beach and submerged bottomlands are the property of the State. Such lands are in custody of the Trustees of the Internal Improvement Fund, a State body, to be held in trust for the benefit of the people of the State. Technically, therefore, the public may not be deprived of the right of access to the beach below high water, except by such lawful regulation as may be imposed in the interest of the public.

13. The beach at Crandon Park (Key Biscayne) and all of the Virginia Key beach are available for public use. Private property owners south of Crandon Park have tried to discourage public bathing in front of their property by building barbed wire fences and other obstructions.

14. Water pollution.--Representatives of the County Health Department have stated verbally that no pollution problem exists in the problem area now. By letter of April 13, 1961, the Acting Director of Public Works furnished assurances that no sewerage disposal system which could contribute to beach pollution in the problem area would be approved.

15. Statement of problem and improvements desired.--a. Virginia Key.--Instability and recession of the ocean shore are the problems leading to this cooperative study. The entire eastern shore has receded over the period of record. The approximate northern half of the key has receded about 700 feet during the period of record, from 1851 to date. About 130 acres of upland property have been lost during that time. The part of the key occupied by Virginia Beach has inadequate dry beach area for present and future demands by bathers on peak days.

b. Key Biscayne.--The problem is prospective more than existent. While some erosion of the beach profile has occurred, recession of the shoreline has not yet occurred to an extent which would seriously threaten existing development. The population growth of the tributary

area has created a need on peak days for more dry beach area for bathers than now exists in the developed part of the publicly owned shore.

c. Improvements desired.--Local interests desire, on Virginia Key, a beach restored to such dimensions that seasonal or storm erosion will not endanger upland property, and that existing and future recreational bathing needs will be satisfied. They desire, on Key Biscayne, such measures as are required to prevent future erosion and recession of the shoreline, and to meet existing and future recreational bathing needs.

16. No public hearings have been held in connection with the beach erosion problem in the study area. Close contact and coordination have been maintained with the cooperating agencies through their designated representatives (Mr. F. J. DeLozier, Jr., Metropolitan Dade County; and Mr. A. P. Crouch, City of Miami) during the course of the study. Local officials have been contacted and their views obtained.

III. FACTORS PERTINENT TO THE PROBLEM

17. Geology.--The State of Florida occupies only a part of a much larger geographic unit, the Floridian Plateau. The deep water of the Gulf of Mexico is separated from the deep water in the Atlantic Ocean by a partially submerged platform nearly 500 miles long and about 250 to 450 miles wide. For many millions of years the plateau has been alternately dry land or covered by shallow seas.

18. The east coast of Florida from the Georgia line to the study area, more than 350 miles, consists of a series of sandy barrier islands, broken here and there by inlets. For the most part, the beach is rather straight. The sand is composed of fine quartz grains and finely divided shell fragments. In general, the shell content increases south of Daytona Beach. The straightness of most of the east coast is probably the result of a continuity of littoral currents and a rather uniform drift of sand in a southerly direction. The shore alinement is generally less regular in the vicinity of inlets, as is the present case, where three inlets exist in the study area.

19. The Dade County shoreline, a barrier bar with a lagoon, bay, or swamp behind it for the most part, is typical of young shorelines of emergence. During recent times the offshore or barrier bar has been built from material cut from the sea floor by wave action and to a lesser extent by deposition of sand from the southward moving currents.

20. Littoral materials.--Silica sand on the Florida east coast is that which has been carried down to the sea by the Savannah, Altamaha, and by other rivers of Georgia and the Carolinas, and gradually shifted southward by shore currents and wave action. Due to the geological history outlined, the underlying material of practically all the beaches contains a large portion of a sand and shell mixture of loose or

unconsolidated sedimentary form which was deposited during the later stages of emergence. Underlying the unconsolidated material are the large areas of coquina laid down as previously described and formed of shell fragments in various stages of consolidation.

21. Surface sand samples were collected on every other profile from 1 through 5 and 8 through 16 at the dune, between high and low water, and at -3, -6, -12, and -18 feet. Median diameters of samples obtained ranged from 0.17 to 1.80 millimeters. Average median diameter of samples collected at about mean high water on Virginia Key is 0.42 millimeter; at -12 feet, average median diameter is 0.38 millimeter. On Key Biscayne, average median diameter at about mean high water is 0.30 millimeter; at -12 feet it is 0.31 millimeter. Samples were not analyzed for shell content. However, a sample previously obtained on about the midtide line at Bakers Haulover Inlet, about 12 miles to the north, had a shell content of 80 percent. Other samples obtained in the same vicinity had shell contents ranging up to 96 percent. Surface sands in the present study area do not appear to contain as much shell. Detailed information concerning beach material is contained in appendix A.

22. Littoral forces.--a. Winds.--(1) The records of winds at Miami for the period January 1, 1928 to December 31, 1940, furnished by the United States Weather Bureau, were analyzed, and the resulting data are represented by the wind diagram shown on plate 1. The diagram indicates the velocity in four separate velocity groups, the directions from which the winds blow, and the duration in days. It shows that velocities were greater from the northeast sector than from the southeast sector, but that the duration was greater from the southeast sector. The following tabulation gives the percent of time and direction from which the winds blew as indicated by those records.

Yearly average winds at Miami, Fla.
(from observations 1928-1940)

<u>Direction</u>	<u>Percent of time</u>	<u>Direction</u>	<u>Percent of time</u>
North	8	South	10
Northeast	17	Southwest	4
East	23	West	3
Southeast	28	Northwest	7

(2) Yearly cumulative average winds over the South Atlantic and gulf coasts were compiled from records of the United States Hydrographic Office for a previous study. The data showed the yearly average winds that prevailed within the 5-degree square of ocean area off Miami as reported by ships at sea from 1879 to 1933. Analysis of the data indicated that average winds from the Atlantic Ocean blow from the different directions as tabulated below.

Yearly average offshore winds
(from observations 1879-1933)

<u>Direction</u>	<u>Percent of time</u>	<u>Direction</u>	<u>Percent of time</u>
North	10	Southwest	6
Northeast	16	West	5
East	22	Northwest	8
Southeast	20	Calms	3
South	10		

The strongest winds are from the northern sector; predominant winds in the general area are from the northern and eastern sectors.

b. Swells and waves.--(1) The ocean swell diagram on plate 1 shows, for the 5-degree square of ocean area off Miami, the percentage of observations during which swells from given directions occurred between 1932 and 1942. The swells are classified according to the height of waves and are indicated on the diagram by the width of lines weighted according to the square of the swell heights. Because of the configuration and bearing of the above in the study area, swells approaching from the north and northeast cause a southerly drift; swells from the southeast and south cause a northerly drift. Swells from the east approach the study area generally normal to the shore except for the lower part of Virginia Key, where they have a southerly component. In that part of Virginia Key they produce southerly drift; otherwise, the easterly swells probably produce little or no drift. Seasonally, the analysis of data for the study area indicates that during the months September through February the prevailing and predominant swells approach from directions which set up a southerly drift; during March, April, and May the resultant directions of drift are uncertain; and from June through August the prevailing and predominant directions of swell approach are such as to create northerly drift. The incidence of swells in the Miami area is influenced by the shelter afforded by the islands of the Bahama group, which limit fetches to the east and southeast.

(2) Records of waves in the Miami area are not available. The slope of the ocean bottom is somewhat flatter than at Palm Beach, so it can be expected that wave heights are somewhat less. Wave heights of 10 feet and periods of 4 to 18.9 seconds have been recorded in the ocean at Palm Beach.

c. Tides and currents.--The mean range of tide in the Atlantic Ocean at Miami Beach is 2.5 feet; the spring range is 3.0 feet. The lowest tide to be expected is 1.4 feet below mean low water. Variations in water-surface elevations of more than 7 feet have resulted from storms. The reported maximum ocean tide of record at Miami Beach, 7.1 feet, occurred during the hurricane of September 1926. A high-water mark of 9.1 feet, which undoubtedly included wave runup, was obtained in that storm on Key Biscayne; a high-water mark of 6.7 feet was obtained in the storm of November 1935. The second highest ocean tide of record at Miami

Beach was 6.3 feet and occurred during the hurricane of October 1950. Maximum tidal current velocities through Government Cut are ordinarily about 5.5 feet a second on average tide, but occasional velocities of about 6.2 feet a second have been recorded during spring tide. Velocities through Norris Cut and Bear Cut have not been measured, but computations indicate maximum normal velocities of about 2.2 and 4.0 feet a second, respectively. With further regard to Norris Cut, the cooperating agency has under consideration an application for a permit to construct a bridge from Virginia Key to Fisher Island. Preliminary plans of the bridge were furnished the District Engineer for review and comment. Analysis indicates that the bridge and its approaches, as planned, would reduce the cross-sectional area of Norris Cut. Velocities in the cut and in Government Cut to the north might be increased, and adverse effects on the littoral regimen in the area might occur. The cooperating agency was advised of those possibilities by letter, and it was suggested that the bridge plans be modified so as to retain at least the existing cross-sectional area in Norris Cut.

23. Storms and their effects.--a. General.--The problem area is subject to frequent visitation by tropical storms of hurricane intensity. The paths of hurricanes which have passed within a 150-mile radius of Miami during the period 1876-1960, are shown on plate 1. Between 1830 and 1960, 48 such hurricanes were experienced, or an average of one hurricane every 2.7 years. Because of the scarcity of information on pre-1900 hurricane occurrences, frequency studies are based on the period 1900-1960. For the same reason, the paths of hurricanes occurring before 1876 are not shown on plate 1. Twenty-nine hurricanes were experienced during that period--about one hurricane every 2 years. There were 2 different years in which the maximum of 3 hurricanes passed within a radius of 150 miles of Miami, 5 years in which 2 or more hurricanes occurred, and 22 years in which 1 or more hurricanes occurred. During the period 1900-1960, a total of 13 hurricanes passed within a radius of 50 miles of Miami, a frequency of 1 in 4.7 years. Because of the limited access and development of these keys prior to 1947 (Rickenbacker Causeway, connecting Virginia Key and Biscayne Key to the mainland, was completed in 1947), data as to the effect of specific storms on the problem area are practically nonexistent. However, the effects of storms on Miami Beach and on Miami, which would indicate the magnitude of the problem in the study area, are given in the following subparagraphs.

b. Specific storms.--(1) September 6-22, 1926.--The storm was one of the most severe of the present century. A minimum barometric pressure of 27.61 inches was recorded by the Miami Weather Bureau Station. A maximum 2-minute wind velocity of 132 miles an hour was recorded. An ocean tide of 7.1 feet was experienced. Miami Beach was entirely inundated, and at the height of the tide the ocean extended to Miami, 3-1/2 miles across Biscayne Bay. Two minor breaches occurred along Miami Beach, but were of short duration. All streets near the ocean at Miami Beach were covered with sand to a depth of several feet. More than 300 one- and two-story apartment buildings were completely washed away. Evaluations of the damage caused by the storm ranged from \$50,000,000 to \$165,000,000.

(2) October 30-November 8, 1935.--The "Yankee Hurricane"--so-called because of its approach from the northeast and its time of occurrence--was severe at Miami. Water was 2.5 feet over the bulkheads at the wharves. Much of the island of Miami Beach was covered with water from 1 to 3 feet deep. Property damage in Miami was estimated at \$3,000,000. A 1-minute-average wind velocity of 75 miles an hour and a barometric pressure of 28.73 inches were recorded at Miami. High tides were responsible for much serious damage along the waterfront. No details of damage at Miami Beach are available but flooding from 1 to 3 feet deep was reported in some areas.

(3) September 12-19, 1945.--Winds at Miami were about 100 miles an hour; tides in the ocean were high at Miami Beach. A minimum barometric pressure of 28.09 inches was recorded at Homestead; minimum pressure recorded at Miami was 29.17. The maximum 1-minute-average wind velocity at Miami was 107 miles an hour; the wind was from the southeast. The surf was heavy at Miami Beach and Collins Avenue was flooded; ocean tides were about 2 feet above normal. This was the most severe hurricane in the Miami area since the 1926 storm. About \$18,000,000 damage was sustained in addition to the \$40,000,000 damage occurring at Homestead and Richmond military installations.

(4) September 11-19, 1947.--Winds of over 100 miles an hour were experienced along a 70-mile reach between Miami and Palm Beach. A minimum barometric pressure of 28.71 inches and a maximum 1-minute-average wind velocity of 90 miles an hour were recorded at Miami; the wind was from the south-southwest. Tides and waves rolled four blocks inland at the north end of the beach. Causeways were under water and sand was deposited along coastal highways. Rock seawalls at Miami and Miami Beach were damaged by wave action to the extent of \$75,000. Strong west winds damaged seawalls and property along the west side of Miami Beach where tides reached the top of seawalls. During the second phase of the storm, tides in the ocean rose 5.4 feet above mean low water; large waves battered the seawalls and washed huge coral boulders at Lummus Park, 100 yards inland. At 71st Street, waves rolled four blocks inland. Many flooding incidents were reported throughout the entire length of Miami Beach. Total damages in Miami and vicinity were estimated at \$5,000,000.

(5) October 15-19, 1950.--The hurricane was small but violent. Highest wind gusts at Miami were 122 to 150 miles an hour. Minimum barometric pressure of 28.20 inches and a maximum 1-minute-average wind velocity of 122 miles an hour were recorded at Miami. The wind was from the south. High tides of about 6 feet were reported, and flooding of the low areas along Miami River and at the beach was noted. Damages sustained at Miami and vicinity (principally structural) amounted to about \$8,000,000.

24. Shoreline changes.--Comparative positions of shoreline are shown on plates 2, 3, and 4. The bases for comparison of mean-high-water shorelines are surveys made by the United States Coast and Geodetic Survey in 1851, 1867, 1913, 1919, 1927, 1935 and 1945-47, and by the Corps of Engineers in 1960.

25. Changes in shoreline, by reaches, are tabulated in table B-1, appendix B. As may be seen in table B-1, data indicate general recession throughout most of the study area, except for the last 15-year period, which shows advance over all of Virginia Key and some parts of Key Biscayne. However, the recent advance has not been sufficient to return the shoreline to previously occupied positions, as indicated by the existence 70 feet offshore of concrete footings of a former waterfront cottage on the southern part of Key Biscayne.

26. Offshore depth changes.--Comparisons of offshore depth changes are based on the surveys of 1852, 1919, and 1960. The results of those surveys are shown on plates 2, 3, and 4. Changes in position of offshore depth contours are given in table B-2, appendix B. As may be seen in table B-2, the 6-foot, 12-foot, and 18-foot contours experienced both advance and recession during the period of record.

27. Prior corrective action in the study area has been limited to the installation of conventional shore-protection structures--seawalls and bulkheads, groins and revetments. According to the Engineering Division of the Dade County Parks Department, no beach fill has been made at Crandon Park or Virginia Beach except for minor (truckload volume) maintenance at localized problem areas. However, some fill was obtained from the ocean in the vicinity of Crandon Park and placed approximately 1,000 feet landward of the shoreline as a base for parking lots in the 1940's. The removal of that material from the ocean did not, in the opinion of local interests, have a significant effect on the shoreline. Inspections during the course of this study did not reveal that the operation had visibly affected adjacent shores. The structures are described briefly in the following paragraph and are shown on plate 5.

28. Existing structures.--a. Virginia Key.--There are no protective structures on the city of Miami property on Virginia Key. On the county property there are 27 timber groins. Some of the groins were originally installed in 1948. In 1956 the remainder were added and some of the original groins were lengthened. The groins are approximately 50 feet long and are spaced 50 to 150 feet apart. The top of the groins is at elevation 4.5 feet. The groins are distributed over a reach of shore approximately 2,700 feet long and are considered effective by county officials. Immediately south of the most southerly groin, approximately 400 feet of shoreline are protected by stone revetment (3- to 4-foot-diameter boulders).

b. Key Biscayne.--(1) Public property.--There are no protective structures for the northernmost 6,000 feet of the Key Biscayne ocean shoreline. Approximately 2,550 feet of county property shoreline are protected by a concrete seawall, 1,670 feet of which were originally built in 1947. In 1956, approximately 440 feet were destroyed; in 1958 the destroyed section was replaced and an additional 880 feet of seawall were provided. The top of the wall is at elevation 85+. A single row of 3- to 5-foot-diameter boulders were dumped by Dade County in the vicinity of the northernmost cabana building in Crandon Park to aid in

preserving the narrow strip of beach. The boulders are now mostly imbedded in sand. They are considered to have been partially effective.

(2) Private property.--There are eight groins of unconsolidated broken pieces of concrete on the Key Colony Motel property. Those groins have had no apparent effect on the shoreline. Immediately south of the rock groins, are two well-constructed timber groins. These groins were built by both the Key Colony and the Silver Sands Motels in 1957. They are approximately 75 feet long. The groins appear to have been slightly effective on the south side; during the time the groins are building up the south beach, the beach to the north is adversely affected. There are no protective structures for the reach between the Silver Sands Motel and the Key Biscayne Hotel (approximately 2,200 ft.). There are approximately 650 feet of seawall on the Key Biscayne Hotel property, 500 feet of which are steel-sheet piling with a concrete cap and the remaining 150 feet are concrete block. For the remainder of the ocean side of Key Biscayne (approximately 7,500 ft.), there are no protective structures except at the extreme southern portion, where there are six deteriorated timber-pile groins. The groins are located in a reach beginning at the lighthouse on Cape Florida and extending northerly approximately 500 feet. Also, beginning at the lighthouse and extending south and west around Cape Florida to the Biscayne Bay shoreline is a well-constructed gravity-section concrete seawall.

29. Beach profiles.--From the data presented in table B-2, appendix B, and shown by the plottings of comparative profiles (plates 1-12 of map No. 24-27,095, on file in the office of the District Engineer), it may be seen that there has been a general steepening of the underwater sections of the profiles on the landward end, while the slope of the seaward end has remained relatively unchanged. The only exception to the preceding condition is at profile 13 on Key Biscayne where there has been a slight steepening of the landward 500 feet and a considerable amount of rise and leveling-off seaward to form an offshore sandbar approximately 1,000 feet long. The crest of the bar was about 600 feet offshore in 1960.

30. Volumetric accretion and erosion.--Details of volumetric change in the study area are given in table B-3, appendix B. The quantities presented are based on the comparative profiles. It may be observed that erosion has occurred over the entire study area. The annual loss rate from the eastern shore of Virginia Key south to about the bridge connecting Virginia Key and Key Biscayne has been about 80,000 cubic yards over the entire length of profile surveyed, and about 30,000 cubic yards over the inner part of the profile. The annual loss rate from the eastern shore of Key Biscayne has been about 100,000 cubic yards over the entire profile length and about 40,000 cubic yards over the inner part of the profile. By "inner part" is meant the part of the profile the past behavior of which provides an indication of what future loss rates would be from a restored beach profile. The division between the inner part and the outer part of the profile has been made near the point where the profile flattens out (in a seaward direction), or where it crosses a

trough and begins to attain higher elevations. The point of division occurs at varying depths on the profiles, ranging from -4 to -15 feet and averaging -8 feet on Virginia Key, and ranging from -2 to -10 feet, and averaging -5 feet on Key Biscayne. The distance offshore of the point of division averages about 750 feet on Virginia Key and about 550 feet on Key Biscayne.

IV. ANALYSIS OF THE PROBLEM

31. Shore processes.--a. General.--The beaches in the study area are composed generally of fine sand and shell fragments. The sand and shell are easily moved by littoral currents and by wave action. Littoral drift is predominantly southward, though periods of drift reversal occur, as evidenced by accumulation of sand on the south side of existing groins at times. The behavior of the shore is influenced by three inlets, Government Cut, Norris Cut, and Bear Cut. Government Cut is protected by jetties which extend about 2,000 to 2,500 feet seaward of the shoreline. The inlets constitute partial littoral barriers. Government Cut is probably almost a complete littoral barrier now; the north jetty, for a distance of several hundred feet from shore, was made essentially sand tight in late 1959 and early 1960. Before that time sand was able to pass freely through the jetty. A general deficiency in supply of littoral material reaching the area has been aggravated by the extensive groin systems on Miami Beach. In addition, some material is probably lost into offshore waters. As a result, severe erosion has been experienced in parts of the study area.

b. Virginia Key.--The most severe erosion has been experienced at the middle of the key, where the shoreline has receded as much as 1,460 feet during the period of record. Lesser erosion has been experienced along the remaining part of the shore to Bear Cut bridge. Erosion along the outer part of the profiles along the northern part of the key has merely resulted in a lowering of the rather flat bottom. Erosion of the southerly profiles has resulted in some steepening of the slope. Average annual loss of material from the inner part of the profiles from the north point to Bear Cut bridge has been about 30,000 cubic yards during the period 1919-1960. That volume is the amount considered to be the present effective erosion rate for the key. The problem could be corrected by nourishing and maintaining the existing beach, or by partially restoring and then periodically nourishing and maintaining the restored beach. Partial restoration would be required to provide the dry beach area needed to accommodate future recreational bathing. It is not considered feasible or desirable to effect complete restoration in the northern part of the key. Restoration would be accomplished by artificial fill placed by a hydraulic dredge in Biscayne Bay. Because of the abrupt change in shoreline alinement at the ends of the reach, and in the middle, groins would be useful to help hold the fill. The groins would not act as a system, but would merely be a hardening of the beach at critical points. The problem area and attendant conditions are not suited to provision of a sand-transfer plant.

c. Key Biscayne.--Erosion and recession of the shoreline have been less severe along Key Biscayne than along Virginia Key. However,

an erosion problem similar to that on Virginia Key does exist. Material is lost into Bear Cut on the north end, offshore into the flats east of the key, and south into the shoal areas extending to the upper end of the Florida Keys. The effective erosion rate along the ocean side of the key during the period 1919-1960 has been about 40,000 cubic yards annually. Along the publicly owned frontage it has been about 18,000 cubic yards annually; from the privately owned frontage it has been about 22,000 cubic yards annually. The problem could be corrected by nourishing and maintaining the existing beach, or by partially restoring and then periodically nourishing and maintaining the restored beach. Partial restoration would be required to provide the dry beach area needed to accommodate future recreational bathing. Groins could be installed at the north and south ends of the key to prevent loss of sand into Bear Cut or into the open waters south of the key.

32. Design criteria.--a. The improvement selected should serve two purposes. Protection should be provided against normal weather and, to a partial degree, against storms; and ample beach area above high water should be provided for present and future recreational needs.

b. The relatively low elevations of the keys more or less dictate the maximum height of a protective beach. Average elevation along the shore of Virginia Key is about 6 feet; average elevation along the shore of Key Biscayne is about 7 feet. An ocean tide of 7.1 feet was experienced in the 1926 storm. For beach erosion control purposes it is not feasible to design for tides of that magnitude, much less take into consideration the wave action which would occur on top of the tide. Therefore, the natural elevation of the keys in the problem area is considered to be the elevation to which a restored beach should be raised.

V. PLAN OF IMPROVEMENT

33. General.--The basic method of achieving the results desired by the cooperating agency consists of initial restoration of eroded areas of beach, with periodic nourishment as required. Data indicate that all of the ocean shore of Virginia Key north of Bear Cut requires partial restoration, and all of the ocean shore of Key Biscayne would benefit from provision of a protective and recreational beach. The restored, or protective and recreational beach should, to the extent feasible, be of such dimensions as required to dissipate wave energy seaward of upland property and provide adequate area for recreational bathing. Because of low natural ground elevations, it is not considered feasible to eliminate all overtopping during severe storm conditions. A berm-crest elevation of 6 feet is considered the maximum feasible for Virginia Key; Key Biscayne, slightly higher, could use a berm-crest elevation of 7 feet. The width of the restored beach would be controlled at berm-crest elevation, and would be 50 feet wider at that elevation than now exists. The average increase in width at mean high water would be about 85 feet. For estimating quantities of fill, the seaward slope of the restored beach has been estimated to be 1 on 20 from berm crest to mean low water, thence 1 on 30 to intersection with the existing bottom. It is believed wave action would shape the fill to about those slopes. Rubblemound groins, which would be installed only after experience proved them necessary and economically justified, would be located generally at points

where the shoreline alinement changes and would follow the profile of the restored beach to a point about 1 foot above mean low water, and then would extend seaward, horizontally, far enough to contain the toe of the slope of the restored beach. Data indicate that a beach as described would require periodic nourishment at average intervals of about 5 years. To avoid the possibility of excessive narrowing of the beach during periods of temporary recession, it is considered desirable to place a 5-year advance supply of nourishment in connection with the initial beach widening. Since material for nourishment so placed in advance would reduce future nourishment requirements during project life, estimates of initial costs do not include cost of that advance supply of nourishment. A typical section of the restored beach and of one of the groins is shown on plate 5.

34. Virginia Key.--The reach considered for restoration extends from profile 4 at the north end of the key to a point about 400 feet north of Bear Cut bridge, a distance of 1.8 miles. The estimated volume of material required for initial restoration is about 650,000 cubic yards (68 cubic yards a linear foot of shore). The restored beach would require periodic replenishment in order to maintain an effective width. Average annual replenishment requirement, based on past loss of material from the inner end of the beach profiles in the area, is estimated to be 30,000 cubic yards. A 5-year advance supply of nourishment would total 150,000 cubic yards. The plan is based on obtaining fill material from Biscayne Bay; at time of actual construction consideration could be given to obtaining the fill from shoal areas in the ocean, as desired by fish and wildlife interests in order to avoid damage to fisheries in Biscayne Bay. When determined to be necessary, groins would be provided near the north end of the key at profile 4, at about the midpoint of the key where the alinement of the shore bends westward, and at a point about 400 feet north of Bear Cut bridge, where a small, revetted cove provides anchorage for small craft. Groin locations are shown on plate 5. Improvement of the city and county frontages could be accomplished separately or together.

35. Key Biscayne.--The reach considered for restoration includes the entire publicly owned ocean frontage, extending from profile 10 south 1.9 miles to a point about 150 feet north of profile 14, and the contiguous privately owned frontage south to profile 17. Improvement of the public frontage could be accomplished separately from that of the private frontage if desired. The estimated volume of material required for initial restoration is about 415,000 cubic yards (42 cubic yards a linear foot of shore) for the public shore and about 690,000 cubic yards for the private shore. Average annual nourishment requirement is estimated to be about 18,000 cubic yards for the public shore and about 22,000 cubic yards for the private shore. A 5-year advance supply of nourishment would total 90,000 cubic yards for the public shore and 110,000 cubic yards for the private shore. Fill material would be obtained from Biscayne Bay (at time of actual construction consideration could be given to use of borrow areas in the ocean--see paragraph 34 above). A groin would be provided at profile 10 where the shore curves to the west, and at profile 17, near the southern tip of the key. Location of the groins is shown on plate 5.

36. Consideration was given to provision of measures which would eliminate or reduce flooding from hurricane tides and waves from the ocean. However, development on Virginia Key is negligible except for the sewage treatment plant near the north end of the key. That plant was erected above elevation 10, and is relatively immune to flooding. Key Biscayne is highly developed in certain areas. A combined beach erosion and hurricane protection fill would eliminate some of the damage to development along the coastal area. However, flooding from Biscayne Bay would still occur, so that the protection provided would be limited to reduction or elimination of wave damage to such development. The relatively minor benefits which would result from such protection fall far short of equaling the incremental cost of raising the beach erosion fill to a point high enough to prevent overtopping from the ocean.

VI. ECONOMIC ANALYSIS

37. Estimates of first costs.--The estimated first costs of the plan of improvement for the shores of Virginia Key and Key Biscayne, based on spring 1961 prices, are summarized in table 1 below; detailed estimates are presented in appendix D. Costs of the beach fill are based on obtaining material in Biscayne Bay by hydraulic dredge and depositing it on the shore by pipeline discharge from the dredge, but are considered adequate for dredging from the shoal area in the ocean opposite Key Biscayne, if suitable equipment for such work is available at the time of construction. Granite for the groins would be shipped to Miami by rail and hauled to the site by truck. All estimates include allowance for contingencies.

38. Estimates of annual costs.--The estimated annual costs of the plan of improvement are summarized in table 2. Annual nourishment costs are based on periodic nourishment at an average interval of 5 years. However, as stated in paragraph 33, material for nourishment would be provided when needed. Details are included in appendix D.

TABLE 1
Estimated first costs

Item	Reach		
	Virginia Key	Key Biscayne Public frontage Entire key	
Beach fill-----	\$469,000	\$316,000	\$838,000
Groins (deferred)-----	472,000	99,000	226,000
Subtotal-----	941,000	415,000	1,064,000
Engineering and design-----	67,000	29,000	75,000
Supervision and adminis- tration-----	75,000	33,000	85,000
Postauthorization costs-----	(1) 8,000	(1) 3,000	(1) 7,000
Total first cost (financial)-----	(2)1,091,000	(2)480,000	(2)1,231,000
Preauthorization cost (cooperative study)-----	12,000	14,000	14,000
Total first cost (economic)--	1,103,000	494,000	1,245,000

NOTES: (1) Consists of engineering and administrative costs to Corps of Engineers in connection with construction by local interests.

(2) Amount subject to apportionment.

TABLE 2
Estimated annual costs

Item	Reach		
	Virginia Key	Key Biscayne	
		Public shores	Entire key
Initial investment (1)-----	\$1,103,000	\$494,000	\$1,245,000
Interest at 2-5/8 pct. and 5 pct. (2)-----	29,000	12,900	50,400
Amortization in 50 years at 2-5/8 pct. and 5 pct. (2)-----	10,900	4,800	8,400
Periodic beach nourishment--	28,300	19,100	42,500
Maintenance of groins-----	4,700	1,000	2,300
Total annual cost (economic)---	72,900	37,800	103,600
Total annual cost (financial) (3)-----	72,400	37,400	103,200

- NOTES: (1) Total first cost (economic). Interest during construction is not a factor since the construction period would be less than 2 years.
- (2) The 5-percent interest rate, applies only to the privately owned shores of Key Biscayne and is based on the assumption that work on private property would be done by private interests.
- (3) Based on initial investment less preauthorization costs.

39. Estimates of benefits.--Benefits are anticipated from the plan of improvement in the form of direct damages prevented, recreational benefits, and enhancement of property values. Benefits due to prevention of loss of land along public shores have been computed (see appendix C), but are not credited to the plan as they would possibly duplicate recreational benefits claimed for those public shores. Estimates of monetary benefits are based on spring 1961 price levels. Benefits are summarized in table 3 below. Details are given in appendix C.

TABLE 3

Summary of benefits

Type	Non-Federal public	Private	Total
<u>VIRGINIA KEY</u>			
<u>City of Miami property</u>			
Damages-to-development benefits-----	-	\$400	\$400
Recreational benefits-----	\$283,000	-	283,000
Total-----	283,000	400	283,400
Percent-----	> 99	< 1	100
<u>Dade County property</u>			
Damages-to-development benefits-----	1,200	-	1,200
Recreational benefits-----	394,000	-	394,000
Total-----	395,200	0	395,200
Percent-----	100	0	100
Total, Virginia Key-----	678,200	400	678,600
Percent-----	> 99	< 1	100
<u>KEY BISCAYNE</u>			
<u>Dade County property</u>			
Damages-to-development benefits-----	1,600	-	1,600
Recreational benefits-----	818,000	-	818,000
Total-----	819,600	-	819,600
Percent-----	100	0	100
<u>Entire key</u>			
Loss-of-land benefits (1)-----	(1)	42,750	42,750
Damages-to-development benefits-----	1,600	3,800	5,400
Recreational benefits-----	818,000	-	818,000
Increased-land-area benefits-----	-	108,000	108,000
Total-----	819,600	154,550	974,150
Percent-----	84	16	100

NOTE: (1) Public lands excluded to avoid duplication of recreational benefits.

40. Justification of improvements.--Annual economic benefits and costs and the benefit-cost ratios are summarized below.

	<u>Economic benefits</u>	<u>Economic costs</u>	<u>Benefit-cost ratio</u>
<u>Virginia Key</u>			
City beach-----	\$283,400	\$21,100	13.4
County beach-----	395,200	51,800	7.6
Entire key-----	678,600	72,900	9.3
<u>Key Biscayne</u>			
County beach only----	819,600	37,800	21.7
Entire key-----	974,150	103,600	9.4

Improvement of both keys, either as a whole or by parts, is, therefore, justified. The benefits and the benefit-cost ratios presented above do not reflect damages to fisheries in Biscayne Bay if borrow areas for beach fill are located there. However, even if benefits were reduced by those damages as approximated from data furnished by the United States Fish and Wildlife Service, the improvements planned would still be justified.

41. Apportionment of costs.--The policy of Federal aid in the restoration and protection of shores against erosion is set forth in Public Law 826, 84th Congress. The maximum Federal aid permitted under that law, one-third of the cost of construction, is applicable to publicly owned shores. There are no federally owned shores in the areas considered for restoration by this study. Periodic beach nourishment is considered construction eligible for Federal aid. It is considered that such aid should be limited to a period of 10 years to permit benefits and beach erosion control techniques to be reevaluated. Financial costs are apportioned between Federal and non-Federal interests as shown in table 4. Details of the apportionment are shown in appendix D. Pre-authorization costs are not subject to apportionment, and are not included in table 4.

TABLE 4

Apportionment of first costs and annual costs (financial)

Item	Federal	Non-Federal	Total
<u>VIRGINIA KEY</u>			
Beach fill and groins, percent-----	33-1/3	66-2/3	100
First costs-----	\$364,000	\$727,000	\$1,091,000
Annual costs:			
Interest and amortization-----	13,100	26,300	39,400
Periodic beach nourishment-----	9,400	18,900	28,300
Groin maintenance-----	0	4,700	4,700
Total annual cost-----	22,500	49,900	72,400
<u>KEY BISCAYNE</u>			
<u>Public shores</u>			
Beach fill and groin, percent-----	33-1/3	66-2/3	100
First costs-----	\$160,000	\$320,000	\$480,000
Annual costs:			
Interest and amortization-----	5,800	11,500	17,300
Periodic beach nourishment-----	6,400	12,700	19,100
Groin maintenance-----	0	1,000	1,000
Total annual cost-----	12,200	25,200	37,400
<u>Entire key</u>			
Beach fill and groins:			
Public shores (same as above)-----	12,200	25,200	37,400
Private shores:			
First costs, percent-----	0	100	100
First costs, amount-----	0	\$751,000	\$751,000
Annual costs:			
Interest and amortization-----	0	41,100	41,100
Periodic beach nourishment-----	0	23,400	23,400
Groin maintenance-----	0	1,300	1,300
Total annual cost			
(private shores)-----	0	65,800	65,800
Total annual cost (entire key)-----	12,200	91,000	103,200

42. Coordination with other agencies.--a. Contact has been maintained between representatives of the Corps of Engineers and of the cooperating agency during the course of the study. Correspondence with the appropriate State agency and the United States Fish and Wildlife

Service indicate that borrow areas for beach fill should be located in the ocean to avoid damage to bay fisheries (see appendix E for report).

b. Correspondence and discussions with designated representatives of Metropolitan Dade County and the city of Miami indicate that the plan of improvement will meet their needs. It is believed that the cooperating agencies will assume responsibility for complying with the local cooperation specified by authorizing legislation.

43. Supplemental report.--Additional information on recommended and alternative projects called for by Senate Resolution 148, 85th Congress, 1st Session, adopted January 28, 1958, is contained in Supplement 1 to this report.

VII. CONCLUSIONS

44. Conclusions.--The District Engineer concludes that the most practicable plans of improvement for the problem areas on Virginia Key and Key Biscayne consist of artificial placement of a protective and recreational beach in the areas, and of deferred construction of rubblemound groins located at points where alinement of the shore changes direction. The groins are deferred because their effectiveness in reducing future nourishment requirements is not known; the benefits creditable to them are indeterminate. The relative costs of the groins and beach fill may change in the future as the demand for bay bottom lands increases, and available borrow areas become more distant from the beaches. Improvement of the keys could be accomplished separately; improvement of Virginia Key could be accomplished as a whole, or improvement of the city and county frontages could be accomplished separately; improvement of Key Biscayne could be accomplished as a whole, or the public shore only could be improved. He further concludes that the plans are justified. The estimated first costs for Virginia Key, excluding preauthorization costs, total \$1,091,000; the estimated first costs for Key Biscayne, excluding preauthorization costs, total \$480,000 for the public shore and \$1,231,000 for the entire key. The Federal share of the apportionable costs is one-third, or \$364,000, for Virginia Key, of which \$181,000 is for beach fill and \$183,000 is for groins (deferred); for the public shore of Key Biscayne the Federal share is one-third, or \$160,000, of which \$122,000 is for beach fill and \$38,000 is for a groin (deferred); and for the entire key the Federal share remains at one-third of the cost of protecting public shores, or \$160,000. The Federal share includes certain postauthorization costs to the Corps of Engineers in connection with construction by the cooperating agency. Reimbursement to the cooperating agencies would amount to one-third of the first cost less those postauthorization costs. Federal aid in periodic nourishment of the shores is justified for a period of 10 years. The estimated Federal share of the annual cost of periodic nourishment is one-third for Virginia Key, now estimated at \$9,400; the Federal share of the annual cost of periodic nourishment for the public shores of Key Biscayne is one-third, or \$6,400. There would be no Federal participation in nourishment of the private shores on Key Biscayne. In order that ample material

for beach fill be available during project life, the District Engineer concludes that the cooperating agency should reserve appropriate submerged lands for use as borrow areas. At time of actual construction, consideration could be given to use of borrow areas in the ocean rather than in the bay, so as to avoid damage to fisheries in the bay.

VIII. RECOMMENDATIONS

45. Recommendations.--The District Engineer recommends:

a. Adoption of a Federal project to provide for reimbursement of local interests of an amount equal to one-third, less postauthorization costs, of the financial costs of protecting the ocean shores of Virginia Key by partially restoring the existing beach along 1.8 miles of the ocean shore as described in paragraph 34 to a berm elevation of 6 feet above mean low water, and widening it to a width of 50 feet greater than now exists at elevation 6. The project includes construction of three groins subject to future determination of their actual need and justification, based on experience, and provides for periodically nourishing in the future the problem areas when and as erosion may occur for a period of 10 years after the initial restoration has been accomplished. Details of the determination of the amount of Federal participation are given in appendix D. As now estimated, reimbursement by the United States for the work (beach fill) recommended for immediate accomplishment would be \$177,000, and for periodic nourishment of the beach would be \$9,400 annually for a period of 10 years. The project could be accomplished as a whole, or the plans for the city and county frontages could be accomplished separately.

b. Adoption of a Federal project to provide for reimbursement of local interests of an amount equal to one-third, less postauthorization costs, of the financial costs of protecting the public ocean shore of Key Biscayne. The plan of improvement for the entire ocean frontage of the key consists of partially restoring the existing beach along 4.3 miles of the ocean shore as described in paragraph 35 to a berm elevation of 7 feet above mean low water, and widening it to a width 50 feet greater than now exists at elevation 7. The project includes construction of two groins subject to future determination of their actual need and justification, based on actual experience, and provides for periodically nourishing in the future the problem areas where and as erosion may occur for a period of 10 years after the initial restoration has been accomplished. Local interests would have the option of adopting the recommended plan for the entire key or for the public frontage only, as the amount of Federal participation is the same for both plans. As now estimated, reimbursement by the United States for the work (beach fill) recommended for immediate accomplishment would be \$120,000, and for periodic nourishment of the beach would be \$6,400 annually for a period of 10 years. The District Engineer further recommends that borrow areas in Biscayne Bay be reserved for future needs of the project.

X

46. He further recommends that the Federal projects for reimbursement be made subject to the condition that responsible local authorities:

a. Obtain approval by the Chief of Engineers, prior to commencement of work, of detailed plans and specifications and arrangements for prosecution of the work on the project;

b. Furnish assurances satisfactory to the Secretary of the Army that they will:

(1) Maintain continued public ownership of the shore upon which the amount of Federal participation is based, and its administration for public use during the economic life of the project;

(2) Maintain the project works and provide periodic nourishment of the protective beach during the economic life of the project, as may be required to serve the intended purpose; and

(3) Control water pollution to the extent necessary to safeguard the health of bathers.

J. V. SOLLOHUB
Colonel, Corps of Engineers
District Engineer

SADER (29 Sep 61)

1st Ind

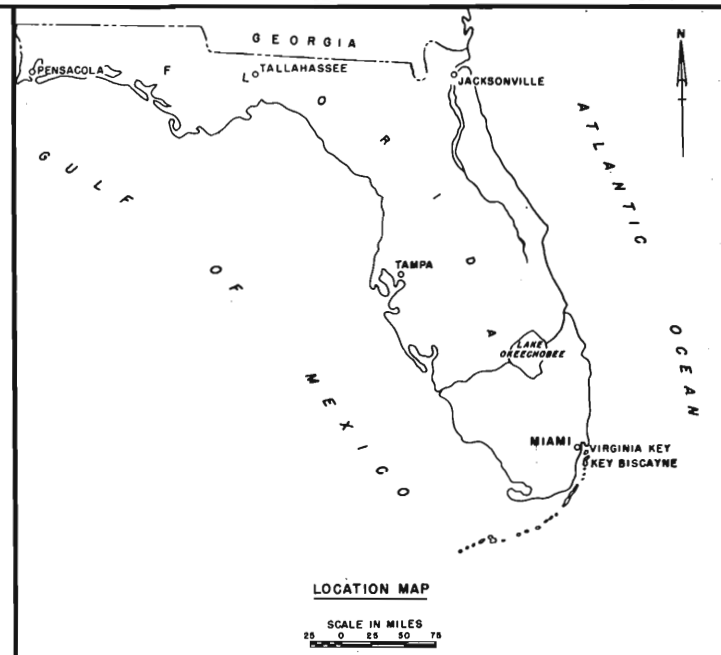
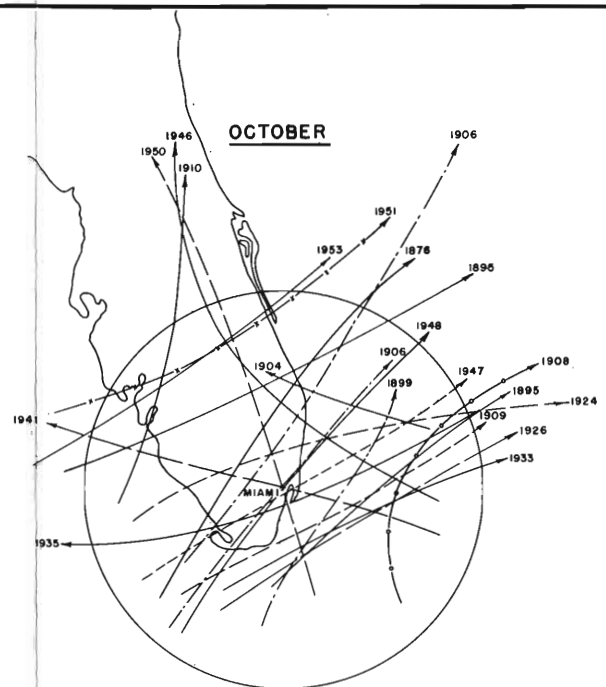
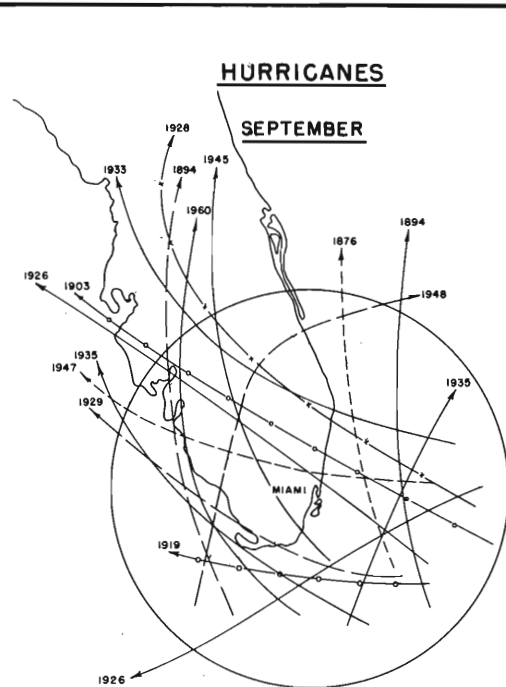
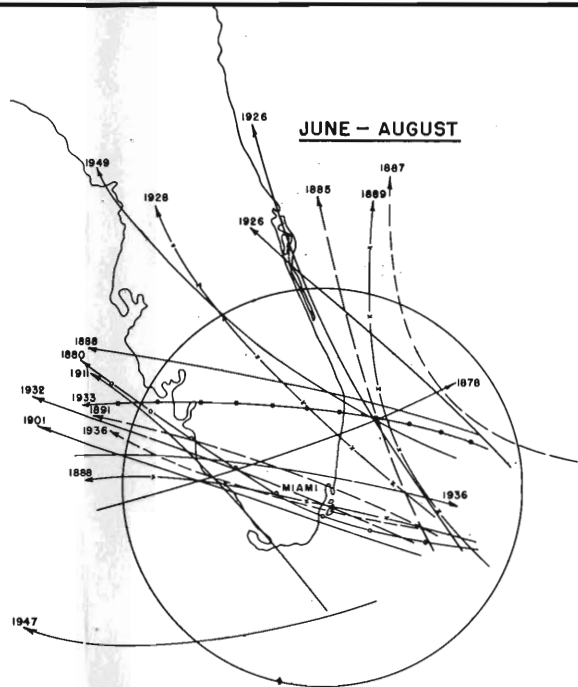
SUBJECT: Beach Erosion Control Report on Cooperative Study of
Virginia and Biscayne Keys, Florida

U. S. Army Engr Div, South Atlantic, Atlanta, Ga., 31 January 1962

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

The Division Engineer concurs in the recommendation of the
District Engineer.

H. A. MORRIS
Brigadier General, USA
Division Engineer



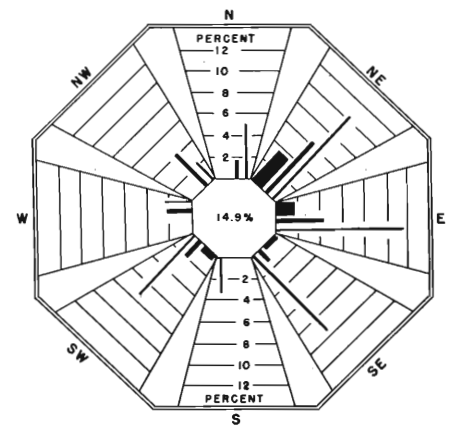
PATHS OF TROPICAL STORMS OF HURRICANE INTENSITY THAT HAVE PASSED WITHIN APPROXIMATELY 150-MILE RADIUS OF MIAMI FROM 1876 TO 1960 INCLUSIVE.

SCALE IN MILES
0 50 100

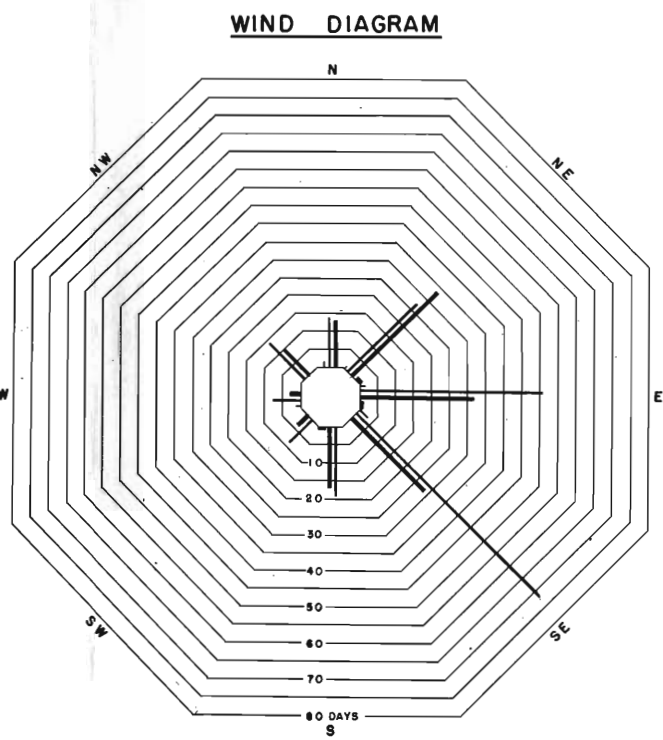
SWELL DIAGRAM

IN THE SWELL DIAGRAM THE LENGTH OF THE BAR DENOTES THE PERCENT OF THE TIME THAT SWELLS OF EACH TYPE HAVE BEEN MOVING FROM OR NEAR THE GIVEN DIRECTION. THE FIGURE IN THE CENTER OF THE DIAGRAM INDICATES THE PERCENT OF CALMS.

SWELL DATA BASED ON OBSERVATION FOR 10-YEAR PERIOD - 1932 - 1942.



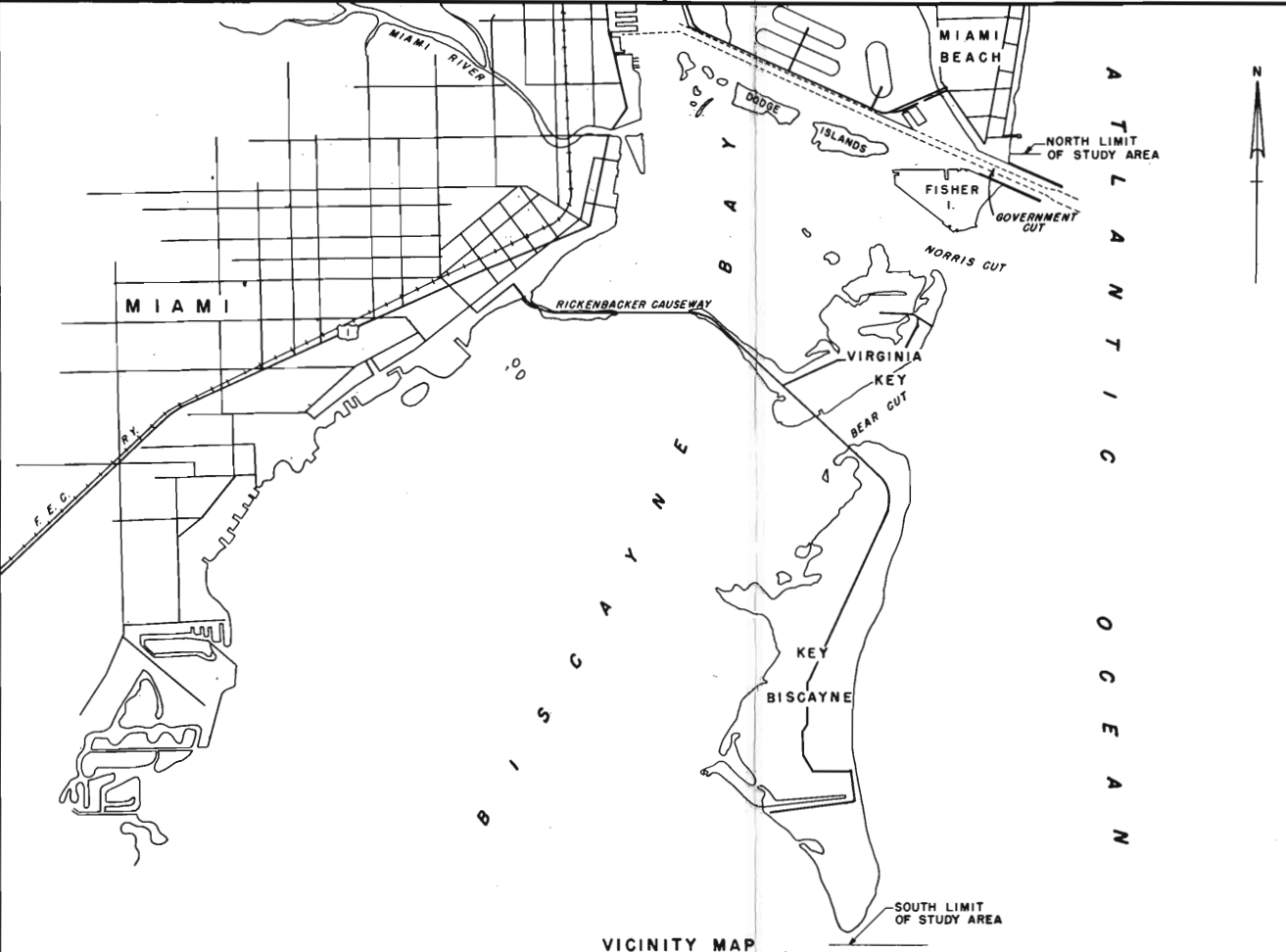
LOW SWELLS (1-6 FT.)
MEDIUM SWELLS (6-12 FT.)
HIGH SWELLS (OVER 12 FEET.)



AVERAGE DIRECTION, DURATION AND VELOCITY OF WINDS FOR ONE YEAR AT MIAMI, FLORIDA.

VELOCITIES MPH
0 TO 5
6 TO 10
11 TO 20
20 OR MORE

BASED ON HOURLY READINGS OVER THIRTEEN-YEAR PERIOD BY THE UNITED STATES WEATHER BUREAU AT MIAMI, FLORIDA.



COOPERATIVE BEACH EROSION STUDY
VIRGINIA KEY AND KEY BISCAYNE
HURRICANE, WIND, AND SWELL
DIAGRAMS

IN 1 SHEET SHEET NO. 1 SCALES: AS SHOWN

U.S. ARMY ENGINEER DISTRICT JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

DRAWN BY: F.O.R. TO ACCOMPANY REPORT D.O. FILE NO.
CHECKED BY: T.E.B. DATED: SEPTEMBER 29, 1961 24-27,094-1



LEGEND

HIGH WATER SHORELINE

1851	-----	USC&GS.
1867	.....	"
1913	.....	"
1919	.....	"
1927	.....	"
1935	.....	"
1945-47	.....	"
1960	.....	USCE

DEPTH CURVES

	6 FT.	12 FT.	18 FT.	30 FT.
1852	-----	-----	-----	-----
1889	-----	-----	-----	-----
1913	-----	-----	-----	-----
1919	-----	-----	-----	-----
1928	-----	-----	-----	-----
1935	-----	-----	-----	-----
1960	-----	-----	-----	-----

NOTES:

Data for all years prior to 1960 based on;
 Beach Erosion Board Sheet, Shoreline & Offshore
 Depth Changes, Virginia Key & Key Biscayne
 (Miami, Florida) July 1959
 1960 Shoreline based on USCE survey;
 Field Books: S-1, S-2 & S-3.

MATCH LINE SHEET 2

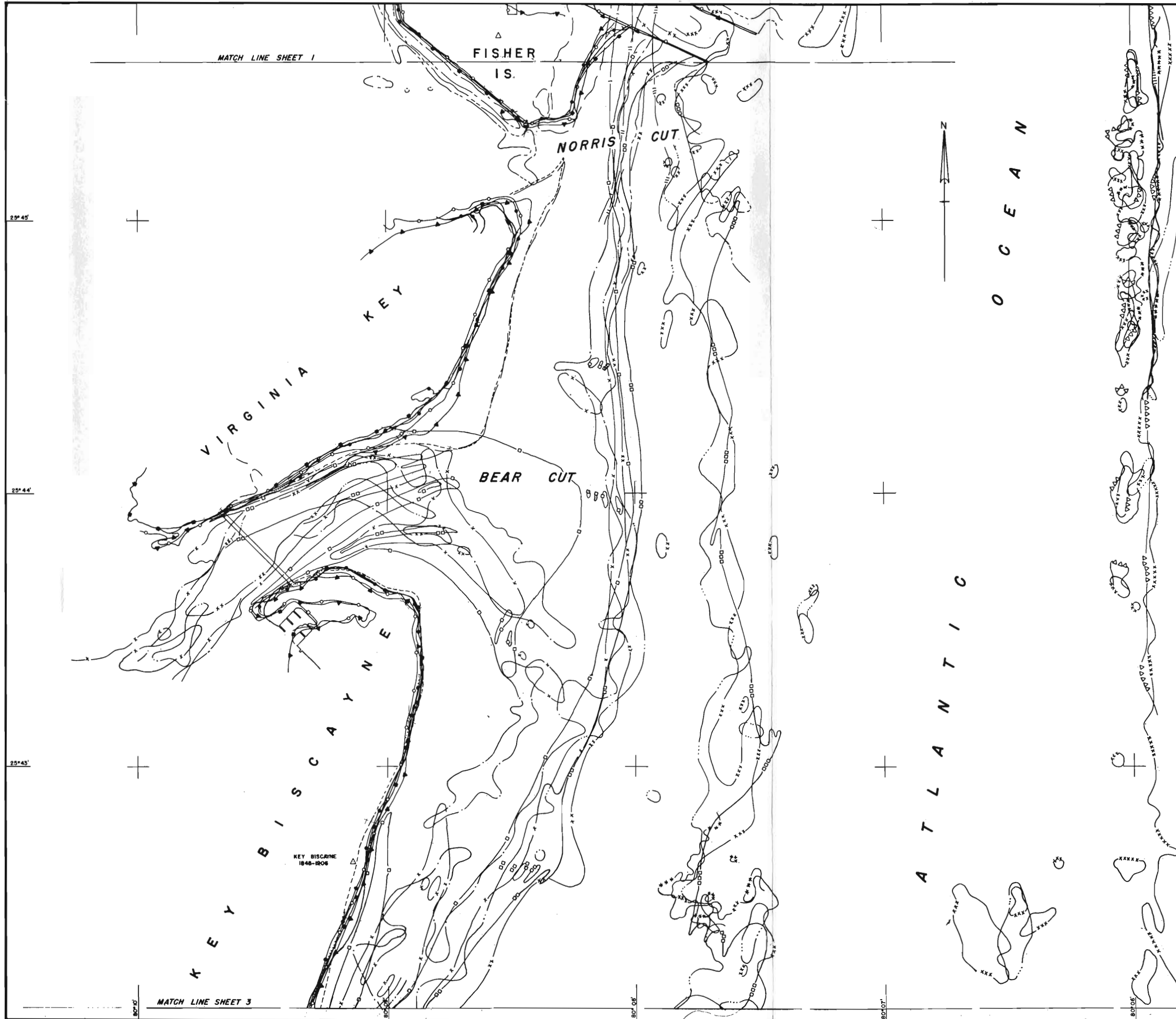
COOPERATIVE BEACH EROSION STUDY
 VIRGINIA KEY AND KEY BISCAYNE
 SHORELINE AND OFFSHORE
 DEPTH CHANGES

SHEET 1 OF 3

SCALE IN FEET
 1000 0 1000 2000

U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
 CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

DRAWN BY: F.D.R. TO ACCOMPANY REPORT D.O. FILE NO.
 CHECKED BY: T.E.B. DATED: SEPTEMBER 29, 1961 24-27,094-2



LEGEND

High Water Shoreline

1851	-----	USC&GS.
1867	.....
1913	.....
1919	.....
1927	.....
1935	.....
1945-47	.....	USCE
1960	.....

DEPTH CURVES

	6 FT.	12 FT.	18 FT.	30 FT.
1852
1889
1913
1919
1928
1935
1960

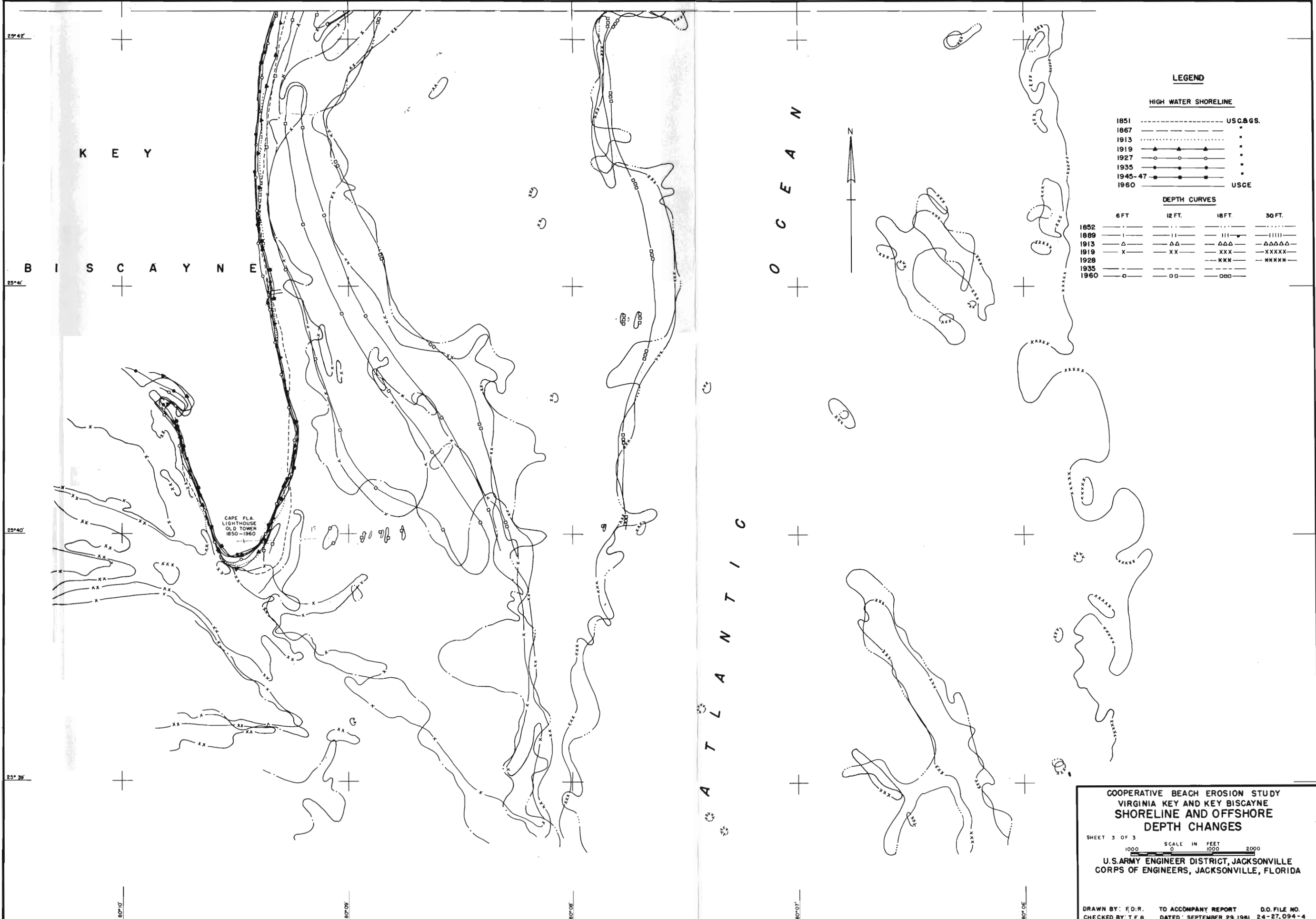
COOPERATIVE BEACH EROSION STUDY
VIRGINIA KEY AND KEY BISCAIYNE
SHORELINE AND OFFSHORE
DEPTH CHANGES

SHEET 2 OF 3

SCALE IN FEET
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U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
 CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

DRAWN BY: F.D.R. TO ACCOMPANY REPORT D.O. FILE NO.
 CHECKED BY: T.E.B. DATED: SEPTEMBER 29, 1961 24-27,094-3



LEGEND

HIGH WATER SHORELINE

1851	-----	USC.&GS.
1867	-----	"
1913	-----	"
1919	-----	"
1927	-----	"
1935	-----	"
1945-47	-----	"
1960	-----	USCE

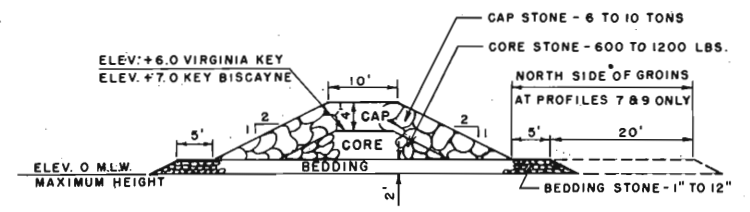
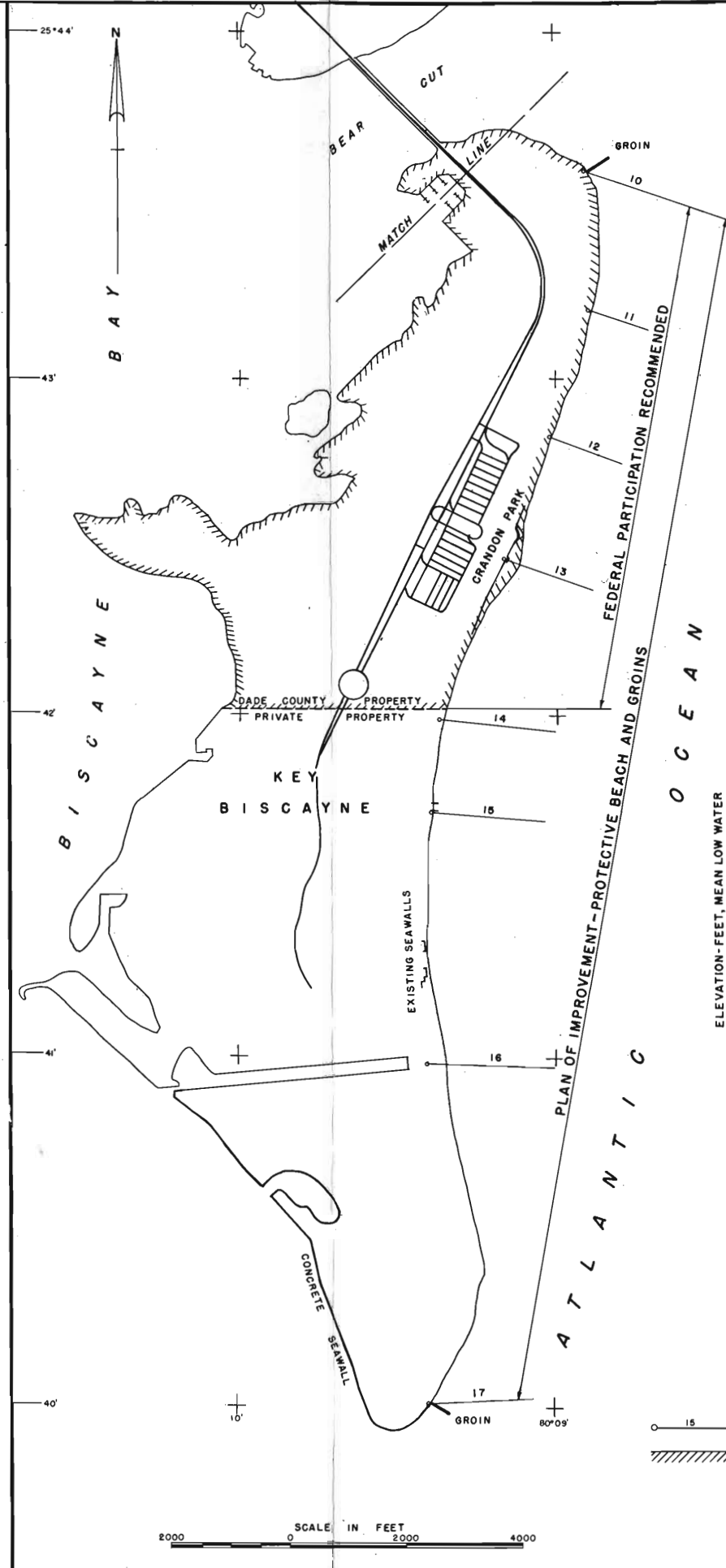
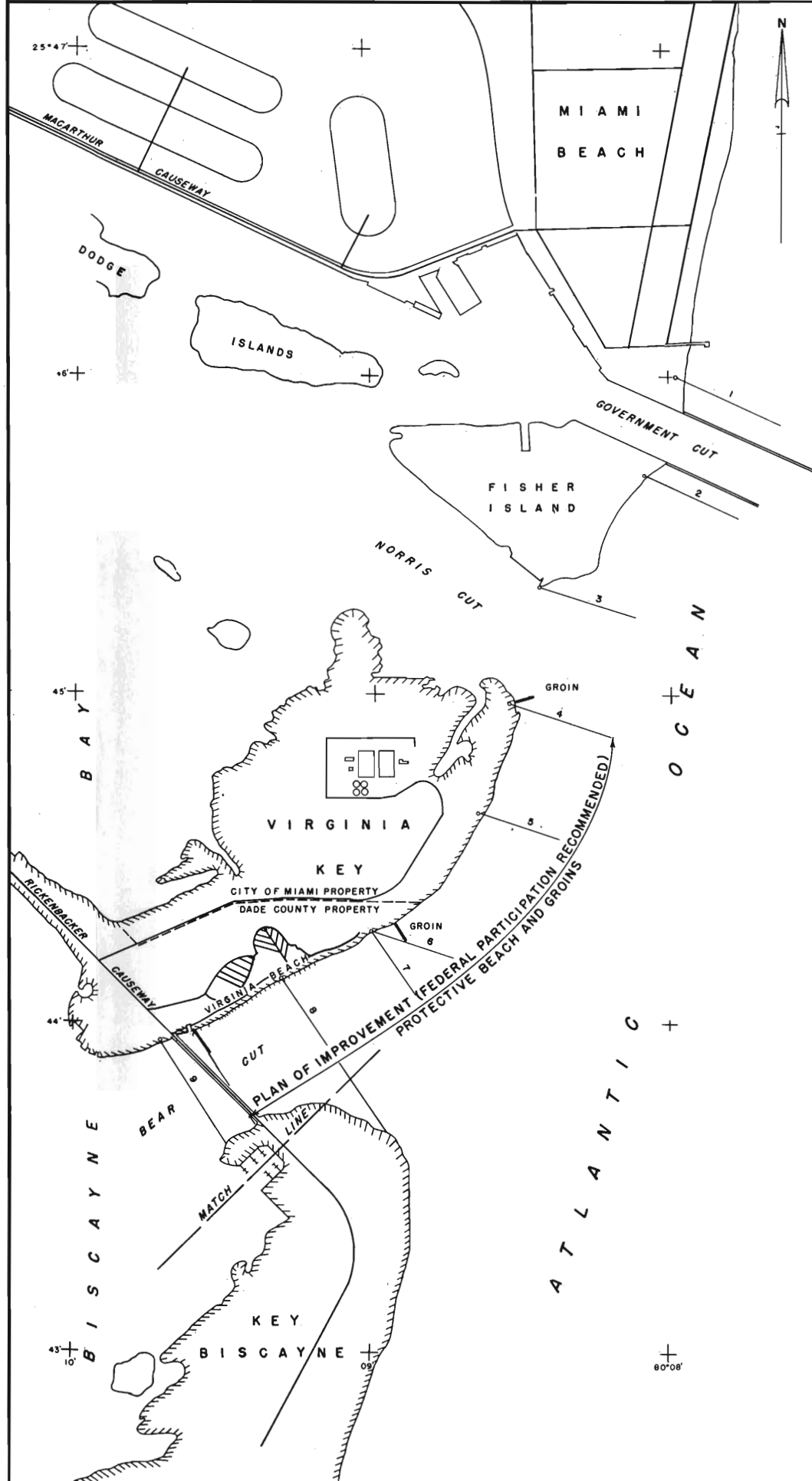
DEPTH CURVES

	6 FT.	12 FT.	18 FT.	30 FT.
1852	-----	-----	-----	-----
1889	-----	-----	-----	-----
1913	-----	-----	-----	-----
1919	-----	-----	-----	-----
1928	-----	-----	-----	-----
1935	-----	-----	-----	-----
1960	-----	-----	-----	-----

COOPERATIVE BEACH EROSION STUDY
 VIRGINIA KEY AND KEY BISCAIYNE
 SHORELINE AND OFFSHORE
 DEPTH CHANGES

SHEET 3 OF 3
 SCALE IN FEET
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 U.S. ARMY ENGINEER DISTRICT, JACKSONVILLE
 CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

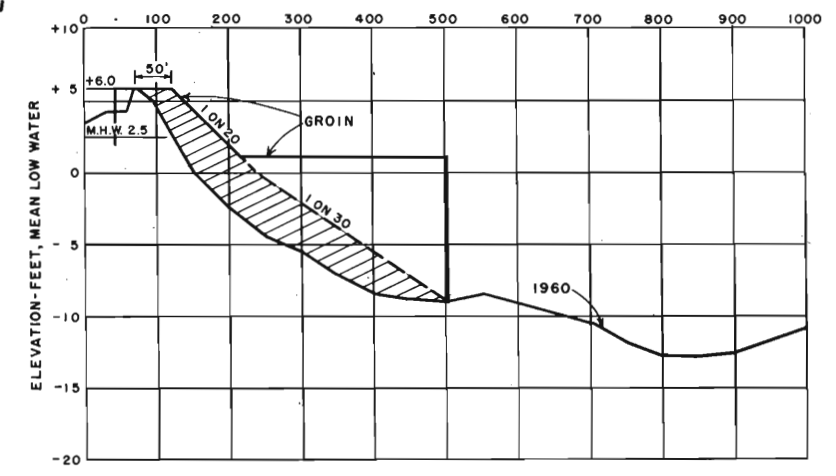
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TYPICAL GROIN SECTION

SCALE IN FEET
0 10 20

NOTE: GROINS WOULD NOT BE CONSTRUCTED UNTIL NEEDED AND JUSTIFIED.



TYPICAL SECTION WITH GROIN
PROFILE 7

GROINS ONLY AT PROFILES 4, 7, 9, 10 AND 17.
EXISTING SECTION ———
IMPROVED SECTION
ELEVATION TOP OF BERM VIRGINIA KEY +6.0
ELEVATION TOP OF BERM KEY BISCAYNE +7.0

LEGEND
○ 15 LOCATION OF PROFILE
 PUBLICLY OWNED SHORE PROPERTY

COOPERATIVE BEACH EROSION STUDY
VIRGINIA KEY AND KEY BISCAYNE
PLAN OF IMPROVEMENT
IN 1 SHEET SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT JACKSONVILLE
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA

SUBMITTED: APPROVAL RECOMMENDED: APPROVED:

CHIEF, PL. & RPTS. BRANCH: CHIEF, ENGINEERING DIVISION: COL. C.E. DISTRICT ENGINEER

DRAWN BY: F.D.R. TO ACCOMPANY REPORT D.O. FILE NO. 24-27,094-5
CHECKED BY: A.J.S. DATED: SEPTEMBER 29, 1961

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX A

SAND-SAMPLE AND SOURCE-OF-MATERIAL TESTS

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VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX A

SAND-SAMPLE AND SOURCE-OF-MATERIAL TESTS

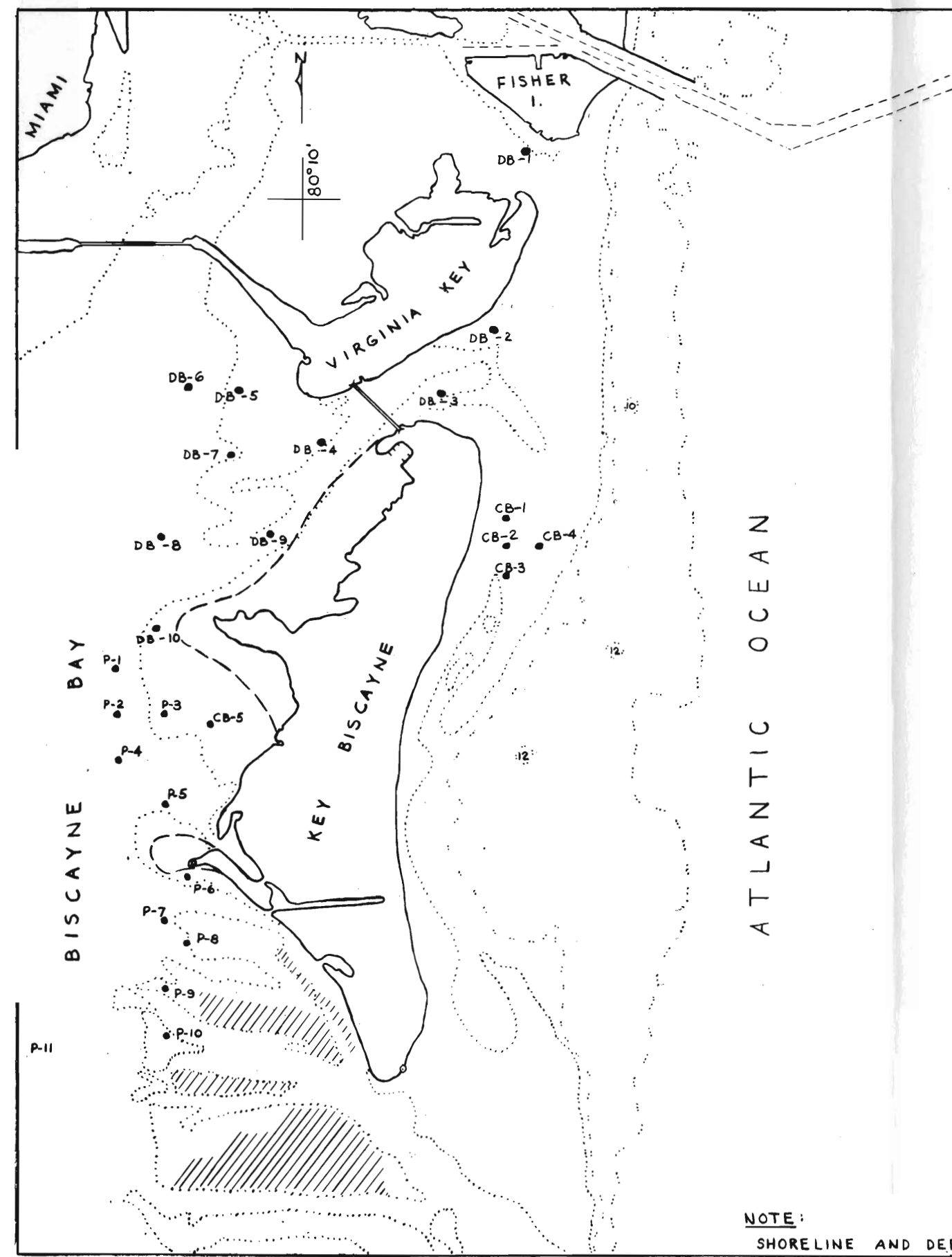
1. Surface sand samples were obtained from the dune, the backshore, the foreshore, and at -3, -6, -12, and -18 feet, mean low water, on 8 representative profiles at Miami Beach, Fisher Island, Virginia Key, and Key Biscayne. Median diameter of the samples obtained ranged from 0.17 to 1.8 millimeters. Average median diameter of samples along the backshore ranged from 0.27 to 0.30 millimeter; average median diameter of samples collected along the foreshore ranged from 0.32 to 0.50 millimeter; average median diameter at -18 feet was 0.59. Results of mechanical analysis of the samples are given in table A-1. The relative coarseness of the sand samples obtained at the 18-foot depth contour can be noted.

2. Sources of material for beach fill.--Subsurface information obtained for this study and available from earlier surveys is shown on figure A-1. There appears to be ample material suitable for beach restoration and for nourishment during project life. Attention is invited to the submerged areas which have been purchased from the Trustees of the Internal Improvement Fund of the State of Florida. Cost estimates are based on use of borrow areas in Biscayne Bay, but there is no assurance that those borrow areas will be available in the future unless the cooperating agency takes steps to reserve them for public use. Core borings in the Atlantic Ocean off the north end of Key Biscayne indicate suitable material exists there. Future development of equipment suited to work in unprotected waters may result in use of that area for fill material.

TABLE A-1

Grain size of surface sand samples collected on beach profiles

Location of sample on profiles	Median sand diameter in millimeters (including shell)																Average, all profiles				
	Profile																				
	1	3	5	8	10	12	14	16	Key Biscayne												
Dune-----	0.27	-	0.43	0.29	-	0.27	0.44	0.28	0.28	0.29	0.27	0.44	0.28	0.28	0.29	0.29	0.28	0.28	0.28	0.28	0.28
Backshore-----	0.29	-	0.36	0.29	-	0.29	0.30	0.23	0.29	0.29	0.29	0.30	0.23	0.29	0.29	0.29	0.23	0.29	0.29	0.29	0.29
Do.-----	0.27	-	0.30	0.28	-	0.30	0.28	0.39	0.30	0.28	0.30	0.28	0.39	0.30	0.28	0.39	0.30	0.30	0.30	0.30	0.30
Do.-----	0.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27
Foreshore-----	0.21	-	0.45	0.38	-	0.27	0.42	0.21	0.32	0.38	0.27	0.42	0.21	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Do.-----	-	-	0.90	0.40	-	0.39	0.49	0.32	0.50	0.40	0.39	0.49	0.32	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Elevation -3-----	0.19	0.51	0.26	0.38	0.72	0.36	0.24	0.28	0.37	0.38	0.36	0.24	0.28	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
-6-----	0.19	-	0.44	0.36	0.72	0.20	-	0.40	0.39	0.36	0.20	-	0.40	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
-12-----	0.17	0.25	0.25	0.51	0.25	0.27	0.40	0.30	0.30	0.25	0.27	0.40	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
-18-----	0.45	0.58	0.37	1.80	0.43	0.38	0.38	0.34	0.59	0.43	0.38	0.38	0.34	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59



LEGEND

- SHORELINE
- 6-FOOT DEPTH CONTOUR
- 12-FOOT DEPTH CONTOUR
- 18-FOOT DEPTH CONTOUR
- - - - - PROPOSED BULKHEAD LINE (APPROXIMATE)
- /////// APPROXIMATE AREA OWNED BY PRIVATE INTERESTS
- DB-1 DRIVE BORING
- CB-1 CORE BORING
- P-1 PROBING

DATA ON BEACH-FILL MATERIAL

LOCATION	MATERIAL	ELEVATION (FT, MLW)	MEDIAN DIAMETER (MM)	
			SURFACE	BOTTOM OF BORING
DB-1	SAND	-3.7 to -19.1	0.36	0.28
DB-2	SAND AND SHELL	-3.5 to -9.0 _R	0.31	0.24
DB-3	DO.	-1.4 to -20.0	0.47	0.38
DB-4	DO.	-6.6 to -19.1 _R	0.17	0.26
DB-5	SAND	-1.0 to -13.0	0.22	0.20
DB-6	SOFT, STICKY SAND	-10.5 to -14.0 _R	0.08	-
DB-7	SAND AND SHELL	-4.1 to -14.3	0.21	0.21
DB-8	FINE SAND	-10.2 to -15.1 _R	0.08	-
DB-9	SAND	-7.5 to -16.5	0.17	0.19
DB-10	SAND AND SHELL	-0.7 to -16.0	0.44	0.56
CB-1	GRAY SAND AND SHELL	-2.3 to -18.0	NOT	AVAILABLE
CB-2	COARSE GRAY SAND AND SHELL	-3.5 to -16.0		DO.
CB-3	GRAY SAND AND SHELL	-5.7 to -18.7		DO.
CB-4	COARSE GRAY SAND AND SHELL	-5.0 to -15.0		DO.
CB-5	SILT, SHELL, SAND, AND MARL	-6.5 to -18.0		DO.
P-1	UNCLASSIFIED SOFT MATERIAL	-11.3 to -19.6		DO.
P-2	DO.	-9.8 to -16.7		DO.
P-3	DO.	-8.2 to -17.0		DO.
P-4	DO.	-10.6 to -18.3		DO.
P-5	DO.	-7.3 to -20.3		DO.
P-6	DO.	-5.0 to -17.5		DO.
P-7	DO.	-7.8 to -18.7		DO.
P-8	DO.	-5.4 to -18.9		DO.
P-9	DO.	-4.1 to -19.0		DO.
P-10	DO.	-1.9 to -18.9		DO.
P-11	DO.	-10.6 to -18.2+		DO.

NOTE:
SHORELINE AND DEPTH CONTOURS TRACED FROM U.S.C.&G.S. CHART 848

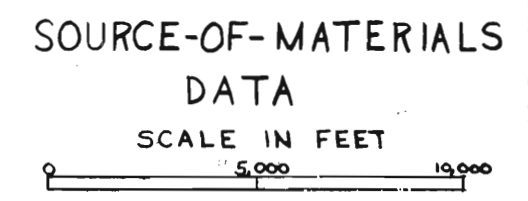


FIGURE A-1

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX B

SHORELINE AND OFFSHORE CHANGES

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VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX B

SHORELINE AND OFFSHORE CHANGES

1. General.--Comparative positions of shorelines over the period of record are shown on plates 2-4, inclusive. The bases for comparison of mean-high-water shorelines are surveys made by the United States Coast and Geodetic Survey in 1851, 1867, 1913, 1919, 1927, 1935, and 1945-47, and by the Corps of Engineers in 1960.

2. Mean-high-water shoreline changes, by reaches, are tabulated in table B-1. As may be seen in table B-1, data indicate general recession throughout most of the study area. For the periods of 1851 to 1919 and 1919 to 1927 there is a pronounced recession rate for both Virginia Key and Key Biscayne. For the period of 1927 to 1935, the northern reach of both keys shows an advance, and the southern reach shows recession. For the period 1935 to 1945-47 the entire reach of the Virginia Key shoreline shows recession, while the Key Biscayne shoreline shows advance. For the period 1945-47 to 1960, the Key Biscayne shoreline shows recession except for the Crandon Park area, which shows advance. For the same period the entire reach of the Virginia Key shoreline shows advance. It can be noted that this advance is not typical of shoreline behavior for the period of record. For example, profile 6, from 1851 to 1960, experienced a net recession of 1,460 feet. In addition, observation in the field does not support the advance indicated by the surveys, at least insofar as the northern part of Virginia Key is concerned.

TABLE B-1

Mean-high-water shoreline changes

Profile	Period											
	1851 to 1919		1919 to 1927		1927 to 1935		1935 to 1945-47		1945-47 to 1960			
	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession
	(feet)											
	<u>MIAMI BEACH</u>											
1	(1)		100		(1)		(1)		100			
	<u>FISHER ISLAND</u>											
2	(1)		110		20		280					100
3	Not applicable. Profile does not intersect shoreline.											
	<u>VIRGINIA KEY</u>											
4	260		90		70		180		70			
5	750		120		80		(1)		90			
6	1,000	(2)430	200	(1)115	300		60	(2)68	100	(2)80		
7	120		100		230	(2)190	40		80			
8	20		100		40		60		60			
9			80		30		(1)					(1)

(Continued)

TABLE B-1--Continued

Profile	Period					
	1851 to 1919	1919 to 1927	1927 to 1935	1935 to 1945-47	1945-47 to 1960	
	Advance Recession	Advance Recession	Advance Recession	Advance Recession	Advance Recession	Advance Recession
	(feet)					
(3) 9		(1)	80	(1)	(1)	(1)
(3) 8	230	140	(1)	(1)	(1)	(1)
10	200	(2)163	200	(2)88	60	20
11	60		70		60	(1)
12	160				30	40
13	160				70	210
14	50					50
15	150					(1)
16	30				100	100
17	420					(1)

KEY BISCAVNE

NOTES.--(1) No change.
 (2) Average change for bracketed reach.
 (3) Beginning at west end of Bear Cut.

3. Offshore depth changes.--Comparison of offshore depth changes is based on the surveys of 1852, 1919, and 1960. The results of those surveys are shown on plates 2-4, inclusive. Changes in position of offshore depth contours between 1852 and 1919, and 1919 and 1960 are given in table B-2. As may be seen in the table, the 6-foot contour shows both advance and recession during the early part of the period. In the latter part of the period the 6-foot contour shows considerable recession, especially opposite Key Biscayne. The 12-foot and 18-foot contours opposite Virginia Key advanced for the entire period of record. The 12-foot contour opposite Key Biscayne shows advance and recession, while the 18-foot contour has generally advanced.

TABLE B-2

Offshore depth changes

Profile	6-foot contour				12-foot contour				18-foot contour			
	1852 to 1919		1919 to 1960		1852 to 1919		1919 to 1960		1852 to 1919		1919 to 1960	
	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession
	(feet)											
	<u>MIAMI BEACH</u>											
1	(1)	(1)	130		(1)	(1)	210		(1)	(1)	410	
	<u>FISHER ISLAND</u>											
2	(1)	(1)	350		(1)	(1)	245		(1)	(1)	510	
3	420		100				155					
	<u>VIRGINIA KEY</u>											
4	430		(1)		(1)	(1)	340				520	
5	400		270		(2)	(2)	100				380	
6	(1)	(1)	550		20	153	390				680	
7							Not applicable				Not applicable	
8			(1)		30	40	Not applicable				Not applicable	
9		(2)	213		Incomplete data	100	Incomplete data				Not applicable	
	<u>KEY BISCAIYNE</u>											
9 (3)					Incomplete data		Incomplete data				Not applicable	
8 (3)					200		50				Not applicable	
10			70		50		240				360	
11			80		270		(2) 408				480	
12	540	(2)	443		610		500				(1)	(1)
13	590	(2)	443		630		800				400	(2) 305
14	200		750		600		600				150	
15	550				200		330				440	
16			50		870		(2) 633				200	
17	950				570		(1)				(1)	220

NOTES: (1) No change.
(2) Average change for bracketed reach.
(3) Beginning at west end of Bear Cut.

4. Volumetric accretion and erosion.--Details of volumetric change in the study area are given in table B-3. The table shows the net change and the average annual change, from 1919 to 1960, for the entire length of profile and for the inner and outer ends of the profile. The quantities presented are based on the comparative profiles (plates 1-12 of map No. 24-27,095, on file in the office of the District Engineer). It may be noted that erosion has occurred over the entire study area. It may also be noted that the average annual erosion rates of the inner ends of the profiles for Virginia Key and Key Biscayne are 30,000 and 42,000 cubic yards, respectively. These rates (the latter rounded to 40,000 cubic yards) are used as the future annual nourishment requirements for the improved sections on the respective keys, since it is considered that predicted future behavior of the outer part of the profile would not influence the beach fill significantly.

TABLE B-3
Volumetric accretion and erosion
1919-1960

Reach	Net change					
	Inner end of profile		Outer end of profile		Entire length of profile	
	Average annual	1919 to 1960	Average annual	1919 to 1960	Average annual	1919 to 1960
	1919 to 1960	(1,000 cubic yards)	1919 to 1960	(1,000 cubic yards)	1919 to 1960	1919 to 1960
<u>MIAMI BEACH</u>						
Profile 1 to north jetty, Government Cut-----					(1)-133	-3
<u>FISHER ISLAND</u>						
South jetty, Government Cut to profile 2-----					-32	-1
Profile 2 to profile 3-----					-440	-11
<u>VIRGINIA KEY</u>						
From point 800 feet north of profile 4 to profile 4-----	-47		0		-28	-1
4 to 5-----	-150		0		-158	-4
5 to 6-----	-484		-18		-1,189	-30
6 to 7-----	-25	(2)-1,195	-15	(2)-2,044	-609	(2)-6,239
7 to 8-----	283		-9		-643	-16
8 to 9-----	-206		-10		-612	-15
9 to point 1,700 feet west of 9-----	-254		-8		-585	-15

(Continued)

TABLE B-3--Continued

Reach	Net change					
	Inner end of profile		Outer end of profile		Entire length of profile	
	1919 to 1960	Average annual	1919 to 1960	Average annual	1919 to 1960	Average annual
			(1,000 cubic yards)			
From point 1,000 feet north of profile 10 to profile 10-----	-44	-1	-250	-6	-294	-7
Profile 10 to 11-----	-104	-3	-942	-24	-1,046	-26
11 to 12-----	-106	-3	-724	-18	-830	-21
12 to 13-----	-72	-2	-30	-1	-112	-3
13 to 14-----	-242	-6	-84	-2	-326	-8
14 to 15-----	-255	-6	-97	-2	-352	-9
15 to 16-----	-497	-12	+156	+4	-341	-9
16 to 17-----	-384	-9	-315	-8	-699	-17
		(2) -1,704	(2) -42	(2) -2,286	(2) -4,000	(2) -100

KEY BISCAIYNE

NOTES: (1) - denotes erosion; + denotes accretion.
 (2) Total change for bracketed reach.

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX C

ESTIMATES OF BENEFITS

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VIRGINIA KEY AND KEY BISCAIYNE, FLA.

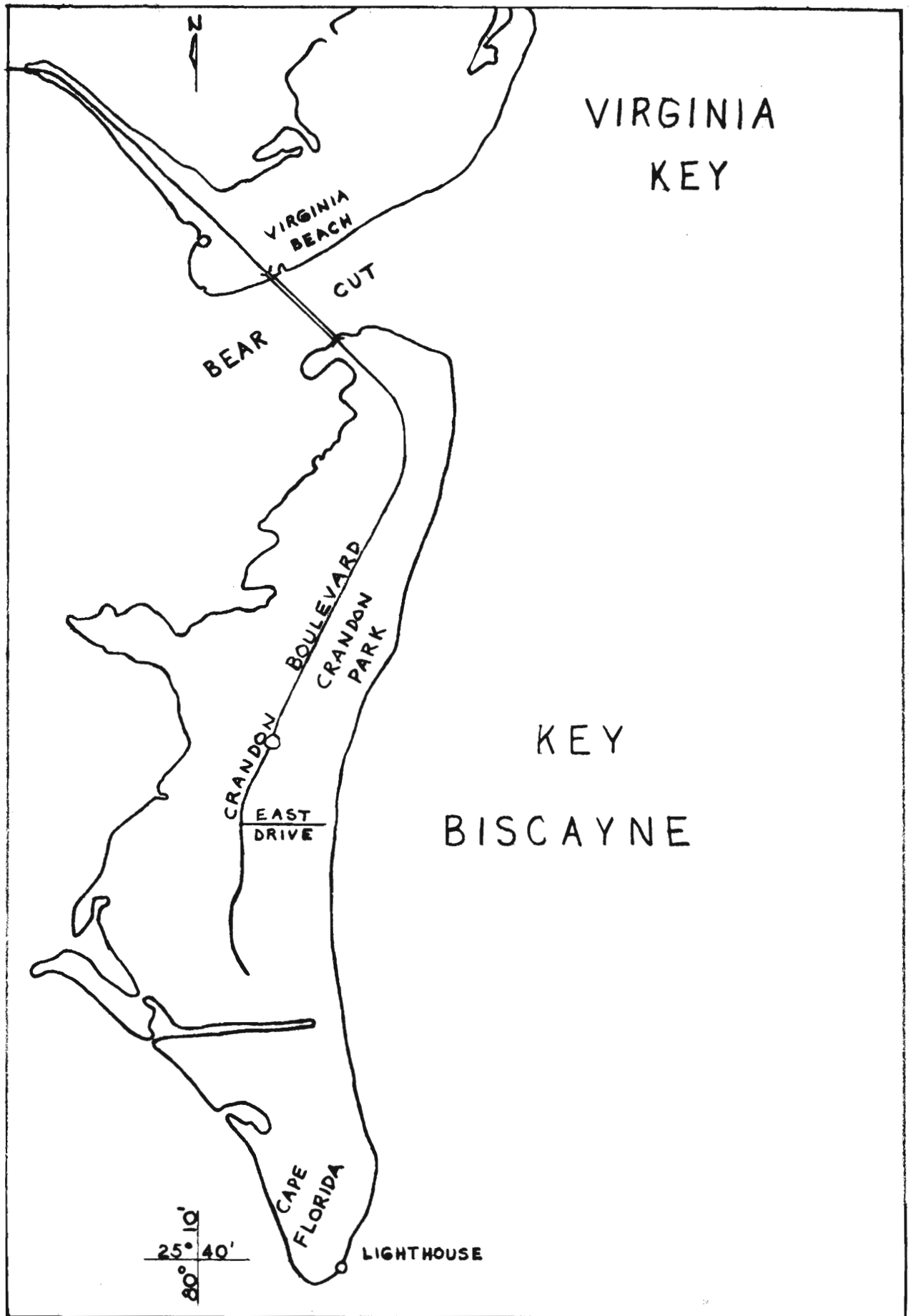
BEACH EROSION CONTROL STUDY

APPENDIX C

ESTIMATES OF BENEFITS

1. General.--Sections of the beaches of Virginia Key and Key Biscayne have eroded severely in the past 50 years. The problem is one of restoring those sections to a semblance of their former dimensions, thereby protecting existing shore structures and upland property, and of providing adequate beach areas for recreational purposes. Benefits computed herein are based on the restoration of the beaches, the protection of existing shore structures and upland property, the promotion and encouragement of the healthful recreation of the people, and, incidentally, on the improvement of shore property and increased values resulting therefrom. Estimates of monetary benefits are based on current (spring 1961) price levels. Analysis is as prescribed by paragraph 1-111 of Part CI, Chapter 1, Engineering Manual for Civil Works Construction; and Engineering Manual 1120-2-108, Beach Erosion Control Benefits; and is based on the plan of improvement described in paragraph 33 of the report. All evaluated benefits would occur in Virginia and Biscayne Keys. Place names referred to in this appendix are shown on figure C-1.

2. Benefits from prevention of damages.--a. Loss of land.--Benefits credited to the plan would consist of direct prevention of loss of land from private property along the reaches of Key Biscayne. Benefits from prevention of loss of public lands have been computed but are not claimed, as that would possibly duplicate net recreational benefits accruing to those lands and evaluated in succeeding paragraphs of this appendix. The area of land which would be lost without the project over the period of evaluation (50 years) was estimated on the basis of the historical rate of shore recession. The anticipated damages due to loss of land were computed as the market value of the average area expected to be lost annually. Land evaluations are based on appraisals furnished by the offices of city and county tax assessors. Computed benefits from prevention of loss of land on Virginia Key are \$24,000 annually for the city shore and \$28,800 annually for the county shore. Computed benefits from prevention of loss of land along the county shore of Key Biscayne are \$25,200 annually. For the entire reach of private shorefront property on Key Biscayne, except the area described below, the estimated average annual benefit from prevention of loss of land is \$24,000 (9,600 square feet evaluated at \$2.50 a square foot). For the area from East Drive (approximately 1,600 feet south of the county property line) south to the end of Crandon Boulevard, the estimated annual average benefit is \$18,750 (5,000 square feet evaluated at \$3.75 a square foot). Total estimated annual benefits credited to the plan from prevention of loss of land are \$42,750, all of which are private.



LOCATION MAP

FIGURE C-1

b. Damages to developments.--(1) Virginia Key.--Benefits would consist of prevention of damages to an electrical power installation located at the shoreline near the north end of the key. Maintenance costs, and interest and amortization charges on \$4,800, the cost of a protective seawall which would be required at the power installation if the project were not provided, are considered equivalent to the average annual benefit. They total \$400 annually; the benefit would be private. There is an average annual public benefit of \$1,000 from the elimination of maintenance of twenty-seven 50-foot groins located at Virginia Beach. Without the project, a service road about 1,200 feet long would require relocating westward at a cost of approximately \$4,000. Interest and amortization charges on that \$4,000 would be \$200, which is the average annual public benefit. The total estimated annual benefits for Virginia Key would be \$400 private plus \$1,200 public, or \$1,600.

(2) Key Biscayne.--Public benefits resulting from the project would consist of elimination of maintenance costs on an existing seawall at Crandon Park, and of elimination of interest and amortization charges and maintenance costs on a seawall which would be required for protection of the cabana area of Crandon Park if the project were not provided. Those benefits amount to \$1,000 and \$600 annually, a total of \$1,600. Private benefits resulting from the project would consist of elimination of maintenance costs on two privately installed seawalls and two privately installed timber groins, and of elimination of interest and amortization charges and maintenance costs on a seawall which would be required for protection of private development if the project were not provided. Those benefits amount to \$1,100 and \$2,700 annually, a total of \$3,800. The total estimated annual benefits from prevention of damages to developments would be \$1,600 public, plus \$3,800 private, or \$5,400.

TABLE C-1

Estimated damage-prevention benefits

Type	Amount		
	Non-Federal public	Private	Total
<u>VIRGINIA KEY</u>			
<u>City of Miami property</u>			
Loss of land-----	(1)	-	-
Damages to development-----	-	(2) \$400	\$400
<u>Dade County property</u>			
Loss of land-----	(1)	-	-
Damages to development-----	\$1,200	-	1,200
Total-----	1,200	400	1,600

(Continued)

TABLE C-1--Continued

Type	Amount		
	Non-Federal public	Private	Total
<u>KEY BISCAYNE</u>			
<u>Dade County property</u>			
Loss of land-----	(1)	-	-
Damages to development-----	\$1,600	-	\$1,600
<u>Private property</u>			
Loss of land-----	-	(3) \$42,750	42,750
Damages to development-----	-	3,800	3,800
<u>Total</u> -----	1,600	46,550	48,150

- NOTES:
- (1) See paragraph 2 above.
 - (2) Damages to electrical power installation on leased city property.
 - (3) Benefit to the area from East Drive (approximately 1,600 ft. south of county property line) south to the end of Crandon Boulevard is \$18,750; benefit to the remainder of the private property is \$24,000, a total of \$42,750.

3. Benefits from increased land area.--All of Virginia Key and approximately the northern half of Key Biscayne are public property, and, therefore, would not yield a direct return on the increased property value due to increased land area except as more recreational bathing area would be provided. Benefits would accrue to owners of private property since such property is subject to resale; such benefits are evaluated as the return on the increase in value invested at 6 percent. Certain areas on Key Biscayne would increase more in value than others because of their higher current values. The increase in value would result from the increased land area due to the project. Assessed evaluations are related to the depth as well as the width of lots, and, therefore, to the area. Based on current assessed market values, the increase in value of the reach from East Drive south to the end of Crandon Boulevard would be \$675,000; the annual return on that invested at 6 percent would be \$40,500. The increase in value for the remaining shorefront area on Key Biscayne would be \$1,125,000; the annual rate on that amount invested at 6 percent is \$67,500. Therefore, the total private benefit from increased land area would be \$108,000 annually.

4. Recreational benefits.--a. General.--Estimated recreational benefits are based on the increase in the use of shorefront recreational facilities which would be possible and expected if the considered plan of improvement is provided. Evaluated benefits are limited to those that would be derived from the improved publicly owned beaches. Numerically, use of private beaches is relatively negligible compared to use of the

public beaches. Estimates of future use of publicly owned recreational areas are based on present and past use of those areas, and on expected growth of the permanent and nonpermanent population in the tributary area. Density of bathers during peak crowds has been fixed at a minimum area of 75 square feet of dry beach area for each bather. The following tabulation of annual bathing attendance at Virginia Beach and Crandon Park is based on data obtained from the Dade County Parks Department. The attendance figures are based on traffic-counting meters placed at entrances to the parking lots, and on an average of 3.5 passengers per car.

<u>Year</u>	<u>Virginia Beach</u>	<u>Crandon Park</u>	<u>Total</u>
1954	295,314	2,481,949	2,777,263
1955	302,689	2,660,611	2,963,300
1956	304,191	2,903,227	3,207,418
1957	245,213	3,215,781	3,460,994
1958	242,236	3,216,586	3,458,822
1959	163,889	2,957,353	3,121,242
1960	184,009	3,215,717	3,399,726

The area tributary to the beaches under study was considered to be Dade County, less certain portions of the county. A portion of the annual tourist visitation (nonpermanent population) was considered as tributary also. Custodians and local officials of the study area were interviewed and their views as to present and future needs obtained. Individual estimates were made of future visitation at each of the public bathing areas and parks in the study area, based on existing conditions and expected population growth. Similar estimates were made of future visitation at the same areas, based on a beach improved and maintained as considered in the plan of improvement. Allowance was made for the fact that future visitation at some areas would include persons who have merely transferred their bathing attendance to another location; estimates of future use of the recreational areas do not include those persons. The public benefits that would be derived from the increased visitations are evaluated in terms of the cost to each additional patron for that form of recreation, and also in terms of the costs of and benefits from competing forms of recreation. The following minimum values for each visit to the various beaches under study were used in accordance with EM 1120-2-108.

Virginia Key:

Developed beach (county-owned)----- \$0.75
 Undeveloped beach (city-owned)----- 0.50

Key Biscayne:

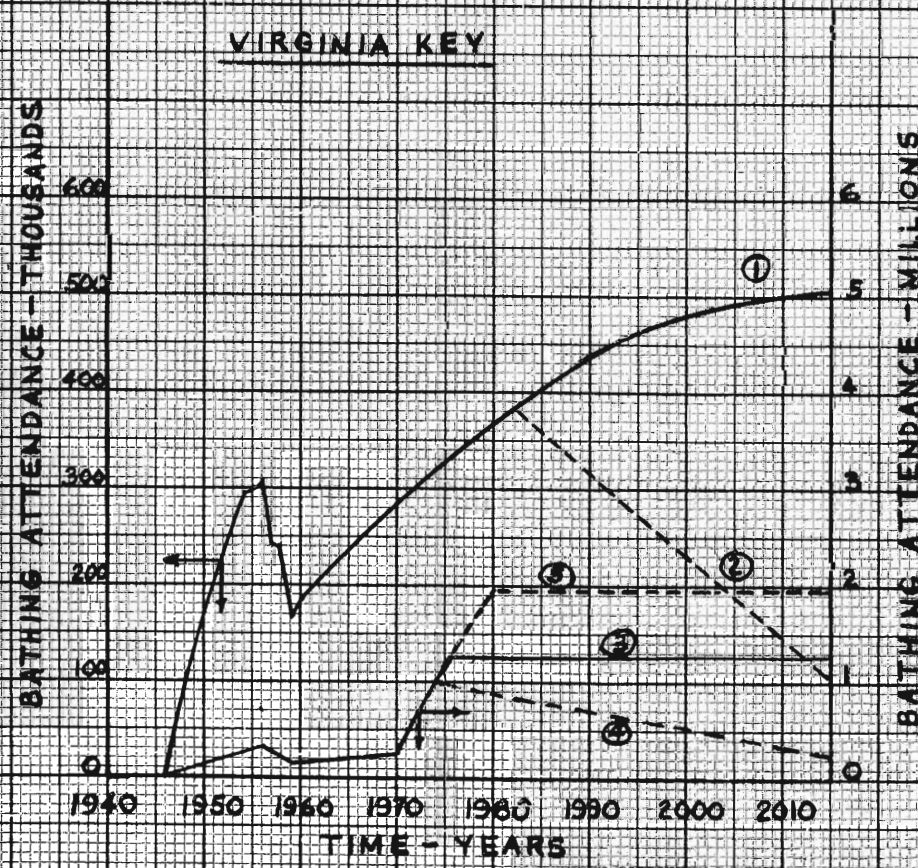
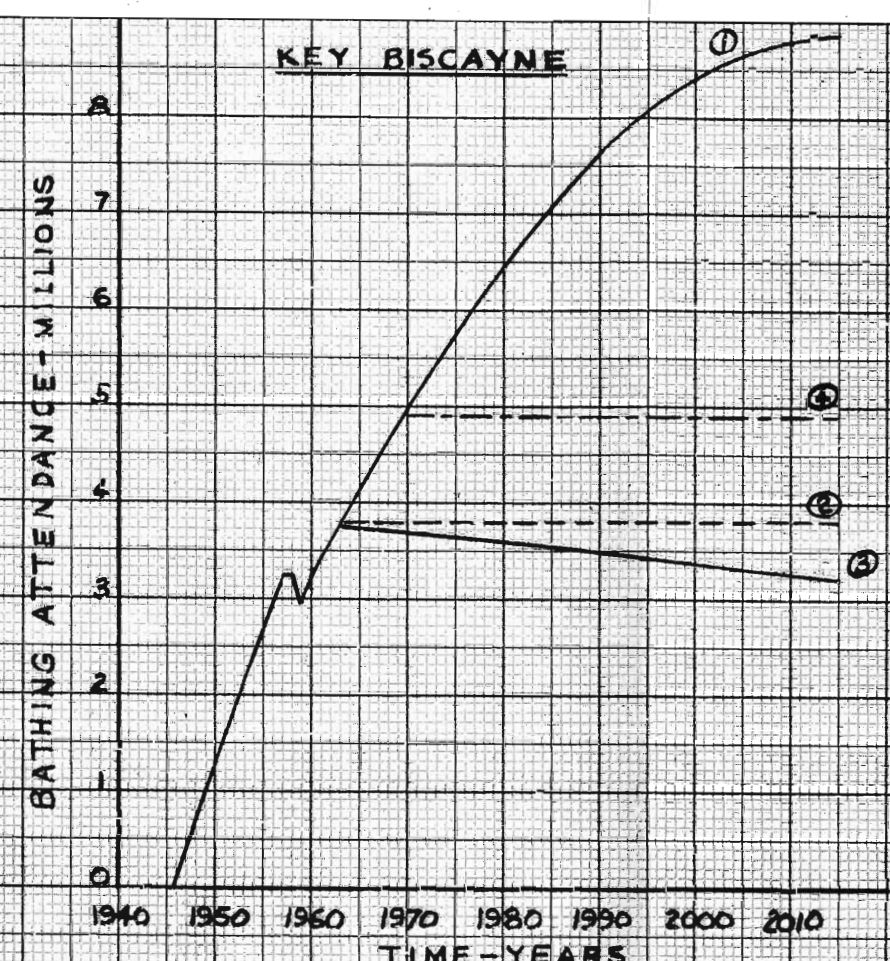
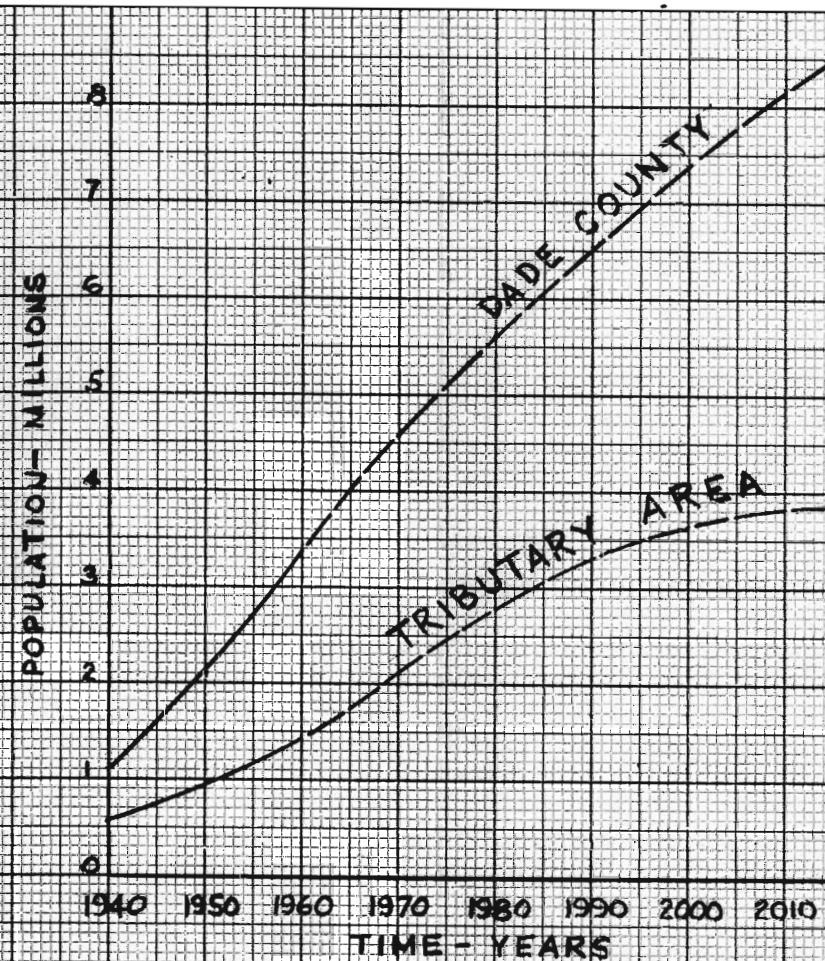
Public beach----- 0.75

The two beaches with unit visitation values of \$0.75 are highly developed and provide practically every recreational service and convenience. The beach with a unit visitation value of \$0.50 is undeveloped, but the visitor has free and easy access to it. No estimates of recreational benefits are presented for the reaches of Key Biscayne south of the county/line as there are no publicly owned shores in those reaches. property

b. Virginia Key.--The tributary area to the beaches on Virginia Key was considered to be Dade County less certain areas, and also a certain portion of the annual tourist visitation to the county. Figure C-2 shows a population curve for Dade County and the tributary area, considering both permanent and nonpermanent population. It also shows curves of estimated future bathing attendance with and without the project on Virginia Key. It may be seen that Virginia Key, considered as an isolated area, would have ample area for future bathing projections based purely on past attendance and future population growth until about 1975. However, it may also be seen that Key Biscayne bathing projections based on past attendance and on future population growth exceed available areas in the early 1960's; it is considered that overflow crowds from Key Biscayne would migrate to Virginia Key if that key could accommodate them. Therefore, increased bathing attendance credited to the plan for Virginia Key is based on initial widening as described in the plan of improvement. It is emphasized that Virginia Key would not require additional bathing area until 1975 unless required to accommodate overflow from Key Biscayne. The average annual equivalent increase on Virginia Key during project life is measured at 1,090,000 persons, of which 565,000 would be on city beaches and 525,000 would be on county beaches. Individual benefits from attendance on the city beaches are evaluated at \$0.50 a person. Therefore, the annual benefit for that reach is \$282,500, say \$283,000. Individual benefits from attendance on the county beaches are evaluated at \$0.75 a person. Therefore, the annual benefit for that reach is \$393,750, say \$394,000. The total annual public recreational benefit for Virginia Key is \$677,000.

c. Key Biscayne.--The tributary area for the public beach at Key Biscayne is the same as described for Virginia Key in paragraph b above. Computations, based on present and past attendance figures for Crandon Park on Key Biscayne, show 60 square feet available to each bather during peak hours on peak days. A figure of 75 square feet was used as the minimum area in estimating future attendance. Figure C-2 shows curves of estimated future bathing attendance with and without the project for the county property on Key Biscayne. It may be seen that projected bathing attendance would exceed available beach areas (both developed and presently undeveloped) early in the 1960's. If the present beach were maintained the area would be sufficient for another year or two. If the beach were widened and maintained as called for by the plan of improvement, the beach area would suffice until 1970, when it would be insufficient to accommodate projected peak crowds. The average annual equivalent increase is based on the difference between curves 3 and 4, and is computed to be 1,090,000 persons. Individual benefits therefrom are evaluated at \$0.75 a person. Therefore, the annual public recreational benefit is \$817,500, say \$818,000.

5. Summary of benefits.--Evaluated benefits are summarized in table C-2.



NOTES:

- KEY BISCAYNE:**
- ① BASED ON TRIBUTARY POPULATION, UNLIMITED BEACH AREA.
 - ② AREA LIMITED TO EXISTING DEVELOPED BEACH PLUS UNDEVELOPED COUNTY FRONTAGE.
 - ③ AREA IN ② ALLOWED TO ERODE AT PAST RATE.
 - ④ AREA IN ② INCREASED BY 50-FOOT WIDER BERM AT ELEVATION +7.
 - ⑤ AVERAGE ANNUAL EQUIVALENT ATTENDANCE BETWEEN ③ AND ④ IS 1,090,000.
- VIRGINIA KEY:**
- ① BASED ON TRIBUTARY POPULATION, UNLIMITED BEACH AREA.
 - ② EXISTING DEVELOPED COUNTY BEACH ALLOWED TO ERODE AT PAST RATE.
 - ③ AREA LIMITED TO EXISTING DEVELOPED BEACH PLUS UNDEVELOPED COUNTY AND CITY FRONTAGE. RECEIVE KEY BISCAYNE OVERFLOW IN 1970.
 - ④ AREA IN ③ ALLOWED TO ERODE AT PAST RATE.
 - ⑤ AREA IN ③ INCREASED BY 50-FOOT WIDER BERM AT ELEVATION +6.
 - ⑥ AVERAGE ANNUAL EQUIVALENT ATTENDANCE BETWEEN ④ AND ⑤ IS 1,090,000.

COOPERATIVE BEACH EROSION STUDY
 VIRGINIA KEY AND KEY BISCAYNE
 FLORIDA
 POPULATION AND BATHING ATTENDANCE

FIGURE C-2

TABLE C-2

Evaluated benefits

Type	Amount
<u>VIRGINIA KEY</u>	
<u>City of Miami property:</u>	
Damages-to-development benefits-----	\$400
Recreational benefits-----	<u>283,000</u>
Total-----	283,400
<u>Dade County property:</u>	
Damages-to-development benefits-----	1,200
Recreational benefits-----	<u>394,000</u>
Total-----	395,200
Total, Virginia Key-----	678,600
<u>KEY BISCAYNE</u>	
<u>Dade County property:</u>	
Damages-to-development benefits-----	1,600
Recreational benefits-----	<u>818,000</u>
Total-----	819,600
<u>Entire key:</u>	
Loss-of-land benefits-----	(1) 42,750
Damages-to-development benefits-----	5,400
Recreational benefits-----	818,000
Increased-land-area benefits-----	<u>108,000</u>
Total, Key Biscayne-----	974,150

NOTE: (1) Public property excluded; see paragraph 2 of this appendix.

Estimates of annual benefits divided as to non-Federal public and private and as to type are presented in table C-3. There are no Federal benefits.

TABLE C-3

Summary of benefits

Type	Non-Federal public	Private	Total
<u>VIRGINIA KEY</u>			
<u>City of Miami property:</u>			
Damages-to-development benefits-----	-	\$400	\$400
Recreational benefits-----	283,000	-	283,000
Total-----	283,000	400	283,400
Percent-----	> 99	< 1	100
<u>Dade County property:</u>			
Damages-to-development benefits-----	1,200	-	1,200
Recreational benefits-----	394,000	-	394,000
Total-----	395,200	0	395,200
Percent-----	100	0	100
Total, Virginia Key-----	678,200	400	678,600
Percent-----	>99	< 1	100
<u>KEY BISCAIYNE</u>			
<u>Dade County property:</u>			
Damages-to-development benefits-----	1,600	-	1,600
Recreational benefits-----	818,000	-	818,000
Total-----	819,600	-	819,600
Percent-----	100	0	100
<u>Entire key:</u>			
Loss-of-land benefits-----	(1)	42,750	42,750
Damages-to-development benefits-----	1,600	3,800	5,400
Recreational benefits-----	818,000	-	818,000
Increased-land-area benefits-----	-	108,000	108,000
Total-----	819,600	154,550	974,150
Percent-----	84	16	100

NOTE: (1) Public property excluded; see paragraph 2 of this appendix.

6. Distribution of benefits.--Non-Federal public and private benefits are distributed to three shore categories as shown in table C-4.

TABLE C-4

Distribution of benefits

Shore category	Length (feet)	Benefits		
		Non-Federal public	Private	Total
<u>VIRGINIA KEY</u>				
Publicly owned:				
City-----	4,250	(1)\$283,000	(2) \$400	\$283,400
County-----	5,400	(3) 395,200	-	395,200
Privately owned but receiving public benefits-----	0	-	-	-
Privately owned but receiving only private benefits-----	0	-	-	-
Total-----	9,650	678,200	400	678,600
<u>KEY BISCAYNE</u>				
Publicly owned (county)-----	9,900	(4) 819,600	-	819,600
Privately owned but receiving public benefits-----	0	-	-	-
Privately owned but receiving only private benefits-----	12,600	-	(5)\$154,550	154,550
Total-----	22,500	819,600	154,550	974,150

- NOTES:
- (1) Recreational benefits.
 - (2) Damages to development prevented.
 - (3) Consists of \$1,200 damages to development prevented and \$394,000 recreational benefits.
 - (4) Consists of \$1,600 damages to development prevented and \$818,000 recreational benefits.
 - (5) Consists of \$42,750 loss-of-land benefits, \$3,800 damages to development prevented, and \$108,000 increased-land-area benefits.

7. Prospective damages from project works.--The borrow areas for beach fill will probably be located in Biscayne Bay due to the known availability of suitable material there and to the present unavailability of dredging equipment suited to working in other than protected waters. As pointed out in the report of the United States Fish and Wildlife Service presented in appendix E, dredging in the bay will damage fisheries there. The Service has not appraised those damages, but from information furnished by the Service, the annual damages have been loosely approximated at \$50,000. Should there be a period of some years before project works are carried out, during which time appropriate dredging equipment is developed, it may be feasible to use borrow areas in the ocean as desired by fish and wildlife interests. For that reason, benefits from beach erosion control have not been reduced by the prospective damages cited above. The project would be economically justified even if those damages were deducted from the beach erosion control benefits.

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX D

ESTIMATES OF COSTS

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VIRGINIA KEY AND KEY BISCAYNE, FLA.

BEACH EROSION CONTROL STUDY

APPENDIX D

ESTIMATES OF COSTS

I. FIRST COSTS

1. General.--The following estimates of first costs are for provision of a protective beach by artificial fill along parts of the reaches under study, and for the construction, when determined necessary and economical, of 3 groins on Virginia Key and 2 groins on Key Biscayne. At current prices, the possible reduction in nourishment requirements creditable to the groins is insufficient to justify their construction. The protective beach would provide 50 additional feet of level berm for both keys. The berm elevation on Virginia Key would be 6.0. The berm elevation on Key Biscayne would be 7.0. Seaward slope of the restored beach, as shaped by wave action, would be about 1 on 20 from the crest of the berm to mean low water, and 1 on 30 from mean low water to intersection with existing bottom. The average increase in width at mean high water would be about 85 feet for both Virginia Key and Key Biscayne. The estimates allow for advance nourishment, at the time of initial restoration, equivalent to 5 years of estimated losses. The considered plan provides for initial restoration of the reaches as now required, with maintenance thereafter by periodic nourishment when and where required. The elevation of the level inner section of the groins on Virginia Key is 6, and on Key Biscayne 7. The groins extend seaward far enough to contain the point of intersection of the restored beach with the existing bottom. Average length of the groins on Virginia Key is about 390 feet and on Key Biscayne is about 300 feet. A typical groin section is shown on plate 5.

2. Virginia Key.--The considered plan provides for initial restoration of 9,650 feet of beach (4,250 feet City of Miami property and 5,400 feet Dade County property). The plan also includes, when and if needed and justified, three rubble-mound groins (1 on city property and 2 on county property).

3. Key Biscayne.--The considered plan provides for initial restoration of 9,900 feet of county property. Because of the interrelationship of shore processes on both county and private property, and in connection with the study of hurricane flooding in Biscayne Bay, cost estimates are also presented for a protective beach along 12,600 feet of private property (the application for this study limits the area for restoration to the publicly owned shores). The plan also includes, when and if needed and justified, 2 rubble-mound groins (1 on county property and the other on private property).

4. Bases of estimates.--Estimates of cost of beach fill in this report are based on use of borrow areas located in Biscayne Bay (see sub-surface data shown on figure A-1 in appendix A). Use of a 27-inch dredge is assumed, with an average pipeline length of about 10,000 feet. Unit dredging costs are based on operating costs of equipment suited to the work and include allowances for insurance costs and for reasonable profit. Plant capacities and time factors are based on known performance of contractors' equipment operating under similar conditions. At time of actual construction, consideration could be given to use of borrow areas in the Atlantic Ocean, as desired by fish and wildlife interests so as to avoid damage to fisheries in Biscayne Bay. Cost estimates are considered adequate for working in the ocean should suitable dredging equipment become available by the time construction is begun. The groin estimates are based on the use of granite shipped by rail to Miami and hauled by truck to the job site. All prices reflect current (spring 1961) price levels.

5. Local interests would be required to provide all necessary lands, easements, and rights-of-way required in connection with the improvements. Allowance for purchase of borrow areas is not included, as it is assumed the cooperating agency could obtain bay bottom lands from the state at nominal cost.

6. Estimates of first cost are given in tables D-1 and D-2 following. City and county costs on Virginia Key are presented separately since improvement of the parts could be accomplished separately.

TABLE D-1

Estimated first costs

Virginia Key

<u>Item</u>	<u>Quantity</u>	<u>Unit cost</u>	<u>Total</u>
<u>CITY PROPERTY</u>			
<u>Placement of beach fill</u> -----	127,000 cu. yd.	\$0.60†	\$76,000
<u>Contingencies</u> -----			<u>15,000</u>
Subtotal-----			91,000
Engineering and design-----			7,000
Supervision and administration-----			7,000
Postauthorization costs-----			(1) 1,000
Total first cost (financial)-----			(2)106,000
Preauthorization costs (cooperative study)-----			<u>6,000</u>
Total first cost (economic)-----			112,000

(Continued)

TABLE D-1--Continued

Item	Quantity	Unit cost	Total
<u>Deferred construction</u>			
<u>Construction of groin</u> -----	4,000 tons	\$18.62	\$74,000
Contingencies-----			<u>15,000</u>
Subtotal-----			89,000
Engineering and design-----			6,000
Supervision and administration-----			7,000
Postauthorization costs-----		(1)	<u>1,000</u>
Total first cost (financial)-----		(2)	103,000
Preauthorization costs (cooperative study)-----			(3)
Total first cost (economic)-----			103,000
<u>COUNTY PROPERTY</u>			
<u>Placement of beach fill</u> -----	527,000 cu. yd.	0.60 ⁺	315,000
Contingencies-----			<u>63,000</u>
Subtotal-----			378,000
Engineering and design-----			27,000
Supervision and administration-----			30,000
Postauthorization costs-----		(1)	<u>3,000</u>
Total first cost (financial)-----		(2)	438,000
Preauthorization costs (cooperative study)-----			<u>6,000</u>
Total first cost (economic)-----			444,000
<u>Deferred construction</u>			
<u>Construction of 2 groins</u> -----	17,800 tons	17.92	319,000
Contingencies-----			<u>64,000</u>
Subtotal-----			383,000
Engineering and design-----			27,000

(Continued)

TABLE D-1--Continued

Item	Quantity	Unit cost	Total
Supervision and administration-----			\$31,000
Postauthorization costs-----			(1) <u>3,000</u>
Total first cost (financial)-----			(2) 444,000
Preauthorization costs (cooperative study)-----			(3)
Total first cost (economic)-----			444,000
<u>ENTIRE KEY</u> (excluding deferred construction)			
Total first cost (financial)-----			544,000
Total first cost (economic)-----			556,000 (Spring 1961)

- NOTES: (1) Consists of engineering and administrative costs to Corps of Engineers in connection with construction by cooperating agency.
 (2) Amount subject to apportionment.
 (3) All preauthorization costs are included in estimates for placement of beach fill.

TABLE D-2
Estimated first costs
Key Biscayne

Item	Quantity	Unit cost	Total
<u>COUNTY PROPERTY</u>			
<u>Placement of beach fill</u> -----	415,000 cu. yd.	\$0.63±	\$263,000
Contingencies-----			<u>53,000</u>
Subtotal-----			316,000
Engineering and design-----			22,000
Supervision and administration-----			25,000
Postauthorization costs-----			(1) <u>2,000</u>
Total first cost (financial)-----			(2) 365,000

(Continued)

TABLE D-2--Continued

Item	Quantity	Unit cost	Total
Preauthorization costs (cooperative study)-----			<u>\$14,000</u>
Total first cost (economic)-----			379,000
<u>Deferred construction</u>			
<u>Construction of groins</u> -----	4,600 tons	\$18.07	83,000
Contingencies-----			<u>16,000</u>
Subtotal-----			99,000
Engineering and design-----			7,000
Supervision and administration-----			8,000
Postauthorization costs-----			(1) <u>1,000</u>
Total first cost (financial)-----			(2) 115,000
Preauthorization costs (cooperative study)-----			(3)
Total first cost (economic)-----			115,000
<u>ENTIRE KEY</u>			
<u>Placement of beach fill</u> -----	1,103,000 cu. yd.	0.63 [†]	698,000
Contingencies-----			<u>140,000</u>
Subtotal-----			838,000
Engineering and design-----			59,000
Supervision and administration-----			67,000
Postauthorization costs-----			<u>5,000</u>
Total first cost (financial)-----			(2) 969,000
Preauthorization costs (cooperative study)-----			<u>14,000</u>
Total first cost (economic)-----			983,000
<u>Deferred construction</u>			
<u>Construction of groins</u> -----	10,500 tons	18.00	189,000
Contingencies-----			<u>37,000</u>
Subtotal-----			226,000

(Continued)

TABLE D-2--Continued

Item	Quantity	Unit cost	Total
Engineering and design-----			\$16,000
Supervision and administration-----			18,000
Postauthorization costs-----			(1) 2,000
Total first cost (financial)-----			(2) 262,000
Preauthorization costs (coopera- tive study)-----			(3)
Total first cost (economic)-----			262,000 (Spring 1961)

- NOTES: (1) Consists of engineering and administrative costs to Corps of Engineers in connection with construction by cooperating agency.
- (2) Amount subject to apportionment.
- (3) All preauthorization costs are included in estimates for placement of beach fill.

II. ANNUAL COSTS

7. General.--The life of the project is considered to be 50 years, and to cover the period 1965-2015. Interest and amortization charges are computed using an interest rate of 2-5/8 percent for all public reaches and 5 percent for the private reach of Key Biscayne. While few municipalities can borrow money at 2-5/8 percent interest, the City of Miami and Dade County, the agencies which would finance the project, have excellent credit ratings. In view of the fluid status of prevailing interest rates, the use of 2-5/8 percent interest is considered appropriate. It is assumed that all local expenditures on the public part of the project would be financed by a non-Federal public agency, while the expenditures for protection of private property would be financed by private interests.

8. Periodic nourishment.--The restored sections of beach would require periodic nourishment if they are to be maintained to a width adequate for protective purposes. Total estimated annual nourishment requirements are as follows:

Virginia Key----- 30,000 cubic yards
Key Biscayne----- 40,000 cubic yards

Periodic nourishment would be accomplished as required. For the purpose of establishing an average annual cost, an average nourishment interval of 5 years is assumed.

9. Estimates.--Estimated annual costs are given in tables D-3 and D-4. There are no charges for interest during construction as the construction period would be less than 2 years.

TABLE D-3

Estimated annual costs

Virginia Key

<u>Item</u>	<u>Amount</u>
<u>CITY PROPERTY</u>	
<u>Placement of beach fill</u>	
<u>Initial investment</u> -----	(1) \$112,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	2,900
Amortization at 2-5/8 pct. for 50 years-----	1,100
Periodic beach nourishment-----	(2) <u>12,500</u>
Total annual cost (economic)-----	16,500
Total annual cost (financial)-----	(3) 16,300
<u>Deferred construction</u>	
<u>Construction of groin</u>	
<u>Initial investment</u> -----	(4) 103,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	2,700
Amortization at 2-5/8 pct. for 50 years-----	1,000
Maintenance-----	<u>900</u>
Total annual cost (economic)-----	4,600
Total annual cost (financial)-----	(5) 4,600
(Continued)	

TABLE D-3--Continued

Item	Amount
<u>COUNTY PROPERTY</u>	
<u>Placement of beach fill</u>	
<u>Initial investment</u>	(6) \$444,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	11,700
Amortization at 2-5/8 pct. for 50 years-----	4,400
Periodic beach nourishment-----	(7) <u>15,800</u>
Total annual cost (economic)-----	31,900
Total annual cost (financial)-----	(8) 31,600
<u>Deferred construction</u>	
<u>Construction of 2 groins</u>	
<u>Initial investment</u> -----	(9) 444,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	11,700
Amortization at 2-5/8 pct. for 50 years-----	4,400
Maintenance-----	<u>3,800</u>
Total annual cost (economic)-----	19,900
Total annual cost (financial)-----	(5) 19,900
<u>ENTIRE KEY</u>	
Total annual cost (economic) (excluding deferred construction)-----	48,400
Total annual cost (financial)----- (excluding deferred construction)	47,900

- NOTES: (1) Estimated first cost, including \$6,000 preauthorization and \$1,000 postauthorization costs.
- (2) Based on depositing 70,000 cubic yards at 5-year intervals. Estimated cost of each deposit is \$62,400. Annual cost is \$62,400/5, or \$12,500.
- (3) Based on initial investment less preauthorization costs, or \$106,000 (\$112,000 - \$6,000 = \$106,000).
- (4) Estimated first cost, including \$1,000 postauthorization costs. All preauthorization costs were included in estimates for placement of beach fill.

(Continued)

TABLE D-3--Continued

- NOTES: (5) Based on initial investment. All preauthorization costs included in estimates for placement of beach fill.
- (6) Estimated first cost, including \$6,000 preauthorization costs and \$3,000 postauthorization costs.
- (7) Based on depositing 80,000 cubic yards at 5-year intervals. Estimated cost of each deposit is \$79,100. Annual cost is \$79,100/5 or \$15,800.
- (8) Based on initial investment less preauthorization costs, or \$438,000 (\$444,000 - \$6,000 = \$438,000).
- (9) Estimated first cost, including \$3,000 postauthorization costs. All preauthorization costs were included in placement of beach fill.

TABLE D-4

Estimated annual costs

Key Biscayne

Item	Amount
<u>COUNTY PROPERTY</u>	
<u>Placement of beach fill</u>	
<u>Initial investment</u> -----	(1) \$379,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	9,900
Amortization at 2-5/8 pct. for 50 years-----	3,700
Periodic beach nourishment-----	(2) <u>19,100</u>
Total annual cost (economic)-----	32,700
Total annual cost (financial)-----	(3) 32,300
<u>Deferred construction</u>	
<u>Construction of groin</u>	
<u>Initial investment</u> -----	(4) 115,000
<u>Annual costs</u>	
Interest at 2-5/8 pct.-----	3,000
Amortization at 2-5/8 pct. for 50 years-----	1,100
Maintenance-----	<u>1,000</u>
Total annual cost (economic)-----	5,100
Total annual cost (financial)-----	(5) 5,100

(Continued)

TABLE D-4--Continued

Item	Amount
<u>ENTIRE KEY</u>	
<u>Placement of beach fill</u>	
<u>Initial investment</u> -----	(6) \$983,000
<u>Annual costs</u>	
Interest at 5 pct. and 2-5/8 pct. (7)-----	40,100
Amortization at 5 pct. and 2-5/8 pct. for 50 years (7)-----	6,600
Periodic beach nourishment-----	(8) 42,500
Total annual cost (economic)-----	89,200
Total annual cost (financial)-----	(9) 88,800
<u>Deferred construction</u>	
<u>Construction of groins</u>	
<u>Initial investment</u> -----	(10) 262,000
<u>Annual costs</u>	
Interest at 5 pct. and 2-5/8 pct. (7)-----	10,300
Amortization at 5 pct. and 2-5/8 pct. for 50 years (7)-----	1,800
Maintenance-----	2,300
Total annual cost (economic)-----	14,400
Total annual cost (financial)-----	(5) 14,400

- NOTES: (1) Estimated first cost, including \$14,000 preauthorization and \$2,000 postauthorization costs.
- (2) Based on depositing 90,000 cubic yards at 5-year intervals. Estimated cost of each deposit is \$95,500. Annual cost is $\$95,500/5 = \$19,100$.
- (3) Based on initial investment less preauthorization costs, or \$365,000 (\$379,000 - \$14,000 = \$365,000).
- (4) Estimated first cost, including \$1,000 postauthorization costs. All preauthorization costs were included in estimates for placement of beach fill.
- (5) Based on initial investment. All preauthorization costs included in estimates for placement of beach fill.

(Continued)

TABLE D-4--Continued

- NOTES:
- (6) Estimated first costs, including \$14,000 preauthorization and \$5,000 postauthorization costs.
 - (7) The 5-percent interest rate applies only to the privately owned shores of Key Biscayne and is based on the assumption that work on private property would be done by private interests.
 - (8) Based on depositing 200,000 cubic yards at 5-year intervals. Estimated cost of each deposit is \$212,500. Annual cost is \$212,500/5 or \$42,500.
 - (9) Based on initial investment less preauthorization costs, or \$969,000 (\$983,000 - \$14,000 = \$969,000).
 - (10) Estimated first cost, including \$2,000 postauthorization costs.

III. APPORTIONMENT OF COSTS

10. General.--The policy of Federal aid in the restoration and protection of shores against erosion is set forth in Public Law 826, 84th Congress. The maximum Federal aid permitted under that law, one-third of the cost of construction, is applicable to publicly owned shores. Privately owned shores are eligible for Federal aid if there is benefit such as that arising from public use or from the protection of nearby public property, or if the benefits to the shores are incidental to the project, and the Federal contribution to the project is adjusted in accordance with the degree of such benefits. Periodic beach nourishment is considered construction eligible for Federal aid. It is also considered that Federal aid toward periodic beach nourishment should be limited to a period of 10 years to permit reevaluation of benefits and techniques. In the present case, benefits consist of local beach erosion control benefits. The application for this cooperative study did not include the private land on Key Biscayne. However, since those private lands occupy a major portion of the key and a hurricane protection plan was developed in connection with a separate study of hurricane flooding in Biscayne Bay (see paragraph 36 of the main body of the report), a beach restoration plan was developed. The plan is economically justified by private benefits; there would be no public benefits. Initial and annual maintenance costs of the plan of improvement are apportioned as follows, in accordance with Public Law 826.

11. Computation of cost apportionment.--a. Project costs subject to apportionment.--

Reach	Item	First costs	Annual costs
Virginia Key-----	Beach restoration	\$544,000	\$28,300
	Groins	547,000	4,700
Key Biscayne-----	Beach restoration:		
	County frontage	365,000	19,100
	Private frontage	604,000	23,400
	Groins:		
	County frontage	115,000	1,000
	Private frontage	147,000	1,300

b. Annual project benefits (see table C-2).--

<u>Reach</u>	<u>Source</u>	<u>Amount</u>
Virginia Key	Restoration and maintenance of beach	\$678,600
Key Biscayne:		
Public shore only	do.	819,600
Entire ocean shore	do.	974,150

c. Basis of cost apportionment (classified under terms of Public Law 826).--

Reach	Length (feet)	Percent of improved beach	Percent of Federal contribution
<u>Virginia Key</u>			
Publicly owned-----	9,650	100	100 x 1/3 = 33-1/3
<u>Key Biscayne</u>			
Publicly owned-----	9,900	100	100 x 1/3 = 33-1/3
Entire key			
Publicly owned-----	9,900	100	100 x 1/3 = 33-1/3
Privately owned----	12,600	100	0

d. Apportionment of first costs.--

Item	First cost subject to apportionment	Non-Federal		Federal	
		Percent	Amount	Percent	Amount
<u>VIRGINIA KEY</u>					
Beach restoration and groins-----	\$1,091,000	66-2/3	\$727,000	33-1/3	(1)\$364,000

KEY BISCAYNE

Beach restoration and groin(s)					
Public property	480,000	66-2/3	320,000	33-1/3	(2) 160,000
Entire key					
Public property	480,000	66-2/3	320,000	33-1/3	(2) 160,000
Private property	751,000	100	751,000	0	0

NOTES: (1) Includes \$8,000 postauthorization costs consisting of engineering and administrative costs to Corps of Engineers in connection with construction by cooperating agency; Federal reimbursement to cooperating agency would be \$356,000.

(2) Includes \$3,000 postauthorization costs to Corps of Engineers; Federal reimbursement to cooperating agency would be \$157,000.

e. Apportionment of annual costs.--

Item	Annual cost subject to apportionment	Non-Federal		Federal	
		Percent	Amount	Percent	Amount
<u>VIRGINIA KEY</u>					
Beach restoration-----	\$28,300	66-2/3	\$18,900	33-1/3	(1)\$9,400
Groins-----	4,700	100	4,700	0	0

KEY BISCAYNE

Public property:					
Beach restoration---	19,100	66-2/3	12,700	33-1/3	(1) 6,400
Groin-----	1,000	100	1,000	0	0
Entire key:					
Public property:					
Beach restoration--	19,100	66-2/3	12,700	33-1/3	(1) 6,400
Groin-----	1,000	100	1,000	0	0
Private property:					
Beach restoration--	23,400	100	23,400	0	0
Groin-----	2,300	100	2,300	0	0

NOTE: (1) This Federal contribution would be for the first 10 years of project life.

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

APPENDIX E

REPORT OF UNITED STATES
FISH AND WILDLIFE SERVICE
AND COMMENT OF FLORIDA
STATE BOARD OF CONSERVATION



UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PEACHTREE-SEVENTH BUILDING
ATLANTA 23, GEORGIA

SOUTHEAST REGION

(REGION 4)

NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
KENTUCKY
TENNESSEE
ALABAMA
MISSISSIPPI
ARKANSAS
LOUISIANA
VIRGINIA
MARYLAND
PUERTO RICO
VIRGIN ISLANDS

ADDRESS ONLY THE
REGIONAL DIRECTOR

CE-SE-sf (Va. Key-Key Biscayne)

October 13, 1961

District Engineer
U. S. Army, Corps of Engineers
Jacksonville, Florida

Dear Sir:

Reference is made to your letters of July 3 and 18, 1961, which requested our comments on the proposed Virginia Key-Key Biscayne Beach Erosion project. Under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and in accordance with your requests, the Bureau of Sport Fisheries and Wildlife submits the following comments.

Your letters state that the plans presently under construction would serve to nourish eroded beaches on the eastern shores of Virginia Key and Key Biscayne, Dade County, Florida. (See attached map.) You propose to obtain materials for such nourishment by dredging and pumping from areas in Biscayne Bay lying generally 1,000 to 2,000 feet off the western shores of the two Keys. Materials for periodic nourishment of the restored beaches over the 50-year life of the project would also be taken from the same general areas.

We understand that project planning is still in the study stage and that no decision has been made as to the exact locations of borrow areas.

The Bureau is not greatly concerned over the beaches which would be restored by the project, for we do not believe that lasting or important damages to fish and wildlife would occur in those areas. We are very much concerned with the matter of borrow area selections on this project and wish you to be aware of that concern in the planning stage. We present herein for your consideration possible alternate borrow areas, areas which in our opinion would be less damaging to fish and wildlife resources than the ones you are now considering.

From other studies which the Bureau has made, we are aware that Biscayne Bay supports one of the most valuable sport fisheries in the State of Florida. This exceptional value results from the fact that there is a large human population around the Bay and because most of the Bay is still very productive of marine and estuarine fishes.

Bridge and boat fishermen, both tourists and residents, make extensive use of Biscayne Bay. A variety of inshore marine species such as mangrove snapper, sheepshead, black drum, snook, croaker, spotted sea trout, and many others, are taken in all seasons. In the winter and spring, bluefish and Spanish mackerel

runs are of top importance. The Bay also supports a live bait shrimp fishery important to the shrimpers and to the sport fishermen who buy and use the catch for bait. Commercial fishing for fin- and shellfish adds to the great value of the fishery resources of Biscayne Bay.

Our recent preliminary survey indicated that much of the borrow area you propose consists of well vegetated bottoms dominated by turtle grass. Trawl sampling in these bottoms produced considerable quantities of fish and shellfish, verifying the high productivity of those bottoms.

Turbid water conditions encountered during our preliminary survey made it impossible to observe all of the bottom off the western shore of Virginia Key that has been proposed as a borrow area. We were, however, able to determine that most of the area between 1,000 and 2,000 feet off that shore was vegetated with turtle grass and a variety of marine algae. This area will be examined again in our future field surveys.

In addition to the already recognized value of grassy bay bottoms, recent research in Boca Ciega Bay on Florida's west coast has shown that undisturbed shallow bottoms which support no rooted aquatic plants may almost equal grassy bottoms in basic productivity. In terms of photosynthetic activity, shallow bottoms which support only microscopic flora have now been shown to have

greater value to the organic cycle than was formerly recognized. The implication of this new finding is that undisturbed shallow bay bottoms which support such flora should also be left undisturbed in order to preserve their contribution via the food chains to the animal populations.

On the basis of our preliminary survey, the Bureau considers that considerable damages to the valuable sport and commercial fisheries of Biscayne Bay could result from use of the borrow areas which are being considered. Destruction of bottoms now vegetated with rooted grasses, and of those supporting only micro-flora, would reduce the capability of the Bay to support desirable fin- and shellfish populations. Since reuse and extension of borrow areas would continue over the 50-year life of the project, very great total damages to the valuable fisheries could result. Further, there would be no means to mitigate such damages.

In light of these circumstances, the Bureau recommends that you do not use the sites you now propose for borrowing. Instead we request that you consider the feasibility of using certain other areas. We have in mind five of these, all of which are designated by numbers and cross-hatching on the attached map. Use of these sites for borrowing would lessen damages to the area's very valuable fish and wildlife resources. Site number 2 would be particularly desirable from our point of view.

The Bureau will appreciate your evaluation of our borrow area proposals. After receiving your evaluations, we will furnish further comments and recommendations to you as may be necessary in project planning.

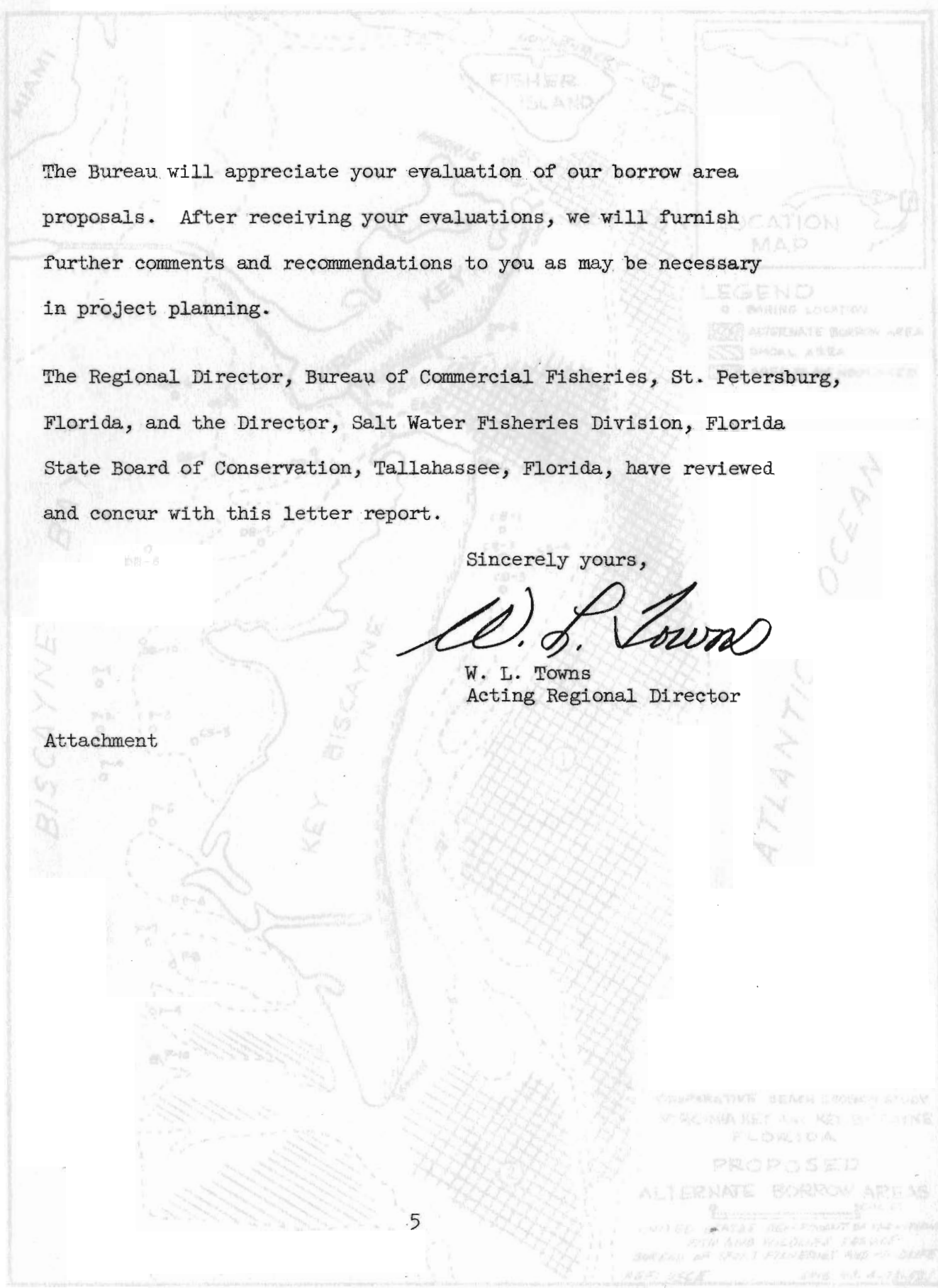
The Regional Director, Bureau of Commercial Fisheries, St. Petersburg, Florida, and the Director, Salt Water Fisheries Division, Florida State Board of Conservation, Tallahassee, Florida, have reviewed and concur with this letter report.

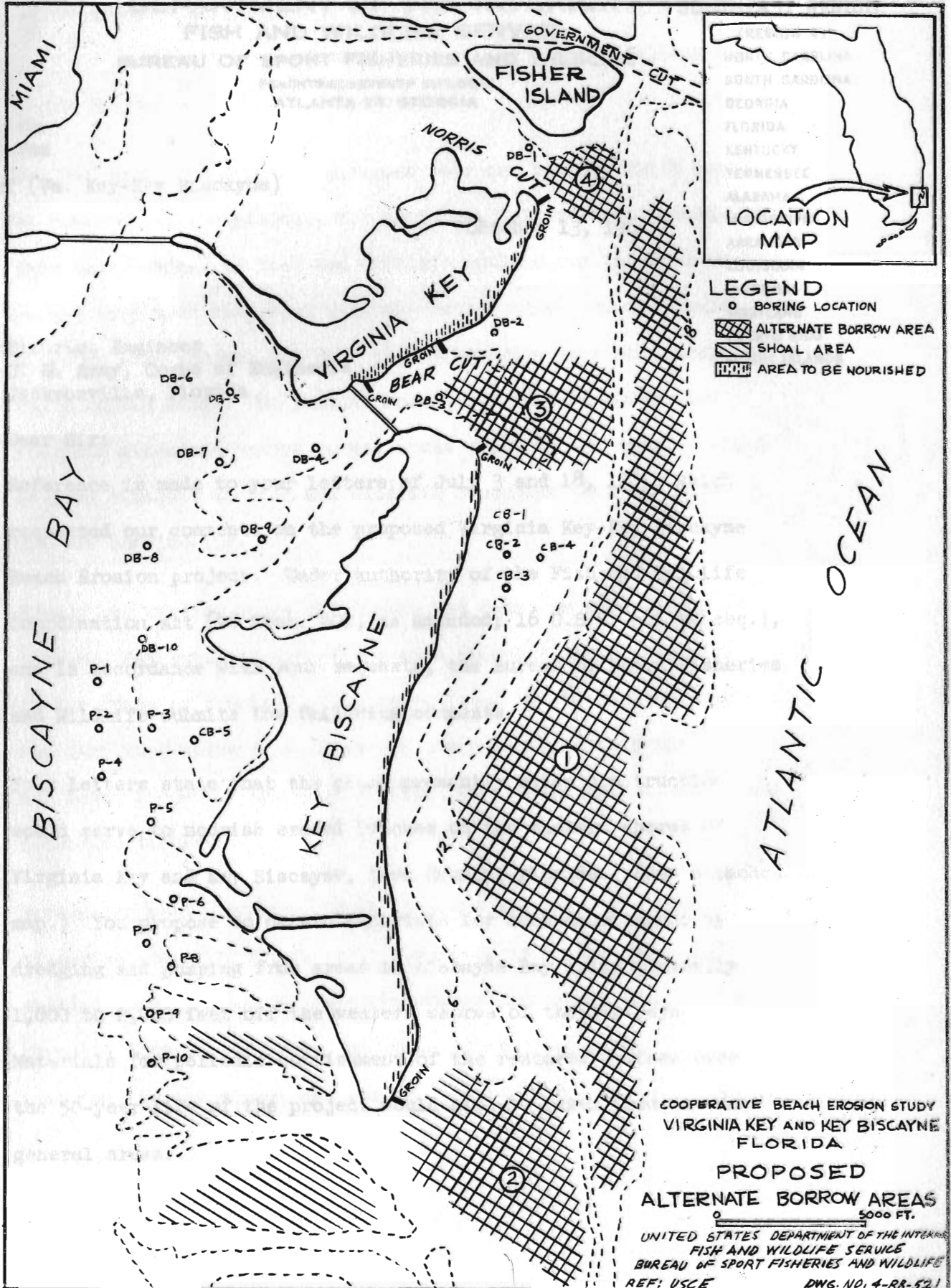
Sincerely yours,



W. L. Towns
Acting Regional Director

Attachment





LEGEND

- BORING LOCATION
- [Cross-hatched] ALTERNATE BORROW AREA
- [Diagonal hatching] SHOAL AREA
- [Grid pattern] AREA TO BE NOURISHED

COOPERATIVE BEACH EROSION STUDY
 VIRGINIA KEY AND KEY BISCAIYNE
 FLORIDA

**PROPOSED
 ALTERNATE BORROW AREAS**

5000 FT.
 UNITED STATES DEPARTMENT OF THE INTERIOR
 FISH AND WILDLIFE SERVICE
 BUREAU OF SPORT FISHERIES AND WILDLIFE
 REF: USCE DWG. NO. 4-RB-521

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
Peachtree-Seventh Building
Atlanta 23, Georgia

December 18, 1961

District Engineer
U. S. Army Engineer District
P. O. Box 4970
Jacksonville 1, Florida

Dear Sir:

On October 13, 1961, we released to you a preliminary report on the beach erosion study you are making for Virginia Key and Key Biscayne, Florida. In that report, we stated that we would make further field surveys of the project area, and report further to you on the results. We have now completed those surveys and the results are presented herein.

Further examination of the borrow areas in Biscayne Bay which you propose to use for the purposes of the project emphasize that these areas are very important to marine fin and shellfish production. If they are used for borrow sites in the project, the productivity of the area will be lessened and its valuable fish and wildlife resources will suffer a significant loss.

Conversely, further field examination substantiates our previous conclusion that borrowing from the four sites we recommend would cause relatively little damage to fish and wildlife resources. It is noted, however, immediately inshore from site number 1 lies a reef, and between the reef and the shore, a productive vegetated flat exists. Dredging from this flat would cause losses to valuable marine resources.

It is our understanding that 100 acres of bay bottom would be dredged in initial project works, and that on the average in each year of project life, an additional four acres would be dredged. Thus, over the 50-year project life, 300 acres would be utilized to obtain beach nourishment materials.

By teletypes to this Bureau dated November 16 and 21, 1961, Mr. George F. Snodgrass of your staff requested us to furnish you estimates of losses to fish and wildlife expected from dredging in Biscayne Bay for project purposes.

From studies of the Biscayne Bay hurricane levee project, we predicted that fishermen, over the life of the project, would spend annually 180,000 days fishing from the Rickenbacker Causeway and 543,400 man-days fishing from boats in this general area of Biscayne Bay. Thus, over an

area of about 50 square miles, fishermen would spend 723,400 man-days fishing, which, based on net values, would be worth \$1,900,200. In addition to this, the production of bait shrimp and other commercial fish products was valued at \$675,000. These figures are as follows:

	<u>Fisherman Days</u>	<u>Dollar Value</u>
Bridge Fishing	180,000	\$270,000
Boat Fishing	543,400	1,630,200
Commercial Fishing		<u>675,000</u>
Total		2,575,200

The fisherman days cited in the above table are based on average annual values established in the Biscayne Bay Hurricane Levee report. Monetary expressions of non-commercial use of fish and wildlife resources are based on the "Interim Schedule of Values for Recreational Aspects of Fish and Wildlife," adopted by the Inter-Agency Committee on Water Resources, October 18, 1960.

The most productive part of Biscayne Bay is the littoral vegetated zone. Without this zone, which totals about 14,600 acres within the area studied, there would be little fishing of value in the Bay area.

The Bureau believes that the additional costs for dredging from the oceanside would be amply justified by the losses mitigated. Because of the value of the resource in question, we therefore ask that your report recognize these values and that dredging of the vegetated littoral zone would cause significant, although not enumerated, losses. Further, we ask that in keeping with your letter of December 1, 1961, your report recognize that material can be obtained at reasonably comparable costs from the oceanside sites. With this, we propose to follow your suggestion and present the problem to and explore possible solutions with the local authorities who will be contracting for the work.

We appreciate the opportunity to comment on project plans.

Sincerely yours,

Walter A. Gresh
Regional Director

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PEACHTREE-SEVENTH BUILDING
ATLANTA 23, GEORGIA

December 7, 1961

District Engineer
U. S. Army, Corps of Engineers
Jacksonville, Florida

Dear Sir:

Reference is made to your letter of December 1, 1961 and previous correspondence on your survey report concerning beach erosion protection at Virginia Key - Key Biscayne, Florida.

We sincerely appreciate the time and effort which you have expended in determining the feasibility of oceanside dredging to protect the bay's fishery resources, and your helpful suggestion as to our future approach.

I regret that we have not as yet been able to provide the estimates of damages to the fishery resources. Our field staff has been so fully occupied with other urgent requests for data and comments that we have not been able to devote the time necessary to prepare the estimates. We do, however, hope to complete them very soon.

Sincerely yours,

Walter A. Gresh
Regional Director

U. S. ARMY ENGINEER DISTRICT, JACKSONVILLE
OFFICE OF THE DISTRICT ENGINEER
CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

SAKGW-1

1 December 1961

Regional Director
Bureau of Sport Fisheries and Wildlife
U. S. Fish and Wildlife Service
50 Seventh Street, NE.
Atlanta 23, Georgia

Dear Sir:

Reference is made to your letter of 18 October and prior exchanges of correspondence on the pending beach erosion protection report for Virginia Key - Key Biscayne, Fla. Your letter report of 13 October 1961 on that subject has also been received.

In your 18 October letter it is requested that further efforts be made at District level to eliminate fishery losses associated with taking material from the bay side of the islands for beach nourishment. The matter has been considered in some detail during the intervening period.

For reasons described rather fully in our 22 September letter, it is doubtful that heavy dredging equipment of the type required for a job of this size could be safely employed in the exposed ocean-side location proposed by the Bureau. Nevertheless, our engineers have undertaken to make comparative cost estimates between bay-side and oceanside dredging areas. While oceanside dredging is found to be more expensive in all instances, it is possible to attain reasonably comparable costs by using oceanside areas generally nearer the islands than those delineated in your letter report. Thus, if a contractor can be found who will hazard his equipment, or if a better type of equipment is developed in the next few years, it may be possible to use the ocean borrow areas. The estimates shown in our pending report will have sufficient contingency factors included to enable the work to be done in that manner, if such should prove to be possible or practicable.

It seems pertinent to mention that beach erosion protection projects--unlike almost all other classes of Corps of Engineers' construction--are usually contracted for and accomplished by local interests with a Federal monetary contribution. Thus, in the final

SAKGW-1
Regional Director
Bureau of Sport Fisheries and Wildlife
U. S. Fish and Wildlife Service

1 December 1961

analysis, construction is most likely to be performed by Dade County and the City of Miami, using a contractor of their choice. If and when the report is approved for Federal participation, it may then be productive for the Bureau to impress those local governmental elements with the advantages to fisheries of offshore borrow.

Your 18 October letter mentions a dredge working under permit in one of the borrow areas proposed in your letter report. That dredge is very light equipment which transfers sand to an adjacent floating barge for transport inland. It is wholly inadequate for a job of the magnitude in question, which would require heavy equipment and long pipelines to shore.

During the recent visit of Mr. Hunter to this office this same subject was discussed at some length. The problems of obtaining offshore dredging contractors and the hazards and difficulties experienced by those who have attempted such work with present-day equipment were explained. The rather negative results of our interviews with responsible dredging firms and the possibilities of pertinent early innovations in dredging equipment were also mentioned.

Your concern in this matter is fully appreciated, but it appears that no further purpose would be served by further delay in submitting the report. Accordingly, it is planned for submittal within a few weeks. A copy of your letter report will be made a part of our report, and your position will be fully explained.

You will recall that in an earlier letter we stated the acreage requirements for bay-side borrow areas and requested an evaluation of the damages to fishery resources to be expected if they were used. That information is still needed and will be included in our report if received in time.

Sincerely yours,

J. V. SOLLOHUB
Colonel, Corps of Engineers
District Engineer

Copy furnished:

As incl to ltr of even date to -
Florida State Board of Conservation
Salt Water Fisheries Division
P. O. Drawer 551
Tallahassee, Florida

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
PEACHTREE-SEVENTH BUILDING
ATLANTA 23, GEORGIA

October 18, 1961

CE-SE-sf (Va. Key-Key Biscayne)

District Engineer
U. S. Army, Corps of Engineers
Jacksonville, Florida

Dear Sir:

Reference is made to your September 22, 1961 reply to the Bureau's letter of September 12 which transmitted a draft of our proposed report on the beach erosion study of Virginia Key and Key Biscayne, Florida. Your letter concluded that mitigation measures we recommended to reduce losses to marine fisheries resources were not feasible, and without further consideration you will forward your report to higher authority without the Bureau's report, but stating our position as indicated in our draft report.

In view of the high value resources involved and intensive public utilization of marine fisheries in this area, we believe it is inappropriate to forward your report to higher authority prior to receipt of the Bureau's report and without attempt to mitigate project-occasioned losses. Although the Bureau's report can receive consideration at a higher echelon and be attached to the report of the Secretary of the Army at the time of submission to the Congress, we feel that further effort should be made at the District level to eliminate any unnecessary losses to the fishery.

Inasmuch as the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) authorizes project modification to accommodate means and measures to prevent loss of and damage to wildlife as an integral part of the cost of a project, we believe that re-location of borrow areas as requested should be given due consideration.

We would like to have your estimates of the costs of obtaining spoil from the sites chosen by your staff, and those which are recommended for mitigation. In making these estimates, we would like you to consider not only the cost of dredging but also the costs of transport and placement of spoil and easements required to accomplish this from sites selected. We feel that when all costs are considered, the difference may not be great. Further, dredging from areas selected for mitigation may not be as hazardous as it first appeared. During the past hurricane season, a small dredge has been operating in one of the borrow areas we proposed, and the contractor's continued interest in this area is evidenced by your Public Notice of Application for Permit 61-428. This would seem to indicate that operating costs at this site are not prohibitive.

Analysis of data requested above would permit more adequate consideration of the high value fishery resources of this area prior to your submission of a report to higher authority.

Sincerely yours,

W. L. Towns
Acting Regional Director

Florida State Board of Conservation
P. O. DRAWER 551 • TALLAHASSEE, FLORIDA

25 September 1961

Mr. Joe J. Koperski
Chief, Engineering Division
U. S. Army Engineers
575 Riverside Avenue
Jacksonville 2, Florida

Dear Mr. Koperski:

Dredging spoil from approximately one square mile of Biscayne Bay bottom for beach replenishment on the eastern or Atlantic frontage of Virginia and Biscayne Keys would result in extensive destruction and damage to seagrass beds that support valuable sports and bait shrimp fisheries in the protected bay waters. Increased water turbidity resulting from extensive dredging in Biscayne Bay would also be a matter of concern to the Marine Laboratory of the University of Miami and the Seaquarium in holding and displaying live salt water animals in aquaria and tanks.

The State Board of Conservation has reviewed a report on this project by the U. S. Fish and Wildlife Service and has concurred in its recommendations of four designated dredging areas on the eastern or ocean side of the two keys. Ample spoil from these less vegetated and less productive bottoms is available east of the two keys, particularly off the southeastern tip of Key Biscayne where an extensive, barren sandy shoal lies. This shoal has apparently been formed by the southward drift of sand from the very beaches that are to be replenished.

Yours very truly,

SALT WATER FISHERIES DIVISION

Ernest Mitts
Director

EM/RMI/hj
cc: Mr. Walter Gresh
Mr. Art Marshall
Mr. K. D. Woodburn

SUPPLEMENT I

VIRGINIA KEY AND KEY BISCAYNE, FLA.
BEACH EROSION CONTROL STUDY

Information Called for by
Senate Resolution 148, 85th Congress, 1st Session
Adopted January 28, 1958

1. Introduction.--The information in this supplement is furnished in response to Senate Resolution 148, 85th Congress, 1st Session, adopted January 28, 1958. That resolution calls for data in addition to that now presented in support of projects recommended for authorization and on possible alternatives thereto. Emphasis is given to reasons why alternatives are rejected in favor of recommended projects and the effects of alternative standards of evaluation, economic analysis, and cost allocation on project feasibility, scope, and cost-sharing arrangements.

2. Project descriptions and economic life.--Virginia Key and Key Biscayne separate Biscayne Bay from the Atlantic Ocean, immediately south of Miami Beach, and east-southeast of Miami, Florida. The recommended projects provide for protection, by beach fill and groins and by periodic nourishment of the ocean shorelines of Virginia Key and Key Biscayne. Protection of either key could be accomplished as a whole or by stages. The total length of shore recommended for restoration on Virginia Key is approximately 1.8 miles; the total length recommended for restoration on Key Biscayne is approximately 4.3 miles. The restored beach would have its berm width increased by 50 feet at elevation 6 on Virginia Key and at elevation 7 on Key Biscayne. Seaward slope from the berm crest to mean low water, as shaped by wave action, would be about 1 on 20 and from mean low water to the point of intersection with existing bottom would be 1 on 30. Estimated economic life is 50 years.

3. Project costs and justification.--Project costs are presented in detail in appendix D of the basic report. Tangible project benefits are derived from prevention of damages, from recreational benefits, and from increased land area. Project costs, benefits, justification, and Federal costs compare as follows for 50-year and 100-year project life.

Item	Virginia Key (1)		Key Biscayne			
	50-year life	100-year life	Public property		Entire key	
			50-year life	100-year life	50-year life	100-year life
Preauthorization costs (cooperative study)	\$12,000	\$12,000	\$14,000	\$14,000	\$14,000	\$14,000
Plan of improvement	1,091,000	1,091,000	480,000	480,000	1,231,000	1,231,000
Total first cost (economic)	1,103,000	1,103,000	494,000	494,000	1,245,000	1,245,000
Interest and amortization at 2-5/8 percent	40,000	31,000	18,000	14,000	(2)59,000	(2)52,000
Periodic beach nourishment	28,000	28,000	19,000	19,000	43,000	43,000
Maintenance of structure	5,000	5,000	1,000	1,000	2,000	2,000
Total annual costs (economic)	73,000	64,000	38,000	34,000	104,000	97,000
Annual benefits	678,600	678,600	819,600	951,600	974,150	1,105,950
Benefit/cost ratio	9.3	10.6	21.6	28.0	9.4	11.4
Federal share of first cost (financial):	33-1/3	33-1/3	33-1/3	33-1/3	(3)	(3)
Amount	(4)\$364,000	(4)\$364,000	(5)\$160,000	(5)\$160,000	(5)\$160,000	(5)\$160,000
Non-Federal share of first cost (financial):	66-2/3	66-2/3	66-2/3	66-2/3	(3)	(3)
Percent	\$727,000	\$727,000	\$320,000	\$320,000	\$1,071,000	\$1,071,000
Amount						

- NOTES:
- (1) Entire key is publicly owned.
 - (2) Interest rate used for private property is 5 percent; for public property 2-5/8 percent.
 - (3) Federal share is one-third of cost of protecting publicly owned shores only.
 - (4) Includes \$8,000 postauthorization costs to Corps of Engineers; Federal reimbursement to cooperating agency would be \$356,000.
 - (5) Includes \$3,000 postauthorization costs to Corps of Engineers; Federal reimbursement to cooperating agency would be \$157,000.

4. Intangible project effects.--There would be some adverse effects on fish and wildlife, according to State and Federal fish and wildlife agencies. Areas proposed as borrow areas for beach fill are in Biscayne Bay, where valuable fisheries are said to exist. The fish and wildlife agencies would prefer to have the borrow areas located in the ocean. Prospective damage to bay fisheries, although not enumerated by the United States Fish and Wildlife Service, have been loosely approximated at \$50,000 annually, based on data furnished by the Service in its letter of December 18, 1961.

5. Physical feasibility and cost of providing for future needs.--Study of protective and recreational needs of the area revealed no significant future need for improvement larger than that recommended until well into project life, when recreational demands for bathing area might exceed the area available. Lesser improvement would not provide adequate protection or recreational area.

6. Allocation of costs.--No allocation of costs among functions is involved in this report, the single function being beach erosion control.

7. Extent of interest in the project.--The City of Miami, Florida, is the cooperating agency for this study. The City of Miami is representing itself and Dade County for the purpose of this study. Contact and coordination have been maintained with the City of Miami and Dade County throughout the study.

8. Repayment schedules.--The basic report proposes Federal reimbursement of local interests after project construction. Repayment schedules are not involved.

9. Effect of project on State and local governments.--The projects would have negligible effect on community services and taxes.

10. Alternative design.--Consideration was given to combining the beach erosion control measures developed by this study with the protective measures required to prevent or reduce hurricane-induced flooding. Measures for reducing or eliminating such flooding were not economically justified, and are not included in the plans of improvement.